

NFPA®

1900

Standard for
Aircraft Rescue and Firefighting
Vehicles, Automotive Fire Apparatus,
Wildland Fire Apparatus, and
Automotive Ambulances

2024

Includes

NFPA 414 | NFPA 1901 | NFPA 1906 | NFPA 1917



NFPA® 1900

Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances

2024 Edition



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An International Codes and Standards Organization

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NFPA® 1900

Standard for

Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances

2024 Edition

This edition of NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulance*, was prepared by the Technical Committees on Fire Department Apparatus, Aircraft Rescue and Firefighting, and Ambulances. It was issued by the Standards Council on October 7, 2022, with an effective date of October 27, 2022.

This edition of NFPA 1900 was approved as an American National Standard on October 27, 2022.

Origin and Development of NFPA 1900

For the first edition of NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances*, the single legacy standards NFPA 414, NFPA 1901, NFPA 1906, and NFPA 1917 were all part of a document consolidation plan that was approved during the April 2019 Standards Council meeting that affects all documents in the Emergency Response and Responder Safety (ERRS) project.

Many of the changes made for this edition were related to the consolidation of the legacy documents NFPA 414, NFPA 1901, NFPA 1906, and NFPA 1917 into NFPA 1900. In addition to those changes that were made to make the document consolidation possible, each of the committees made significant changes to the areas of the document they are responsible for. For the aircraft rescue and firefighting (ARFF) vehicles requirements within NFPA 1900, the ARFF committee made changes to further explain the equivalency statement to better assist the AHJ. The ARFF committee also made changes to the lettering, numbering, and striping requirements for ARFF vehicles, and they included requirements for the use of hybrid electric or electric ARFF vehicles given the increased use and demand for these types of ARFF vehicles.

For the portions of NFPA 1900 that are made up of the legacy documents NFPA 1901 and NFPA 1906, some of the changes included the deletion of duplicative material and duplicative chapters, resulting in a further consolidation of the material relative to structural apparatus or wildland apparatus. Another change was the moving of the equipment requirements from the main body of the document to the annex. The fire department apparatus committee also included new requirements that address the various types of engines that might be used on new apparatus, they updated the requirements around lettering, striping, and the use of colors and retro-reflective materials, which gives the AHJ increased flexibility, and they made changes to the optical warning systems on the apparatus.

For the portions of NFPA 1900 that are made up of the legacy document NFPA 1917, many of the changes made related to the consolidation of the document. One of the most significant changes made by the ambulance committee was to remove the requirement on seatbelt warning systems. The committee provided a detailed substantiation for this change and included annex material relating to the change. The ambulance committee also made changes to the requirements to the optical warning systems.

For more information about the ERRS consolidation project, see nfpa.org/errs.

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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 1900

Standard for

Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances

2024 Edition

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

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard defines the minimum requirements for the design, performance, acceptance criteria, and testing of aircraft rescue and firefighting apparatus, new automotive fire apparatus and trailers, wildland fire apparatus, and automotive and remounted ambulances.

1.1.2* Vehicles without wheels are not covered by this standard.

1.2 Purpose. The purpose of this standard is to specify minimum requirements for the following:

- (1) Aircraft rescue and firefighting vehicles with on- and off-pavement performance capabilities
- (2) New automotive fire apparatus and trailers
- (3) New automotive wildland fire apparatus
- (4) New and remounted automotive ambulances

1.3* Application. This standard can be applied as follows:

- (1) Chapters 1 through 3, 4 through 6, and Annexes A, B, C, and I constitute NFPA 414.
- (2) Chapters 1 through 3, 7 through 14, 16 through 25, and Annexes A, D, E, F, G, and I constitute NFPA 1901.
- (3) Chapters 1 through 3, 7 through 12, 15 through 19, 24, 26, 27, and Annexes A, F, G and I constitute NFPA 1906.
- (4) Chapters 1 through 3, 28 through 34, and Annexes A, H, and I constitute NFPA 1917.

Chapter 2 Referenced Publications

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

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

NFPA 70®, *National Electrical Code®*, 2023 edition.

NFPA 460, *Standard for Aircraft Rescue and Firefighting Services at Airports*, 2024 edition.

NFPA 950, *Standard for Data Development and Exchange for the Fire Service*, 2020 edition.

NFPA 1910, *Standard for the Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels*, 2024 edition.

NFPA 1931, *Standard for Manufacturer's Design of Fire Department Ground Ladders*, 2020 edition.

NFPA 1932, *Standard on Use, Maintenance, and Service Testing of In-Service Fire Department Ground Ladders*, 2020 edition.

NFPA 1961, *Standard on Fire Hose*, 2020 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 2019 edition.

NFPA 1964, *Standard for Spray Nozzles*, 2018 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, 2019 edition.

NFPA 1989, *Standard on Breathing Air Quality for Emergency Services Respiratory Protection*, 2019 edition.

NFPA 2500, *Standard for Operations and Training for Technical Search and Rescue Incidents and Life Safety Rope and Equipment for Emergency Services*, 2022 edition.

2.3 Other Publications.

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

ANSI A14.2, *Ladders — Portable Metal — Safety Requirements*, 2017.

ANSI A14.5, *Ladders — Portable Reinforced Plastic — Safety Requirements*, 2017.

ANSI S1.4, *Specification for Sound Level Meters*, 2014.

ANSI/NEMA Z535.4, *Product Safety Signs and Labels*, 2017.

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

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013.

Boiler and Pressure Vessel Code, 2021.

Boiler and Pressure Vessel Code, Section VIII, Division 1, 2021.

2.3.3 ASNT Publications. American Society for Nondestructive Testing, Inc., P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518. www.asnt.org.

ANSI/ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel*, 2020.

2.3.4 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, www.astm.org.

ASTM B647, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage*, 2016.

ASTM B648, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor*, 2015.

ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, 2019.

ASTM E6, *Standard Terminology Relating to Methods of Mechanical Testing*, 2015.

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*, 2018.

ASTM E18, *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*, 2020.

ASTM E114, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method*, 2020.

ASTM E165/E165M, *Standard Test Method for Liquid Penetrant Examinations*, 2018.

ASTM E384, *Standard Test Method for Microindentation Hardness of Materials*, 2017.

ASTM E569/E569M, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation*, 2020.

ASTM E650, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*, 2017.

ASTM E661, *Standard Test Method for Performance of Wood and Wood-Based Floor and Roof Sheathing Under Concentrated Static and Impact Loads*, 2003 (2015).

ASTM E709, *Standard Guide for Magnetic Particle Testing*, 2021.

ASTM E797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*, 2021.

ASTM E1004, *Standard Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method*, 2017.

2.3.5 AWS Publications. American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672, www.aws.org/w/a.

AWS B1.10M/B1.10, *Guide for the Nondestructive Examination of Welds*, 2016.

AWS D1.1/D1.1M, *Structural Welding Code — Steel*, 2020.

AWS D1.2/D1.2M, *Structural Welding Code — Aluminum*, 2014.

AWS D1.3/D1.3M, *Structural Welding Code — Sheet Steel*, 2018.

2.3.6 CGA Publications. Compressed Gas Association, 8484 Westpark Drive, Suite 220, McLean, VA 22102, www.cganet.com.

G-7, *Compressed Air for Human Respiration*, 2019.

G-7.1, *Commodity Specification for Air*, 2018.

2.3.7 CSA Publications. CSA Group, 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, www.csagroup.org.

CSA W47.1, *Certification of Companies for Fusion Welding of Steel*, 2019.

CSA W47.2, *Certification of Companies for Fusion Welding of Aluminum*, 2015.

2.3.8 FAA Publications. Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 2059, www.faa.gov/airports/resources/advisory_circulars/.

FAA Advisory Circular No. 150/5210-19A, *Driver's Enhanced Vision System (DEVS)*.

2.3.9 FAMA Publications. Fire Apparatus Manufacturers Association, P.O. Box 3065, Ocala, FL 34478, www.fama.org.

FAMA TC008, *Graphical Symbols for Automotive Fire Apparatus*, 2014

FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*, 2019.

FAMA TC079, *Ember Separator Test*, 2021.

Fire Apparatus Safety Guide, 2020.

2.3.10 IPC Publications. IPC, 3000 Lakeside Drive, 309 S, Bannockburn, IL 60015, www.ipc.org.

IPC A-610H, *Acceptability of Electronic Assemblies*, 2020.

2.3.11 ISEA Publications. International Safety Equipment Association, 1101 Wilson Blvd, Suite #1425, Arlington, VA 22209-1762, www.safetysystem.org.

ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Accessories*, 2020.

2.3.12 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

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

ISO/IEC 17020, *Conformity Assessment: Requirements for the operation of various types of bodies performing inspection*, 2012.

ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*, 2017.

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

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Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

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

3.2.7 Standard. An NFPA standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases “standards development process” or “standards development activities,” the term “standards” includes all NFPA standards, including codes, standards, recommended practices, and guides.

3.3 General Definitions.

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

3.3.2 Acceptance Tests. Tests performed on behalf of or by the purchaser at the time of delivery to determine compliance with the specifications for the vehicle.

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

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

3.3.5 Aerial Device. An aerial ladder, elevating platform, or water tower that is designed to position personnel, handle materials, provide continuous egress, or discharge water.

3.3.6 Aerial Fire Apparatus. A vehicle equipped with an aerial ladder, elevating platform, or water tower that is designed and equipped to support firefighting and rescue operations by positioning personnel, handling materials, providing continuous egress, or discharging water at positions elevated from the ground.

3.3.7 Aerial Ladder. A self-supporting, turntable-mounted, power-operated ladder of two or more sections permanently attached to a self-propelled automotive fire apparatus and designed to provide a continuous egress route from an elevated position to the ground.

3.3.8 Air Control Panel. A consolidated arrangement of valves, regulators, gauges, and air system piping at a location that allows the operator to monitor and control the airflow and pressure within the air system from a centralized location.

3.3.9* Aircraft Rescue and Firefighting (ARFF). The firefighting action taken to prevent, control, or extinguish fire involved or adjacent to an aircraft for the purpose of maintaining maximum escape routes for occupants using normal and emergency routes for egress. [440, 2024]

3.3.10 Air-Mechanical Brakes. See 3.3.38.1, Air-Mechanical Brakes.

3.3.11 Air-Over-Hydraulic Brakes. See 3.3.38.2, Air-Over-Hydraulic Brakes.

3.3.12 Air Quality Monitors. Electronic instruments that monitor the air for such elements as carbon monoxide levels and moisture levels and that are capable of sending a signal to automatically shut down the air system.

3.3.13* Air Tank. A storage vessel meeting the requirements of either U.S. Department of Transportation (DOT) or American Society of Mechanical Engineers (ASME) and used to store an accumulation of air under pressure.

3.3.14 All-Wheel Drive. A vehicle with the ability to apply tractive power to all wheels.

3.3.15 Ambient Temperature. The temperature of the surrounding medium; usually used to refer to the temperature of the air in which a structure is situated or a device operates.

3.3.16 Ambulance. A vehicle used for out-of-hospital medical care and patient transport that provides a driver's compartment; a patient compartment to accommodate an emergency medical services provider (EMSP) and at least one patient located on the primary cot positioned so that the primary patient can be given emergency care during transit; equipment and supplies for emergency care at the scene as well as during transport; safety, comfort, and avoidance of aggravation of the patient's injury or illness; two-way radio communication; and audible and visual traffic warning devices.

3.3.16.1* Substantially Similar Ambulance. An ambulance in which the relevant area or component that is being compared or considered is comparable. Applicable to the test being considered for an ambulance in which like areas are compared.

3.3.16.2 Type I Ambulance. An ambulance with a 10,001 lb (4536 kg) to 14,000 lb (6350 kg) gross vehicle weight rating (GVWR) constructed on a cab chassis with a modular ambulance body.

3.3.16.3 Type I-AD (Additional Duty) Ambulance. An ambulance with a 14,001 lb (6351 kg) or more GVWR constructed on a cab chassis with a modular ambulance body.

3.3.16.4 Type II Ambulance. An ambulance constructed on a van.

3.3.16.5 Type III Ambulance. An ambulance with a 10,001 lb to 14,000 lb GVWR constructed on a cutaway van chassis with integrated modular ambulance body.

3.3.16.6 Type III-AD (Additional Duty) Ambulance. An ambulance with a 14,001 lb or more GVWR constructed on a cutaway van chassis with integrated modular body.

3.3.17 Angle.

3.3.17.1* 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 vehicle in front of the front axle.

3.3.17.2* 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 vehicle behind the rear axle.

3.3.18 Apparatus Operator Manual. Document(s) provided by the chassis or apparatus manufacturer that covers how the complete apparatus should be safely operated and serviced.

3.3.19 Articulating Boom. An aerial device consisting of two or more folding boom sections whose extension and retraction modes are accomplished by adjusting the angle of the knuckle joints.

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

3.3.21 Authorized Person. A person approved or assigned to perform specific types of duties or to be at a specific location at the job site.

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

3.3.23 Automatic Locking Differential. A type of nonslip differential that operates automatically.

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

3.3.25 Auxiliary Braking System. A braking system in addition to the service brakes, such as an engine retarder, transmission retarder, driveline retarder, or exhaust retarder.

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

3.3.27 Auxiliary Hydraulic Power. A small gasoline engine, diesel engine, or electric motor–driven hydraulic pump used to operate an aerial device in an emergency or in lieu of the main hydraulic system.

3.3.28 Auxiliary Pump. A water pump mounted on the fire apparatus in addition to a fire pump and used for firefighting either in conjunction with or independent of the fire pump.

3.3.29 Back-Up Alarm. An audible device designed to warn that the fire apparatus is in reverse gear.

3.3.30 Base Rail. The lower chord (rail) of an aerial ladder to which rungs and reinforcements are attached.

3.3.31 Base Section. The first or bottom section of an aerial device.

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

3.3.33 Bonded (Bonding). Connected to establish electrical continuity and conductivity.

3.3.34* Boom. The structural member of an apparatus, other than an aerial ladder, which can be elevated, rotated, or extended.

3.3.35 Booster Hose. Thick-walled flexible hose that retains its round cross-section when it is not under pressure.

3.3.36 Booster Pump. See 3.3.28, *Auxiliary Pump*.

3.3.37 Booster Supplied Air System. A system that is capable of increasing air pressure from an air storage system or a compressor system.

3.3.38 Brakes.

3.3.38.1 Air-Mechanical Brakes. Brakes in which the force from an individual air chamber is applied directly to the friction surfaces through a mechanical linkage.

3.3.38.2 Air-Over-Hydraulic Brakes. Brakes in which the force of a master air cylinder is applied to the friction surfaces through an intervening hydraulic system.

3.3.38.3 Service Brake. A system capable of decelerating the vehicle at a controlled rate to a desired, reduced speed or complete stop.

3.3.39 Breathing Air System. The complete assembly of equipment such as compressors, a purification system, pressure regulators, safety devices, manifolds, air tanks or receivers, and interconnected piping required to deliver breathing air.

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

3.3.41 Bulk Air System. A method of piping air tanks together to allow air to be supplied to an air system or SCBA fill station, using one or more tanks where all tanks are used simultaneously and are at the same pressure.

3.3.42 Bulkhead. The partition dividing the driver compartment from the patient compartment.

3.3.43 Burst Pressure. The pressure at which a hydraulic component fails due to stresses induced as a result of the pressure.

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

3.3.45 Cascade System. A method of piping air tanks together to allow air to be supplied to the SCBA fill station using a progressive selection of tanks each with a higher pressure level.

3.3.46* Center of Gravity. The point at which the entire weight of the vehicle is considered to be concentrated so that, if supported at this point, the apparatus would remain in equilibrium in any position.

3.3.47* Chassis. The basic operating motor vehicle including the engine, frame, and other essential structural and mechanical parts, but exclusive of the body and all appurtenances for the accommodation of driver, property, passengers, appliances, or equipment related to other than control.

3.3.48 Child Restraint Seat. See 3.3.250.1.

3.3.49 Class A Fires. Class A fires are fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics. [10, 2018]

3.3.50 Class A Foam. Foam for use on fires in Class A fuels. [1150, 2022]

3.3.51 Class A Fuel. Materials such as vegetation, wood, cloth, paper, rubber, and some plastics in which combustion can occur at or below the surface of the material. [1150, 2022]

3.3.52 Class B Fire. A fire in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

3.3.53 Class B Foam. Foam intended for use on Class B fires.

3.3.54 Combination Vehicle. A vehicle consisting of a towing vehicle and one or more towed units.

3.3.55 Command and Communications Apparatus. A fire apparatus used primarily for communications and incident command.

3.3.56 Compartment.

3.3.56.1 Exterior Compartment. A weather-resistant area designed to protect stored items from environmental damage that is confined on six sides and equipped with an access opening(s) that can be closed and latched.

3.3.56.2 Interior Storage Compartment. A cabinet, drawer, pouch style system, or other means used to contain and secure EMS supplies, tools, medical devices, or other equipment within an enclosed area.

3.3.56.3 Patient Compartment. The enclosed portion of an ambulance intended for transporting patients.

3.3.57* Complementary Extinguishing Agent. An agent that provides unique extinguishing capability beyond the primary chosen agent.

3.3.58 Component Manufacturer's Certification. A signed application approval furnished by the vehicle manufacturer certifying that the components are approved as being installed in the vehicle for their intended use, or that the components comply with the criteria required by the standard.

3.3.59* Compound Gauge. A gauge that indicates pressure both above and below atmospheric pressure.

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

3.3.61 Compressed Breathing Air. A respirable gas mixture derived from either normal atmospheric air or from manufactured synthetic air, stored in a compressed state in storage cylinders and respirator breathing air cylinders, and supplied to the user in gaseous form. [1989, 2019]

3.3.62 Conductor.

3.3.62.1 Grounding Conductor. A non-current-carrying conductor used to connect equipment or the ground circuit of a wiring system to the power source grounding system.

3.3.62.2 Line Voltage Conductor. An ungrounded current-carrying conductor of a line voltage circuit.

3.3.62.3 Neutral Conductor. The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.

3.3.63 Continuous Duty. Operation at a substantially constant load for an indefinitely long time.

3.3.64 Continuous Egress. A continuous exit or rescue path down an aerial device from an elevated position to the ground.

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

3.3.66 Convenient Reach. The ability of the operator to manipulate the controls from a driving/riding position without excessive movement away from the seat back or without excessive loss of eye contact with the roadway.

3.3.67 Curb Weight. The total weight of the complete vehicle less the payload.

3.3.68 Dead Load. The weight of the aerial device structure and all materials, components, mechanisms, or equipment permanently fastened thereto.

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

3.3.70 Designated Primary Seating Position. Front driver and officer seats and any additional seating positions designated by the purchaser to be used by firefighters wearing personal protective clothing and equipment as the apparatus is used in regular service.

3.3.71 Designated Secondary Seating Position. Any seating position other than a designated primary seating position that is not intended to be occupied as the vehicle is used in regular service and not intended to be used by firefighters wearing protective clothing.

3.3.72* Diagonal Opposite Wheel Motion. The measurement of the vertical movement relationship of the wheel and suspension travel.

3.3.73 Discharge Outlet Size. The nominal size of the first fire hose connection from the pump on a discharge.

3.3.74 Documentation. Any written data or information supplied by the manufacturer or contractor relative to the vehicle and its components and systems, including information on its operation, service, and maintenance.

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

3.3.76 Drain Time (Foam). The time period it takes for a specified percent of the total solution contained in the foam to revert to liquid and to drain out of the bubble structure.

3.3.77 Driver's Enhanced Vision System (DEVS). See 3.3.274.1.

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

3.3.79 Dump Valve. A large opening from the water tank of a mobile water supply apparatus for unloading purposes.

3.3.80 Dynamic Balance. A physical condition that exists when a vehicle is driven into a turn at high speed and the vehicle displays no tendencies to pitch weight forward on the front steering wheels nor exhibits any understeer or oversteer conditions that could make the vehicle unstable.

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

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

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

3.3.84 Electric Vehicle. A vehicle made up of a propulsion system using only power from the rechargeable energy storage system to operate the vehicle drive.

3.3.85 Electrical Appliance. An electrical device or instrument designed to perform a specific function, such as scene lights, battery charger, medical equipment, and so forth.

3.3.86 Electrical Equipment. See 3.3.102, Fixed Electrical Equipment, and 3.3.209, Portable Electrical Equipment.

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

3.3.88 Electronic Stability Control System. See 3.3.274.2.

3.3.89 Elevating Platform. A self-supporting, turntable-mounted device consisting of a personnel-carrying platform attached to the uppermost boom of a series of power-operated booms that articulate, telescope, or both and that are sometimes arranged to provide the continuous egress capabilities of an aerial ladder.

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

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

3.3.92* Engine. A machine that provides mechanical power for the vehicle or vehicle system.

3.3.92.1 Electrical Vehicle (EV) Motor. An electrical machine that converts electrical energy into mechanical energy.

3.3.92.2 Fuel Cell. A device for converting a chemical fuel to electrical power without combustion.

3.3.92.3 Internal Combustion (IC) Engine. A machine that converts combustible fuel directly into mechanical energy.

3.3.93 Equipment Allowance. Any equipment added to the vehicle that is not directly required for the vehicle to discharge water or other firefighting agent(s) on the initial attack.

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

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

3.3.96 Exterior. A nonsheltered location exposed to the environment, either continuously or intermittently.

3.3.97 Exterior Compartment. See 3.3.56.1.

3.3.98 Federal Motor Vehicle Safety Standards (FMVSS). Regulations promulgated by the National Highway Traffic Safety Administration (NHTSA) of the United States under Public Law 89-563 that are mandatory and must be complied with when motor vehicles or items of motor vehicle equipment are manufactured and certified thereto.

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

3.3.100 Fire Apparatus. A vehicle designed to be used under emergency conditions to transport personnel and equipment or to support the suppression of fires or mitigation of other hazardous situations.

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

3.3.102 Fixed Electrical Equipment. Any electrical equipment that is not removable without the use of tools or is hard wired to the vehicle's electrical system.

3.3.103 Fixed Power Source. Any line voltage power source except a portable generator.

3.3.104 Fly Section. Any section of an aerial telescoping device beyond the base section.

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

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

3.3.107 Foam Concentrate. A concentrated liquid foaming agent as received from the manufacturer.

3.3.108 Foam Concentration. The quantity of foam liquid concentrate in water identified in percentage.

3.3.109 Foam Expansion. The ratio between the volume of foam produced and the volume of solution used in its production.

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

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

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

3.3.113* Forward-Looking Infrared (FLIR). The detection of heat energy radiated by objects to produce a "thermal image." This thermal image is converted by electronics and signal processing into a visual image that can be viewed by the operator.

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

3.3.115 Fully Loaded Vehicle. See 3.3.301.1, Fully Loaded Vehicle.

3.3.116 Gallon. United States gallon [231 in.³ (3.785 L)].

3.3.117 Gauge. A visual device that indicates a measurement.

3.3.118 Gauge Pressure. Pressure measured by an instrument where the pressure indicated is relative to atmospheric pressure.

3.3.119 GAWR. Gross axle weight rating. See 3.3.306.1.

3.3.120 GCWR. Gross combination weight rating. See 3.3.306.2.

3.3.121 Generator. An electromechanical device for the production of electricity.

3.3.122 Global Positioning System (GPS). See 3.3.274.3, Global Positioning System (GPS).

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

3.3.124 Ground Clearance. The vertical distance from the vehicle component to the ground.

3.3.125 Ground Sweep Nozzle. See 3.3.185.1, Ground Sweep Nozzle.

3.3.126* Ground-Fault Circuit Interrupter (GFCI). A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a ground-fault current exceeds the values established for a Class A device. [70, 2023]

3.3.127 Grounding Conductor. See 3.3.62.1.

3.3.128 GVWR. Gross vehicle weight rating. See 3.3.306.3.

3.3.129 Halogenated Agents. A liquefied gas extinguishing agent that extinguishes fire by chemically interrupting the combustion reaction between fuel and oxygen.

3.3.130 High Pressure. See 3.3.226.1.

3.3.131 High-Idle Speed Control. A control or switch system that provides a means to increase the engine operating speed from an idle condition to a higher preset operating speed.

3.3.132 High-Voltage Interlock. A means to control the high-voltage battery such that all HV connections and serviceable components must be secure before energizing the rechargeable energy storage system; an electrical circuit or loop that proves all HV connections are secure.

3.3.133 High-Voltage Isolation Monitor. A system to monitor the high-voltage system to ensure the high-voltage system, including the rechargeable energy storage system, the hybrid propulsion unit, and any other devices connected to the high-voltage system, is isolated electrically from the vehicle chassis.

3.3.134 Hybrid Propulsion Unit. A device or system capable of providing mechanical power from two sources such as electrical power from a rechargeable energy storage system or an

internal combustion engine, or from both sources simultaneously.

3.3.135 Hybrid Vehicle. A vehicle made up of a propulsion system having sufficient mechanical power available from a rechargeable energy storage system and from the engine to operate the vehicle drive from either source without the aid of the other source.

3.3.136 Hydrodynamic Test. A test performed by operating a fire pump to develop pump discharge pressure to pressurize the pump discharge structure and connected discharge piping and valves to a prescribed value while the intake piping, intake valves, and intake structure of the pump are not subjected to the prescribed pump discharge pressure.

3.3.137 Hydrostatic Test. A test performed by filling pressure-containing components completely with water or other incompressible fluid while expelling all contained air, closing or capping all open ports of the pressure-containing components, and then raising and maintaining the contained pressure to pressurize the pressure-containing components to a prescribed value through an externally supplied pressure-generating device.

3.3.138 Improved Surface. See 3.3.271.1.

3.3.139 Indicator. A device that provides a visual signal or annunciation regarding the operating condition or status of electrical circuits, systems, or equipment.

3.3.140 Infant Restraint Seat. See 3.3.250.2.

3.3.141 Initial Attack Apparatus. Fire apparatus with a fire pump of at least 250 gpm (1000 L/min) capacity, water tank, and hose body whose primary purpose is to initiate a fire suppression attack on structural, vehicular, or vegetation fires, and to support associated fire department operations.

3.3.142 In-Service Fire Apparatus. Any fire apparatus, including reserve apparatus, that is available for use under emergency conditions to transport personnel and equipment and to support suppression of fires and mitigation of other hazardous conditions.

3.3.143 In-Service Weight. The maximum actual vehicle weight under any conditions of mobile operation, sometimes referred to as gross vehicle weight.

3.3.144 Instability. A condition of a mobile unit in which the sum of the moments tending to overturn the unit exceeds the sum of the moments tending to resist overturning.

3.3.145 Instruction Plate. A visual indication whether in pictorial or word format that provides instruction to the operator in the use of a component.

3.3.146 Intake Connection Size. The nominal size of the first fire hose connection from the pump on an intake.

3.3.147 Intake Relief Valve. A relief valve piped to the intake manifold of a pump and designed to automatically relieve excessive pressure from the incoming flow of water by discharging water to the environment.

3.3.148* Intended Airport Service. All aspects of aircraft rescue and firefighting services as provided by this standard.

3.3.149* Interaxle Clearance (Ramp Breakover Angle). The measure of the ability of a fully loaded vehicle to negotiate a

ramp without encountering interference between the vehicle and the ramp between any two axles.

3.3.150 Interaxle Differential. A differential in the line of drive between any two axles.

3.3.151 Interior. A sheltered location not exposed to the environment.

3.3.152 Interior Storage Compartment. See 3.3.56.2.

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

3.3.154 ISO. Insurance Services Office.

3.3.155 “J” Turn Test. The measure of a vehicle’s ability to traverse a 90 degree turn at a prescribed speed.

3.3.156 Knuckle. A point of connection between upper and lower booms of an articulating device; the point at which lower and upper booms are hinged together.

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

3.3.158 Ladder Section. A structural member normally of an open “U” truss-type design that includes the rungs and comprises the base or fly section of an aerial ladder.

3.3.159 Latch. A mechanical device used to position the door in a closed position relative to the body framework with provision for controlled release or operation.

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

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

3.3.162 Line Voltage Conductor. See 3.3.62.2.

3.3.163 Live Load. Forces acting on the aerial device from personnel, portable equipment, water, wind, and nozzle reaction.

3.3.164 Load Distribution Plan. A drawing or spreadsheet of shelves, cabinets, drawers, compartment, or otherwise storage with a maximum weight attached to each location.

3.3.165* Loose Equipment. Equipment other than the occupants and the cot that is intended to be stored on the ambulance.

3.3.166 Low-Voltage Circuit, Equipment, or System. An electrical circuit, equipment, or system where the voltage does not exceed 30 V rms (ac), 42.4 V peak (ac), or 60 V dc; usually 12 V dc in vehicles.

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

3.3.168 Manufacturer. The person(s) or entity responsible for turning raw materials or components into a finished product.

3.3.169 Material Yield Strength. See 3.3.315, Yield Strength.

3.3.170 Maximum Discharge Pressure Capability Rating. The maximum permissible discharge gauge pressure at which the fire pump can be operated.

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

3.3.172 Minimum Continuous Electrical Load. The electrical current required to continuously operate a defined set of electrical devices.

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

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

3.3.175 Mobile Foam Fire Apparatus. Fire apparatus with a permanently mounted fire pump, foam proportioning system, and foam concentrate tank(s) whose primary purpose is the control and extinguishment of flammable and combustible liquid fires in storage tanks and spills.

3.3.176 Mobile Water Supply Apparatus (Tanker, Tender). A vehicle designed primarily for transporting (pickup, transporting, and delivering) water to fire emergency scenes to be applied by other vehicles or pumping equipment.

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

3.3.178 Multiple Configuration. Variable configurations or positions of the aerial device (e.g., elevation, extension) in which a manufacturer's different rated load capacities are allowed.

3.3.179 National Hose Thread (NH). A standard screw thread that has dimensions for inside (female) and outside (male) fire hose connections as defined in NFPA 1963.

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

3.3.181 Neutral Conductor. See 3.3.62.3.

3.3.182* Neutral Point. The common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or midpoint of a 3-wire, direct current system.

3.3.183 No-Load Condition. The status of an engine with standard accessories operating without an imposed load, with the vehicle drive clutches and any special accessory clutches in a disengaged or neutral condition.

3.3.184 Normal Pressure. See 3.3.226.2.

3.3.185 Nozzle.

3.3.185.1 Ground Sweep Nozzle. A small nozzle(s) mounted in front of the vehicle that disperses foam solution in front to provide protection.

3.3.185.2 Piercing Nozzle. A nozzle designed to penetrate into an aircraft to discharge fire extinguishing agent(s).

3.3.185.3 Undertruck Nozzle. A small nozzle device that hangs below the vehicle and disperses foam solution in a manner that provides protection for the vehicles from ground or grass proximity fires; these devices spray agent from wheel to wheel and front to back of the underside of the truck.

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

3.3.187 NWCG. National Wildfire Coordinating Group.

3.3.188* Off-Pavement Performance. A vehicle's ability to perform or operate on other than paved surfaces.

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

3.3.190 Operational Tests. An all-vehicle test conducted by the manufacturer to ensure that each vehicle is fully operational when it is delivered and to ensure that the original level of performance of the prototype vehicle has been maintained.

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

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

3.3.193 Optical Element. Any individual lamp or other light emitter within an optical source.

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

3.3.195 Optical Signaling Characteristics. The specific classification of the flash pattern, color, location, and optical power for optical warning devices.

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

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

3.3.198 Optical Warning System. The optical warning devices along with automatic or manual sensors, switches, or other devices used to activate, alter, or deactivate optical warning devices.

3.3.199* Overall Height, Length, and Width. The dimensions determined with the vehicle fully loaded and equipped, unless otherwise specified.

3.3.200 Override. A system or device used to neutralize a given action or motion.

3.3.201 Override (Aerial Device). The takeover of all aerial device movement control functions by an operator at a second control station.

3.3.202 Panelboard. A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front. [70:100]

3.3.203 Patient Compartment. See 3.3.56.3.

3.3.204 Patient Cot. An elevating patient conveyance device upon which the primary patient is transported, and which is also known as a stretcher, transporter, gurney, and carrier.

3.3.205* Percent Grade. The ratio of the change in elevation to the horizontal distance traveled multiplied by 100.

3.3.206 Personal Gear. The weight of personal clothing and items for personal hygiene carried on the fire apparatus by each crew member when they expect the response to be of long duration.

3.3.207 Photometric Measurement Point. The defined geometric point of an optical measurement within the horizontal and vertical axial planes originating from the optical center of the optical source or optical device.

3.3.208 Piercing Nozzle. See 3.3.185.2.

3.3.209 Portable Electrical Equipment. Any electrical equipment that is not fixed. (See 3.3.102, *Fixed Electrical Equipment*.)

3.3.210* Portable Generator. A mechanically driven power source that can be removed from the fire apparatus and operated at a location that is remote from the fire apparatus.

3.3.211 Power-Assist Steering. A system using hydraulic or air power to aid in the steering assist. This system is supplementary to the mechanical system in order to maintain steering ability in the event of power failure.

3.3.212 Power Source. A device that produces line voltage electricity.

3.3.213 Power Supply Assembly. Any cord or distribution assembly that is partly comprised of the neutral conductor, grounding conductor, and line voltage conductors connected from the output terminals of the power source to the first main overcurrent protection device.

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

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

3.3.216 Pressure Relief System. A device or method for reducing pressure in vessels, stages, or equipment when pressure has increased above a particular limit.

3.3.217 Primary Patient Care Seat. The seating position designated by the AHJ from which the EMSP is expected to provide primary patient care.

3.3.218 Primary Turret. See 3.3.282.2, Primary Turret.

3.3.219* Propellant Gas. A gas pressurizing an agent container.

3.3.220 Proper(ly). In accordance with the manufacturer's specifications or as recommended by the manufacturer.

3.3.221 Propulsion System. A vehicle system made up of a combination of multiple elements, including engine(s), transmission(s), hybrid propulsion unit(s), and rechargeable energy storage system(s), representing the source of propulsion power to the vehicle drive.

3.3.222 Prototype Vehicle. See 3.3.301.2, Prototype Vehicle.

3.3.223 psi. Pounds per square inch.

3.3.224 PTO. Power takeoff.

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

3.3.226 Pump Discharge Pressure Classification.

3.3.226.1 High Pressure. Pump discharge pressure from 500 psi (3500 kPa) to less than 1100 psi (7600 kPa).

3.3.226.2 Normal Pressure. Pump discharge pressure less than 500 psi (3500 kPa).

3.3.226.3 Ultra-High Pressure. Pump discharge pressure of 1100 psi (7600 kPa) or greater.

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

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

3.3.229 Pumper. Fire apparatus with a permanently mounted fire pump of at least 750 gpm (3000 L/min) capacity, water tank, and hose body whose primary purpose is to combat structural and associated fires.

3.3.230 Purchaser. The authority having responsibility for the specification and acceptance of the vehicle.

3.3.231 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.

3.3.232 Purification System. A combination of mechanical, chemical, and physical devices such as separators, filters, adsorbents, and catalysts designed to remove or alter contaminants within the compressed air stream to produce effluent air that is breathable.

3.3.233 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems related to the subject matter, the work, or the project. [1451, 2022]

3.3.234* Quint. Fire apparatus with a permanently mounted fire pump, a water tank, a hose storage area, an aerial ladder or elevating platform with a permanently mounted waterway, and a complement of ground ladders.

3.3.235 Radio Suppression. Suppression of the ignition and electrical system noises that normally interfere with radio transmission and reception.

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

3.3.237 Rated Capacity (Aerial Device). Operational capacity for each condition of extension, elevation, and rotation as indicated on the load chart.

3.3.237.1 Rated Horizontal Capacity — Dry (Aerial Device).

The total amount of weight of all personnel and equipment that can be supported at the outermost rung of an aerial ladder or in the platform of an elevating platform under the following conditions: (1) aerial device placed in the horizontal position; (2) stabilizers fully deployed; (3) apparatus on firm and level ground; and (4) aerial device extended and rotated to any position the control system will allow that produces the lowest capacity.

3.3.237.2 Rated Horizontal Capacity — Wet (Aerial Device).

The total amount of weight of all personnel and equipment that can be supported at the outermost rung of an aerial ladder or in the platform of an elevating platform under the following conditions: (1) aerial device placed in the horizontal position; (2) stabilizers fully deployed; (3) apparatus on firm and level ground; (4) aerial device extended and rotated to any position the control system will allow that produces the lowest capacity; (5) monitor or water pipe flowing maximum rated water capacity; and (6) monitor pointed in the direction that produces the greatest overturning moment.

3.3.238 Rated Capacity (Water Pump). The flow rate to which the pump manufacturer certifies compliance of the pump when it is new.

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

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

3.3.241* Rechargeable Energy Storage System. An energy storage system that has the capability to be charged and discharged.

3.3.242 Remounted Ambulance Patient Compartment. An ambulance patient compartment that has been removed from its original chassis and installed on a different chassis.

3.3.243 Removable Winch. A winch with quick disconnects for power and controls that can be temporarily mounted on the apparatus at a permanently installed mounting receiver.

3.3.244 Reserve Capacity. The ability of a battery to sustain a minimum electrical load in the event of a charging system failure or a prolonged charging system deficit.

3.3.245 Reserved. The contents that would go in this section are not applicable to this document, but for consistency with

other NFPA documents, the chapter, section, or subsection number is maintained.

3.3.246 Road Spray Location. Any underbody or underchassis location that is subject to road spray.

3.3.247* Rubber-Gasketed Fitting. A device for providing a leakproof connection between two pieces of pipe while allowing moderate movement of one pipe relative to the other.

3.3.248 SCBA Fill Hose. Flexible hose plumbed to connect SCBA cylinders to the compressed air supply for filling purposes.

3.3.249 SCBA Fill Station. A containment enclosure for refilling self-contained breathing cylinders to guard personnel from fragments due to accidental cylinder rupture.

3.3.250 Seat.

3.3.250.1 Child Restraint Seat. A seat capable of transporting a child 66 lb (30 kg) or less in accordance with 49 CFR 571, FMVSS 213 and mounted in accordance with the seat manufacturer's recommendation.

3.3.250.2 Infant Restraint Seat. A seat capable of transporting an infant 22 lb (10 kg) or less in accordance with 49 CFR 571, FMVSS 213 and mounted in accordance with the seat manufacturer's recommendation.

3.3.251 Seat Belt. A two-point lap belt, a three-point lap/shoulder belt, or a four-point lap/shoulder harness for vehicle occupants designed to limit their movement in the event of an accident, rapid acceleration, or rapid deceleration by securing individuals safely to a vehicle in a seated position.

3.3.252 Service Brake. See 3.3.38.3.

3.3.253 Side Entry Door. The body door on the side of the ambulance body that provides entry into the patient compartment and through which patients can be loaded and unloaded.

3.3.254 Side Slope. This angle is measured as either the percent of slope or the tilt angle at which the vehicle would become unstable should the vehicle be placed on the side of a steep, angled hill or sloped surface.

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

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

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

3.3.258* Special Services Fire Apparatus. A multipurpose vehicle that primarily provides support services at emergency scenes.

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

3.3.260 Stabilizer. A device integral with or separately attached to the chassis of a fire apparatus with an aerial device that is used to increase the moments tending to resist overturning the apparatus.

3.3.261 Stabilizer Pad. A plate inserted beneath a stabilizer shoe to give greater surface bearing area.

3.3.262 Stabilizer Shoe. A permanently mounted shoe on a stabilizer to provide a ground surface area.

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

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

3.3.265* Structural Fire Apparatus. Fire apparatus other than wildland fire apparatus, whether used to respond to structural incidents or other non-wildland incidents.

3.3.266 Substantially Similar Ambulance. See 3.3.16.1.

3.3.267 Suction Hose. A hose that is designed to prevent collapse under vacuum conditions so that it can be used for drafting water from below the pump (lakes, rivers, wells, etc.). [1961, 2020]

3.3.268 Suction Lift. The sum of the vertical lift and the friction and entrance loss caused by the flow through the intake strainers and hose expressed in feet of water (meters of water) head.

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

3.3.270 Supply Hose. Hose designed for the purpose of moving water between a pressurized water source and a pump that is supplying attack lines. [1961, 2020]

3.3.271 Surface.

3.3.271.1 Improved Surface. Surfaces that are classed as main thoroughfares, paved roadways, runways, taxiways, parking aprons, and secondary routes of vehicle travel including mediums that are normally of paved, asphalted, or concrete construction.

3.3.271.2 Unimproved Surface. Surfaces that are not paved or surface coated for heavy automotive travel and include dirt, clay, shale, or crushed rock that is not maintained on a regular basis.

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

3.3.273 Switch. Any set of contacts that interrupts or controls current flow through an electrical circuit.

3.3.274 System.

3.3.274.1* Driver's Enhanced Vision System (DEVS). An enhanced vision and navigation system for guiding aircraft

rescue and firefighting vehicles at night and during certain low-visibility conditions.

3.3.274.2* *Electronic Stability Control System.* A closed-loop stability-control system that relies on proven antilock brake system and traction control system components.

3.3.274.3* *Global Positioning System (GPS).* A satellite-based radio navigation system comprised of three segments: space, control, and user.

3.3.275 Top Rail. The top chord (rail) of an aerial ladder to which reinforcements are attached.

3.3.276 Total Continuous Electrical Load. The total current required to operate all the devices permanently connected to the vehicle that can be simultaneously energized, excluding intermittent-type loads such as primers, reel rewind motors, and starters.

3.3.277 Tow Vehicle. A motor vehicle used to tow a trailer under emergency response conditions whether the tow vehicle-trailer combination is designed to remain together as a single unit or to be separated at the incident to allow the trailer to be used independently of the tow vehicle.

3.3.278 Trailer. A vehicle designed to be pulled by a tow vehicle and used to transport equipment or other vehicles under emergency response conditions.

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

3.3.280* Turntable. A structural component that connects the aerial device to the chassis and stabilization system through a rotating bearing that permits 360-degree continuous rotation of the aerial device.

3.3.281 Turntable Alignment Indicator. An indicator that facilitates alignment of the aerial device with the boom support for bedding purposes.

3.3.282 Turret. A vehicle-mounted device for directing a stream of water or agent that has a nozzle attached to it and provides vertical and horizontal movement.

3.3.282.1* *Boom-Mounted Turret.* An elevated device permanently mounted on the top of the vehicle.

3.3.282.2* *Primary Turret.* The largest capacity foam turret used to apply primary extinguishing agent.

3.3.283* Twenty-Five Percent Drainage Time. The time in minutes that it takes for 25 percent of the total liquid contained in the foam collected in a specified manner to drain.

3.3.284 Type I Ambulance. See 3.3.16.2.

3.3.285 Type I-AD (Additional Duty) Ambulance. See 3.3.16.3.

3.3.286 Type II Ambulance. See 3.3.16.4.

3.3.287 Type III Ambulance. See 3.3.16.5.

3.3.288 Type III-AD (Additional Duty) Ambulance. See 3.3.16.6.

3.3.289 Type A Aircraft Door. A floor-level exit door with a rectangular opening not less than 1067 mm (42 in.) wide by 1829 mm (72 in.) high, with corner radii not greater than 178 mm (7 in.).

3.3.290* Type 4 Rating. A rating for electrical equipment that is intended for outdoor use because it provides a degree of protection from falling rain, splashing water, and hose-directed water.

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

3.3.292 Ultra-High Pressure. See 3.3.226.3.

3.3.293 Underaxle Clearance. The clearance distance between the ground and the center drive train of the vehicle; generally this measurement is taken at the low point bottom of the drive differentials.

3.3.294* Underbody Clearance. The vertical distance from the ground to the lowest part of the vehicle except axle assemblies and items designed to swing clear, measured with the vehicle loaded and equipped.

3.3.295 Undertruck Nozzle. See 3.3.185.3, Undertruck Nozzle.

3.3.296 Unequipped Fire Apparatus. The completed fire apparatus excluding personnel, agent(s), and any equipment removable without the use of tools.

3.3.297 Unimproved Surface. See 3.3.271.2.

3.3.298 Unitized Rigid Body and Frame Structure. A structure in which parts that generally comprise a separate body are integrated with the chassis frame to form a single, rigid, load-carrying structure.

3.3.299 Usable Payload. The weight of the loose equipment, occupants, and cot that can be carried in the ambulance without exceeding the GVWR.

3.3.300 Utility Air. Air used for purposes other than human respiration.

3.3.301 Vehicle.

3.3.301.1* *Fully Loaded Vehicle.* Consists of the fully assembled vehicle, complete with a full complement of crew, fuel, equipment, and firefighting agents.

3.3.301.2* *Prototype Vehicle.* The first vehicle of a unique vehicle configuration built to establish its performance capability and the performance capability of all subsequent vehicles manufactured from its drawings and parts list.

3.3.302* Vehicle Types. Vehicle types are designated as 4 × 4, and so forth, and these designations are used to indicate the number of wheels on the vehicle and the number of wheels that propel or drive the vehicle.

3.3.303* Wall-to-Wall Turning Diameter. A measurement of the space that completely contains a vehicle as it is being turned.

3.3.304 Water Tower. An aerial device consisting of permanently mounted power-operated booms that articulate, telescope, or both, and a waterway designed to supply a large capacity mobile elevated water stream.

3.3.305* Weather Resistant. Sufficiently protected to prevent the penetration of rain, snow, and wind-driven sand, dirt, or dust under all operating conditions.

3.3.306 Weight Rating.

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

3.3.306.2* Gross Combination Weight Rating (GCWR). The final-stage manufacturer's specified maximum loaded weight for a combination (articulated) vehicle consisting of a tow vehicle and one or more towed units.

3.3.306.3* Gross Vehicle Weight Rating (GVWR). The final-stage manufacturer's specified maximum load-carrying capacity of a single vehicle.

3.3.307 Weight Scale Measurement. The accurate measurement of vehicle weight by means of a scale to verify or check a stated or estimated weight.

3.3.308 Wet Location. A location subject to saturation with water or other liquids, or a location exposed to the weather. (See also 3.3.246, *Road Spray Location*.)

3.3.309 Where Specified. Options selected by the purchaser beyond the minimum requirements of the standard.

3.3.310* Wildland Fire Apparatus. Fire apparatus primarily used for wildland fire response.

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

3.3.312 Wildland Fire Pump. A water pump that meets the requirements of Section 15.2 of this standard.

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

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

3.3.315 Yield Strength. The stress at which a material exhibits a specified permanent deformation or set.

agency for the purpose of rescuing occupants and conducting rescue and firefighting operations.

4.1.1.2 Vehicles without wheels, such as track, amphibious, or air-cushion types, are not covered by this standard.

4.1.2 Purpose.

4.1.2.1 The purpose of Chapters 4 through 6 is to specify features and components that, when assembled, produce an efficient and capable firefighting vehicle for both on-pavement and off-pavement performance. Off-pavement capability is important to ensure timely and effective response of these vehicles to aircraft accident sites located off paved surfaces.

4.1.2.2 It is not the purpose of this standard to serve as a detailed purchase specification. Drafting of complete specifications for bidding purposes is the responsibility of the purchaser.

4.1.3* Equivalency. Nothing in Chapters 4 through 6 is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

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

4.1.3.2 The system, method, or device employed shall be demonstrated to meet the acceptance criteria for the intended purpose to the authority having jurisdiction.

4.1.4 Units of Measure.

4.1.4.1 The units of measure in Chapters 4 through 6 shall be presented in the International System (SI) of units followed by US customary units (inch-pound units) in parentheses.

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

4.2* General.

4.2.1* The design criteria for the standard vehicles described by this document shall consider temperature extremes ranging from 0°C to 43.3°C (32°F to 110°F).

4.2.1.1 For cold weather operation where temperatures range from -40°C to 0°C (-40°F to 32°F) or lower, some type of winterization system shall be specified by the purchaser.

4.2.1.2 Vehicles shall comply with Table 4.2.1.2(a), Table 4.2.1.2(b), Table 4.2.1.2(c), Table 4.2.1.2(d), and other requirements in this chapter.

4.2.2 The category of vehicles shall encompass a range of water capacity commencing at 454 L (120 gal) and extending to over 6000 L (1585 gal).

4.2.3* Certain vehicles shall be required to carry complementary agents in addition to carrying foam as the primary agent.

4.2.4 Because the same performance cannot be expected of all vehicles within this range, vehicles shall be classified by water capacity as listed in Table 4.2.1.2(a) and Table 4.2.1.2(b).

4.2.5* Additional vehicle options, where needed, shall be selected by the purchaser.

Chapter 4 Aircraft Rescue and Firefighting Vehicles (NFPA 414)

4.1 Administration.

4.1.1 Scope.

4.1.1.1* Chapters 4 through 6 shall specify the minimum design, performance, and acceptance criteria for aircraft rescue and firefighting (ARFF) vehicles intended to transport personnel and equipment to the scene of an aircraft emer-

Table 4.2.1.2(a) Fully Loaded Vehicle Performance Parameters (SI Units)

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥454 to ≤1999 L	Vehicle Water Tank Capacity >1999 to ≤6000 L	Vehicle Water Tank Capacity >6000 L
Side slope stability (degrees)	30	30	30
Dynamic balance (kph), minimum speed on a (30 m) radius circle	40	35.5	35.5
Angle of approach (degrees)	25	30	30
Angle of departure (degrees)	30	30	30
Interaxle clearance (degrees)	12	12	12
Underbody clearance (cm)	33	46	46
Underaxle clearance at differential housing bowl (cm)	26.7	33.0 (26.7)	33
Diagonal opposite wheel motion (cm)	25.4	36	36
Wall-to-wall turning diameter	<Three times the vehicle's overall length	<Three times the vehicle's overall length	<Three times the vehicle's overall length
Maximum acceleration time from 0 to 80.5 kph (sec)	30	25	35
Top speed (kph)	≥113	≥113	≥113
Service brake: Stopping distance from 33 kph (m) from 64 kph (m)	≤11 ≤40 m	≤11 ≤40 m	≤12 ≤49 m
Percent grade holding of fully loaded vehicle:			
Ascending	≥50 %	≥50 %	≥50 %
Descending	≥50 %	≥50 %	≥50 %
Emergency brake stopping distance at 64 kph (m)	≤88	≤88	≤88
Parking brake: Percent grade holding for the parking brake			
Ascending	≥20 %	≥20 %	≥20 %
Descending	≥20 %	≥20 %	≥20 %
Evasive maneuver test, NATO Document AVTP 03-16W (kph)	56	56	56
“J” turn test at 46 m radius (kph)	48	48	48

Table 4.2.1.2(b) Fully Loaded Vehicle Performance Parameters (US Customary Units)

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 120 to ≤ 528 gal	Vehicle Water Tank Capacity > 528 to ≤ 1585 gal	Vehicle Water Tank Capacity > 1585 gal
Side slope stability (degrees)	30	30	30
Dynamic balance (mph) minimum speed on a (100 ft) radius circle	25	22	22
Angle of approach (degrees)	25	30	30
Angle of departure (degrees)	30	30	30
Interaxle clearance (degrees)	9	12	12
Underbody clearance (in.)	13	18	18
Underaxle clearance at differential housing bowl (in.)	8.5	13 (10.5)	13
Diagonal opposite wheel motion (in.)	10	14	14
Wall-to-wall turning diameter	<Three times the vehicle's overall length	<Three times the vehicle's overall length	<Three times the vehicle's overall length
Maximum acceleration time from 0 to 50 mph (sec)	30	25	35
Top speed (mph)	≥ 70	≥ 70	≥ 70
Service brake: Stopping distance from 20 mph (ft) from 40 mph (ft)	≤ 35 ≤ 131	≤ 35 ≤ 131	≤ 40 ≤ 160
Percent grade holding of fully loaded vehicle:			
Ascending	≥ 50 %	≥ 50 %	≥ 50 %
Descending	≥ 50 %	≥ 50 %	≥ 50 %
Emergency brake stopping distance at 40 mph (ft)	≤ 288	≤ 288	≤ 288
Parking brake: Percent grade holding for the parking brake			
Ascending	≥ 20 %	≥ 20 %	≥ 20 %
Descending	≥ 20 %	≥ 20 %	≥ 20 %
Evasive maneuver test, NATO Document AVTP 03-16W (mph)	35	35	35
“J” turn test at 150 ft radius (mph)	30	30	30

Table 4.2.1.2(c) Agent System Performance Parameters (SI Units)

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 454 to ≤ 1999 L	Vehicle Water Tank Capacity > 1999 to ≤ 6000 L	Vehicle Water Tank Capacity > 6000 L
1. Water tank percent of deliverable water			
a. On level ground	100 %	100 %	100 %
b. On 20 % side slope	85 %	85 %	85 %
c. 30 % ascending/descending grade	85 %	85 %	85 %
2. Turret(s) discharge	Total flow rate can be achieved with handlines	Total flow rate can be achieved using a roof turret, boom-mounted turret, bumper turret, or a combination thereof	Total flow rate can be achieved using a roof turret, boom-mounted turret, bumper turret, or a combination thereof
2a. Roof turret:			
a. Total minimum flow rate (L/min) OR	≥ 227 (–0%/+10%)	≥ 2839 (–0%/+10%)	≥ 4731 (–0%/+10%)
Individual flow rate of the roof turret, if used in combination with a bumper turret (L/min)	N/A	≥ 1892 (–0%/+10%)	≥ 3785 (–0%/+10%)
b. Entrained stream pattern/distances:			
i. Straight/far point (m)	≥ 46	≥ 58	≥ 70
ii. Dispersed/far point (m)	≥ 15	≥ 20	≥ 21
iii. Dispersed/width (m)	≥ 9	≥ 11	≥ 11
2b. Boom-mounted turret:			
a. Individual flow rate of the boom-mounted turret if used in combination with a bumper turret (L/min)	N/A	≥ 1892 (–0%/+10%)	≥ 3785 (–0%/+10%)
b. Entrained stream pattern/distances:			
i. Straight/far point (m)	N/A	≥ 58	≥ 58
ii. Dispersed/far point (m)	N/A	≥ 20	≥ 21
iii. Dispersed/width (m)	N/A	≥ 11	≥ 11
2c. Bumper turret:	Can be used as the primary turret and must follow roof turret flows and ranges	Can be used as the primary turret and must follow roof turret flows and ranges	Can be used as the primary turret and must follow roof turret flows and ranges
a. Flow rate (L/min)	≥ 227 (–0%/+10%)	≥ 946 (–0%/+10%)	≥ 946 (–0%/+10%)
b. Straight entrained stream distance (m)	≥ 46	≥ 46	≥ 46
c. Dispersed pattern distances:			

(continues)

Table 4.2.1.2(c) *Continued*

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 454 to ≤ 1999 L	Vehicle Water Tank Capacity > 1999 to ≤ 6000 L	Vehicle Water Tank Capacity > 6000 L
i. Far point (m)	≥ 15	≥ 15	≥ 15
ii. Width (m)	≥ 9	≥ 9	≥ 9
iii. Near point (m)	Within 9 m of front bumper	Within 9 m of front bumper	Within 9 m of front bumper
2d. Ground sweep nozzle:	Where specified	Where specified	Where specified
a. Flow rate (L/min)	N/A	≥ 378 to ≤ 1135 (-0%/+10%)	≥ 378 to ≤ 1135 (-0%/+10%)
b. Dispersed pattern distances:			
i. Far point (m)	N/A	≥ 9	≥ 9
ii. Width (m)	N/A	≥ 3.5	≥ 3.5
2e. Undertruck nozzle flow rate (L/min)	Where specified > 57 (-0%/+10%)	Where specified > 57 (-0%/+10%)	Where specified > 57 (-0%/+10%)
2f. Piercing nozzle flow rate (L/min)	Where specified ≥ 946 (-0%/+10%)	Where specified ≥ 946 (-0%/+10%)	Where specified ≥ 946 (-0%/+10%)
3. Number of water-foam handlines required per vehicle (select from following)	1	2	2
3a. Woven jacket water-foam handline:			
a. Nozzle flow rate (L/min)	≥ 360 (-0%/+10%)	≥ 360 (-0%/+10%)	≥ 360 (-0%/+10%)
b. Straight entrained stream distance (m)	≥ 20	≥ 20	≥ 20
c. Dispersed entrained stream pattern:			
i. Range (m)	≥ 6	≥ 6	≥ 6
ii. Width (m)	≥ 4.5	≥ 4.5	≥ 4.5
d. Hose inside diameter (mm)	≥ 38	≥ 38	≥ 38
e. Hose length (m)	≥ 46	≥ 46	≥ 46
3b. Reeled water-foam handline:			
a. Nozzle flow rate (L/min)	360 (-0%/+10%) (≥ 227 for dual agent lines)	360 (-0%/+10%) (≥ 227 for dual agent lines)	360 (-0%/+10%) (≥ 227 for dual agent lines)
b. Straight entrained stream distance (m)	≥ 20	≥ 20	≥ 20
c. Dispersed entrained stream pattern:			
i. Range (m)	≥ 6	≥ 6	≥ 6
ii. Width (m)	≥ 4.5	≥ 4.5	≥ 4.5
d. Hose length (m)	≥ 46 (≥ 30 for dual agent lines)	≥ 46 (≥ 30 for dual agent lines)	≥ 46 (≥ 30 for dual agent lines)
4. Complementary agent			

(continues)

Table 4.2.1.2(c) *Continued*

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥454 to ≤1999 L	Vehicle Water Tank Capacity >1999 to ≤6000 L	Vehicle Water Tank Capacity >6000 L
a. Capacity (kg)	≥45	≥45	≥45
4a. Dry chemical handline:	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥2.3	≥2.3	≥2.3
b. Hose length (m)	≥30	≥30	≥30
4b. Dry chemical turret:	≥454 and ≤1999 L	>1999 and ≤6000 L	Above >6000 L
a. Powder discharge rate (kg/sec)	≥7 and ≤10	≥7 and ≤10	≥7 and ≤10
b. Stream range (m)	See 2a/2c	See 2a/2c	See 2a/2c
c. Stream width (m)	≥5	≥5	≥5
4c. Dry chemical boom-mounted turret	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥5.5	≥5.5 and ≤10	≥5.5 and ≤10
4d. Halogenated agent handline:	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥2.3	≥2.3	≥2.3
b. Hose inside diameter (mm)	≥25.4	≥25.4	≥25.4
c. Hose length (m)	≥30	≥30	≥30

4.3 Requirements for All Aircraft Rescue and Firefighting Vehicles — Responsibility of Contractors/Suppliers.

4.3.1* Certification. The aircraft rescue and firefighting vehicle manufacturer shall assume responsibility for the design, construction, and performance of all component parts of the complete vehicle, even if major portions are subcontracted, and certify that the completed vehicle meets the requirements of this standard.

4.3.1.1 The manufacturer shall supply at the time of delivery the following documents in electronic format:

- (1) Component manufacturers certificates per Section 6.2
- (2) Operational test data sheets per Section 6.4
- (3) Product warranties

4.3.2 Manuals.

4.3.2.1 The manufacturer shall supply at the time of delivery the following manuals in electronic format:

- (1) Operator's manual
- (2) Service manual
- (3) Parts manual

4.3.2.2 These manuals shall cover the entire vehicle and be in accordance with 4.3.2.3 through 4.3.2.5.9.

4.3.2.3 Operator's Manual.

4.3.2.3.1 Operating instructions shall include all information required for operation of the vehicle, vehicle components, fire-fighting systems, and integral vehicular options.

4.3.2.3.2 The location and function of all controls and instruments shall be covered by illustrations and descriptions.

4.3.2.3.3 These instructions, as a minimum, also shall include the following:

- (1) Complete description of the vehicle and special equipment
- (2) Preparation for use of the vehicle upon receipt
- (3) Daily maintenance and mission readiness checks to be performed by the operator
- (4) Periodic operator inspection

4.3.2.4 Service Manual. The service manual shall contain the regular maintenance schedule including operating hours, mileage, and cycle time.

4.3.2.4.1 The repair and overhaul instructions shall be factual, specific, concise, and clearly worded.

4.3.2.4.2 The instructions shall cover such typical maintenance and repair operations as troubleshooting and adjustment procedures.

4.3.2.4.3 The instructions also shall include data that include tolerances, specifications, and capacities.

4.3.2.4.4 Illustrations, wiring diagrams, and exploded views shall be used to clarify text and appear as close to the related text as possible.

4.3.2.4.5 Special tools needed for the repair and overhaul of the equipment shall be specified and illustrated.

4.3.2.4.6 The service manual shall contain a suitable index.

Table 4.2.1.2(d) Agent System Performance Parameters (US Customary Units)

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 120 to ≤ 528 gal	Vehicle Water Tank Capacity > 528 to ≤ 1585 gal	Vehicle Water Tank Capacity > 1585 gal
1. Water tank percent of deliverable water			
a. On level ground	100 %	100 %	100 %
b. On 20 % side slope	85 %	85 %	85 %
c. 30 % ascending/descending grade	85 %	85 %	85 %
2. Turret(s) discharge	Total flow rate can be achieved with handlines	Total flow rate can be achieved using a roof turret, boom-mounted turret, bumper turret, or a combination thereof	Total flow rate can be achieved using a roof turret, boom-mounted turret, bumper turret, or a combination thereof
2a. Roof turret:			
a. Total minimum flow rate (gpm) OR	≥ 60 (–0%/+10%)	≥ 750 (–0%/+10%)	≥ 1250 (–0%/+10%)
Individual flow rate of the roof turret, if used in combination with a bumper turret (gpm)	N/A	≥ 500 (–0%/+10%)	≥ 1000 (–0%/+10%)
b. Entrained stream pattern/distances:			
i. Straight/far point (ft)	≥ 65	≥ 190	≥ 230
ii. Dispersed/far point (ft)	≥ 20	≥ 65	≥ 70
iii. Dispersed/width (ft)	≥ 15	≥ 35	≥ 35
2b. Boom-mounted turret:			
a. Individual flow rate of the boom-mounted turret if used in combination with a bumper turret (gpm)	N/A	≥ 500 (–0%/+10%)	≥ 1000 (–0%/+10%)
b. Entrained stream pattern/distances:			
i. Straight/far point (ft)	N/A	≥ 190	≥ 190
ii. Dispersed/far point (ft)	N/A	≥ 65	≥ 70
iii. Dispersed/width (ft)	N/A	≥ 35	≥ 35
2c. Bumper turret:	Can be used as the primary turret and must follow roof turret flows and ranges	Can be used as the primary turret and must follow roof turret flows and ranges	Can be used as the primary turret and must follow roof turret flows and ranges
a. Flow rate (gpm)	≥ 60 (–0%/+10%)	≥ 250 (–0%/+10%)	≥ 250 (–0%/+10%)
b. Straight entrained stream distance (ft)	≥ 65	≥ 150	≥ 150
c. Dispersed pattern distances:			

(continues)

Table 4.2.1.2(d) Continued

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥120 to ≤528 gal	Vehicle Water Tank Capacity >528 to ≤1585 gal	Vehicle Water Tank Capacity >1585 gal
i. Far point (ft)	≥20	≥50	≥50
ii. Width (ft)	≥15	≥30	≥30
iii. Near point (ft)	Within 30 ft of front bumper	Within 30 ft of front bumper	Within 30 ft of front bumper
2d. Ground sweep nozzle:	Where specified	Where specified	Where specified
a. Flow rate (gpm)	N/A	≥100 to ≤300 (−0%/+10%)	≥100 to ≤300 (−0%/+10%)
b. Dispersed pattern distances:			
i. Far point (ft)	N/A	≥30	≥30
ii. Width (ft)	N/A	≥12	≥12
2e. Undertruck nozzle flow rate (gpm)	Where specified >15 (−0%/+10%)	Where specified >15 (−0%/+10%)	Where specified >15 (−0%/+10%)
2f. Piercing nozzle flow rate (gpm)	Where specified ≥250 (−0%/+10%)	Where specified ≥250 (−0%/+10%)	Where specified ≥250 (−0%/+10%)
3. Number of water-foam handlines required per vehicle (select from following)	1	2	2
3a. Woven jacket water-foam handline:			
a. Nozzle flow rate (gpm)	≥95 (−0%/+10%)	≥95 (−0%/+10%)	≥95 (−0%/+10%)
b. Straight entrained stream distance (ft)	≥65	≥65	≥65
c. Dispersed entrained stream pattern:			
i. Range (ft)	≥20	≥20	≥20
ii. Width (ft)	≥15	≥15	≥15
d. Hose inside diameter (in.)	≥1.50	≥1.50	≥1.50
e. Hose length (ft)	≥150	≥150	≥150
3b. Reeled water-foam handline:			
a. Nozzle flow rate (gpm)	95 (−0%/+10%) (≥60 for dual agent lines)	95 (−0%/+10%) (≥60 for dual agent lines)	95 (−0%/+10%) (≥60 for dual agent lines)
b. Straight entrained stream distance (ft)	≥65	≥65	≥65
c. Dispersed entrained stream pattern:			
i. Range (ft)	≥20	≥20	≥20
ii. Width (ft)	≥15	≥15	≥15
d. Hose length (ft)	≥150 (≥100 for dual agent lines)	≥150 (≥100 for dual agent lines)	≥150 (≥100 for dual agent lines)
4. Complementary agent			

(continues)

Table 4.2.1.2(d) *Continued*

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥120 to ≤528 gal	Vehicle Water Tank Capacity >528 to ≤1585 gal	Vehicle Water Tank Capacity >1585 gal
a. Capacity (lb)	≥100	≥100	≥100
4a. Dry chemical handline:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥5	≥5	≥5
b. Hose length (ft)	≥100	≥100	≥100
4b. Dry chemical turret:	≥120 and ≤528 gal	>528 and ≤1585 gal	Above >1585 gal
a. Powder discharge rate (lb/sec)	≥16 and ≤22 (>7)	≥16 and ≤22	≥16 and ≤22
b. Stream range (ft)	See 2a/2c	See 2a/2c	See 2a/2c
c. Stream width (ft)	≥17	≥17	≥17
4c. Dry chemical boom-mounted turret:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥12	≥12 and ≤22	≥12 and ≤22
4d. Halogenated agent handline:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥5	≥5	≥5
b. Hose inside diameter (in.)	≥1.00	≥1.00	≥1.00
c. Hose length (ft)	≥100	≥100	≥100

4.3.2.5 Parts Manual.

4.3.2.5.1 The parts list shall include illustrations and exploded views necessary for the proper identification of all parts, assemblies, and subassemblies.

4.3.2.5.2 Assemblies or components shall be shown in illustrations and shall be identified by reference numbers that correspond to the reference numbers in the parts list.

4.3.2.5.3 The size, thread dimensions, and special characteristics shall be given on all nonstandard nuts, bolts, washers, grease fittings, and similar items.

4.3.2.5.4 The parts identification manual shall provide the description and quantity of each item used per vehicle.

4.3.2.5.5 The parts identification manual shall contain a numerical index.

4.3.2.5.6 The vehicle manufacturer shall ensure that in-stock parts critical to the mission of the vehicle are shipped to the purchaser within 48 hours (business days).

4.3.2.5.7 The original equipment manufacturers shall be disclosed to the owner if the vendor is unable to supply the necessary parts within 48 hours to allow local purchase of an equivalent part.

4.3.2.5.8 A qualified and responsible representative of the contractor shall instruct personnel specified by the purchaser in the operation, care, and maintenance of the vehicle delivered.

4.3.2.5.9 The purchasers shall specify provisions for training, including the location and duration, and agree on suitable training aids such as video tapes and training manuals.

4.3.2.5.10* Parts manuals shall not be required for commercial chassis vehicles supplied to a component manufacturer.

4.3.2.5.11 Parts manuals shall be required for upfit components added to the commercial chassis.

4.3.3 Metal Finish.

4.3.3.1 All exposed ferrous metal surfaces that are not plated or of stainless steel or that are not otherwise treated to resist corrosion shall be cleaned, prepared, and painted in the color(s) specified by the purchaser.

4.3.3.2 If nonferrous body components are furnished, the purchaser shall specify which surfaces are to be painted.

4.3.3.3 The paint, including the primer, shall be applied in accordance with the paint manufacturer's recommendation.

4.3.3.4 Paint finish shall be selected for maximum visibility and be resistant to damage from firefighting agents.

4.3.3.5 Dissimilar metals shall not be in contact with each other.

4.3.3.5.1 Metal plating or metal spraying of metals of dissimilar base to provide electromotively compatible abutting surfaces shall be permitted.

4.3.3.5.2 The use of dissimilar metals separated by suitable insulating material shall be permitted.

4.3.3.5.3 In systems where bridging of insulation materials by an electrically conductive fluid can occur, dissimilar metals shall not be permitted.

4.3.3.6 Materials that deteriorate when exposed to sunlight, weather, or operational conditions normally encountered during service shall comply with one of the following:

- (1) Not be used
- (2) Have a means of protection against such deterioration that does not prevent compliance with performance requirements

4.3.3.7 Protective coatings that chip, crack, or scale with age or extremes of climatic conditions or when exposed to heat shall not be used.

4.3.3.8 The use of proven, nonmetallic materials in lieu of metal shall be permitted, provided such use contributes to reduced weight or less maintenance and there is no degradation in performance.

4.3.4 Lettering, Numbering, and Striping.

4.3.4.1 All retroreflective materials used shall conform at minimum to the requirements of ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1, for Type I sheeting.

4.3.4.2 Colors that are not listed in ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1, shall have a minimum coefficient of retroreflection of 10 with an observation angle of 0.2 degrees and an entrance angle of -4 degrees.

4.3.4.3 Lettering, numbering, and striping shall be in contrast to the vehicle color.

4.3.4.3.1 Reflective striping shall be placed horizontally on the sides of the vehicle below the body centerline.

4.3.4.3.2 The striping shall be at a minimum 20.3 cm (8 in.) in height and be at least 60 percent of the overall vehicle length.

4.3.4.3.3 Reflective striping shall be placed horizontally on the rear of the vehicle below the body centerline.

4.3.4.3.4 The striping shall be at a minimum 20.3 cm (8 in.) in height and be at least 60 percent of the overall vehicle width.

4.3.4.4 Vehicles shall display a unique reflective identification number on each side and on their roof.

4.3.4.4.1 Roof "primary" numbers shall be 61 cm (24 in.) in height and placed so that the base of the number is facing the front of the vehicle.

4.3.4.4.2 Side "secondary" numbers shall be 40.6 cm (16 in.) in height and placed above the vehicle centerline.

4.3.4.5 A graphical design shall be permitted, provided the design covers the minimum height and width requirements listed in 4.3.4.3.2 and 4.3.4.3.4.

4.3.5 Vehicle Information Data Plate. A data plate that contains, as a minimum, all the information presented in Figure 4.3.5 shall be installed in the cab of the vehicle.

4.4 Weights and Dimensions.

4.4.1* Weights.

4.4.1.1 The actual gross vehicle weight of a fully loaded vehicle shall not exceed the manufacturer's gross vehicle weight rating as recorded on the vehicle information data plate.

Manufacturer _____	
Vehicle (make and model year) _____ and _____	
Drive type: ☐ 4 × 4 ☐ 6 × 6 ☐ 8 × 8 ☐ 10 × 10	
The vehicle was tested to _____ degrees in both directions (table angle).	
Was a trip/slip rail used? ☐ No ☐ Yes	
If yes, height of rail [maximum 50 mm (2 in.)] _____ [mm (in.)]	
Date of test: _____	
Front axle loading*	_____ [kg (lb)]
Second axle loading*	_____ [kg (lb)]
3rd axle loading* (if applicable)	_____ [kg (lb)]
4th axle loading* (if applicable)	_____ [kg (lb)]
5th axle loading* (if applicable)	_____ [kg (lb)]
Tire manufacturer	_____
Tire model	_____
Tire pressure	_____ [kPa (psi)]
Front wheel track	_____ [cm (in.)]
Rear wheel track	_____ [cm (in.)]
Crew capacity	_____ (Number of personnel)
Fuel tank capacity	_____ [L (gal)]
Equipment allowance	_____ [kg (lb)]
Water tank capacity	_____ [L (gal)]
Foam tank capacity	_____ [L (gal)]
Auxiliary agent capacity (if applicable)	_____ [kg (lb)]
*The "loading" is to be in accordance with the definition of a fully loaded vehicle as presented in Chapters 1 through 6 of NFPA 1900.	

FIGURE 4.3.5 Aircraft Rescue and Firefighting Vehicle Tilt Table Certification per Chapters 1 through 6.

4.4.1.2* The weight shall be distributed over the axles and tires of the fully loaded vehicle.

4.4.1.2.1 The difference in weight between tires on any axle shall not exceed 5 percent of the average tire weight for that axle.

4.4.1.2.2 The difference in weight between any two axles shall not exceed 10 percent of the weight of the heaviest axle if the heavy axle is a rear axle.

4.4.1.2.3 The requirement in 4.4.1.2.2 shall not apply to vehicles with a capacity of less than 1999 L (528 gal).

4.4.1.2.4 If the heavy axle is a front axle, the weight difference between that axle and any other axle shall not exceed 5 percent of the heavy axle weight.

4.4.1.2.5 Under no circumstances shall the axle and tire manufacturers' ratings be exceeded.

4.4.1.3 The center of gravity of every vehicle shall be tested at the time of manufacture and kept as low as possible under all conditions of loading.

4.4.1.4 If a commercial chassis is utilized, the chassis manufacturer's recommended center of gravity shall not be exceeded.

4.4.1.5 It shall be the end user's responsibility to ensure that vehicles modified by the end user comply with performance requirements.

4.4.1.6 The vehicle shall not exhibit oversteer characteristics. (See 6.3.7.3 for test requirements.)

4.4.2 Dimensions.

4.4.2.1* The axle clearances in Table 4.2.1.2(a) and Table 4.2.1.2(b) shall be measured with vehicle tires inflated to high-way inflation pressure.

4.4.2.1.1 The dimensions in Table 4.2.1.2(a) and Table 4.2.1.2(b) shall be permitted to be reduced to give more stable performance on hard pavement if the suspension is designed to raise the vehicle to these clearances when vehicle is traveling off pavement.

4.4.2.1.2 Where an active suspension provides vehicle leveling and maintenance of the underbody clearance of the lower underaxle, clearances shown in the parentheses in Table 4.2.1.2(a) and Table 4.2.1.2(b) shall be used.

4.4.2.1.3 If this option is used, the vehicle shall be tested in accordance with Table 4.2.1.2(a) and Table 4.2.1.2(b).

4.4.2.2 Field of Vision.

4.4.2.2.1 The vehicle shall be constructed so that a seated driver, having an eye reference point of 80.7 cm (31¾ in.) above the seat cushion and 30.5 cm (12 in.) forward from the seat back, shall be capable of the following:

- (1) To see the ground 6.1 m (20 ft) ahead of the vehicle
- (2) To have a field of vision of at least 5 degrees above the horizontal plane
- (3) To have a field of vision in the horizontal plane of at least 90 degrees on each side from the straight ahead position
- (4) Not to have his or her vision obstructed by more than 7 degrees per obstruction

4.4.2.3 Adjustable rearview mirrors with a glass area of not less than 387.1 cm² (60 in.²) shall be provided on each side of the vehicle.

4.4.2.3.1 Each side shall be provided with a minimum 45.2 cm² (7 in.²) wide-angle (convex) mirror.

4.4.2.3.2 Rearview outside mirrors shall be motorized and controlled from the driver's position.

4.4.2.3.3 Convex mirrors shall not be required to be motorized.

4.4.2.3.4 In lieu of mirrors, audiovisual devices that meet or exceed the field of vision provided by the wide-angle mirrors shall be permitted.

4.5 Propulsion System.

4.5.1 Performance Requirements.

4.5.1.1 Propulsion System Characteristics.

4.5.1.1.1 The vehicle's propulsion system shall have the horsepower, torque, and speed characteristics to meet and maintain all vehicular performance characteristics specified in Chapters 4 through 6.

4.5.1.1.2 The engine manufacturer shall certify that the installed engine is approved for this application.

4.5.1.2* The fully loaded vehicle shall be able to accelerate consistently from 0 kph to 80.5 kph (0 mph to 50 mph) on dry, level concrete pavement at the operational airport within the times specified in Table 4.2.1.2(a) and Table 4.2.1.2(b).

4.5.1.2.1 The maximum speed shall not be less than 112 kph (70 mph).

4.5.1.2.2 The acceleration times provided in Table 4.2.1.2(a) and Table 4.2.1.2(b) shall be achieved with the propulsion system at the component manufacturers' recommended operating temperatures and state of charge if applicable at any ambient temperature from -17.8°C to 43.3°C (0°F to 110°F) and at elevations up to 609.6 m (2000 ft) above sea level, unless a higher elevation is specified.

4.5.1.2.3 For airports above 609.6 m (2000 ft), the elevation at which the vehicle operates shall be specified to ensure the necessary performance.

4.5.1.3 The vehicle also shall be capable of ascending, stopping, starting, and continuing ascent on a 40 percent grade on dry pavement at a speed up to at least 1.6 kph (1 mph) with extinguishing agents being discharged from the primary turret nozzle(s).

4.5.2 Engine Cooling Systems.

4.5.2.1 An engine coolant preheating device shall be provided as an aid to rapid starting and high initial engine performance.

4.5.2.2 This device shall be fitted with an automatic thermostat.

4.5.2.3 If the engine coolant preheating device requires electrical power from an outside source to operate, a grounded receptacle shall be provided to allow a pull-away connection from the local electric power supply to the engine coolant preheating device.

4.5.2.3.1 The cooling system shall be designed so that the stabilized engine coolant temperature remains within the engine manufacturer's prescribed limits under all operational conditions and at all ambient temperatures identified in 4.2.1 that might be encountered at the operational airport.

4.5.2.3.2 The cooling system shall be provided with an automatic thermostat for rapid engine warming.

4.5.2.3.3 Where specified, radiator shutters, where furnished for cold climates, shall be both of the following:

- (1) Automatic
- (2) Designed to open automatically upon failure

4.5.3 Fuel System.

4.5.3.1 A complete fuel system shall be installed with the engine manufacturer's approval.

4.5.3.2 The fuel system shall be protected from the following:

- (1) Damage
- (2) Exhaust heat
- (3) Exposure to ground fires
- (4) Vapor lock

4.5.3.3 Accessible filtration for each fuel supply line and a drain shall be provided at the bottom of the fuel tank.

4.5.3.3.1 A fuel-water separator equipped with a manual drain shall be supplied where the vehicle is equipped with a diesel-fueled engine.

4.5.3.3.2 The fuel-water separator shall meet the engine manufacturer's requirements.

4.5.3.4 Fuel tanks shall not be installed in a manner that allows gravity feed.

4.5.3.5 Fuel Capacity.

4.5.3.5.1 For vehicles with a water tank capacity <1999 L (<528 gal), the fuel tank shall have the capacity to provide for a minimum of 48.3 km (30 mi) of highway travel at 88.5 kph (55 mph), plus 2 hours of pumping at the full rated discharge.

4.5.3.5.2 For vehicles with a water tank capacity <1999 L (<528 gal), additional fuel capacity shall be provided for a minimum of 4 hours of operation of each accessory item (such as a generator or fuel-fired heaters) that uses the common fuel tank as a source.

4.5.4 Exhaust System.

4.5.4.1 The exhaust system shall be constructed in such a manner that exhaust discharge is directed away from any operators.

4.5.4.1.1 The exhaust system shall be of high-grade, rust-resistant materials.

4.5.4.1.2 The exhaust system shall include a muffler to reduce engine noise.

4.5.4.2 The exhaust system shall be protected from damage that could result from traversing rough terrain.

4.5.4.3 The tailpipe shall not be directed toward the ground.

4.6 Vehicle Electrical System.

4.6.1 Electrical Systems and Warning Devices.

4.6.1.1 Any low-voltage electrical systems or warning devices installed on the fire apparatus shall be appropriate for the mounting location and intended electrical load and meet the specific requirements of this section.

4.6.1.1.1 Wiring. All electrical circuit feeder wiring supplied and installed by the fire apparatus manufacturer shall meet the requirements of 4.5.1.1.2 through 4.6.1.1.23.

4.6.1.1.2 The circuit feeder wire shall be stranded copper or copper alloy conductors of a gauge rated to carry 125 percent of the maximum current for which the circuit is protected.

4.6.1.1.3 Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent.

4.6.1.1.4 The use of star washers for circuit ground connections shall not be permitted.

4.6.1.1.5 All circuits shall otherwise be wired in conformance with SAE J2202, *Heavy-Duty Wiring Systems for On-Highway Trucks*, or for trailer wiring, SAE J2174, *Heavy-Duty Wiring Systems for Trailers 2032 mm or More in Width*.

4.6.1.1.6 Wiring and Wire Harness Construction.

4.6.1.1.7 All insulated wire and cable shall conform to SAE J1127, *Low-Voltage Battery Cable*, or SAE J1128, *Low-Voltage Primary Cable*, type SXL, GXL, or TXL.

4.6.1.1.8 All conductors shall be constructed in accordance with SAE J1127 or SAE J1128, except where good engineering practice dictates special strand construction.

4.6.1.1.9 Conductor materials and stranding, other than copper, shall be permitted if all applicable requirements for

physical, electrical, and environmental conditions are met as dictated by the end application.

4.6.1.1.10 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127 or SAE J1128, except where good engineering practice dictates special conductor insulation.

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

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

4.6.1.1.13 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection.

4.6.1.1.14 The wiring connections and terminations shall be installed in accordance with the device manufacturer's instructions.

4.6.1.1.15 All ungrounded electrical terminals shall have protective covers, enclosures, or a means to protect from accidental shorting.

4.6.1.1.16 Wire nut, insulation displacement, and insulation piercing connections shall not be used.

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

4.6.1.1.18 Wiring shall be uniquely identified at least every 2 ft (0.6 m) by color coding or permanent marking with a circuit function code and reference a wiring diagram.

4.6.1.1.19 Circuits shall be provided with properly rated low-voltage overcurrent protective devices.

4.6.1.1.20 Such devices shall be readily accessible and protected against heat in excess of the overcurrent device's design range, mechanical damage, and water spray.

4.6.1.1.21 Circuit protection shall be accomplished by utilizing fuses, circuit breakers, fusible links, or solid state equivalent devices.

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

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

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

4.6.1.2 Line Voltage Electrical Systems. The line voltage electrical systems shall be in accordance with Chapter 21.

4.6.1.3 High-Voltage Electrical System.

4.6.1.3.1 Where specified, high-voltage wiring between propulsion system components exceeding 50V shall meet the requirements of SAE J1673, *High Voltage Automotive Wiring Assembly Design*.

4.6.1.3.2 Where specified, a rechargeable energy storage system shall meet the requirements of UN 38.3, *Certification for Lithium Batteries*, and SAE J2929, *Electric and Hybrid Vehicle Propulsion Battery System Safety Standard — Lithium-based Rechargeable Cells*.

4.6.1.3.3 Where specified, high-voltage systems shall be labeled in accordance with SAE J2910, *Recommended Practice for the Design and Test of Hybrid Electric and Electric Trucks and Buses for Electrical Safety*.

4.6.1.3.4 Where specified, high-voltage systems shall meet high-voltage isolation requirements of SAE J2578, *Recommended Practice for General Fuel Cell Vehicle Safety*, and SAE J2344, *Guidelines for Electric Vehicle Safety*.

4.6.1.3.5 High-voltage electrical energy storage devices shall be marked with a warning symbol.

4.6.1.3.5.1 The symbol shall be visible on electrical protection barriers that, when removed, expose live parts of high-voltage sources.

4.6.1.3.5.2 The symbol shall be yellow, and the bordering and the arrow shall be black.

4.6.1.3.6 Cables for high-voltage sources that are not located within electrical protection barriers shall be identified by having an outer covering with the color orange.

4.6.1.3.7 Hybrid electric or electric vehicles shall include a high-voltage isolation monitor that meets the requirements of SAE J2578, *Recommended Practice for General Fuel Cell Vehicle Safety*; UL 2231-1, *Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements*; and UL 2231-2, *Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems*.

4.6.1.3.8 Hybrid electric or electric vehicle rechargeable energy storage system shall have a high-voltage interlock in accordance with SAE J2578, *Recommended Practice for General Fuel Cell Vehicle Safety*, and SAE J2344, *Guidelines for Electric Vehicle Safety*.

4.6.1.3.9 Hybrid electric or electric vehicles shall meet the bonding requirements of IEC 62477-1, *Safety Requirements for Power Electronic Converter Systems and Equipment*.

4.6.2 Battery Chargers.

4.6.2.1 A built-in battery charger shall be provided on the vehicle to maintain a full charge on all batteries.

4.6.2.2 A grounded ac receptacle shall be provided to allow a pull-away connection from the local electric power supply to the battery charger.

4.6.3 The electrical grounding procedures used on the vehicle shall be in accordance with SAE J1908, *Electrical Grounding Practice*, or an equivalent electrical grounding standard.

4.6.4 Where specified, an onboard battery charger/conditioner shall have a minimum output rating of 0.5 percent of

the cold-cranking ampere rating at 0°C (32°F) of the engine-starting battery system.

4.6.4.1 The battery charger shall be supplied from an external power source with a voltage as specified by the end user.

4.6.4.2 This battery charger/conditioner shall be the type that can be connected to the batteries at all times and yet maintain a charge to the batteries without causing any damage.

4.6.4.3 The unit shall reduce its charging output level to a point where a small amount of charge is allowed to the batteries continuously or it shall shut off completely.

4.6.4.4 The charger/conditioner shall have protection built into it to protect it from damage during high current demands such as those caused by starting the engine.

4.6.4.5 The unit shall be provided with a grounded ac plug to allow a pull-away connection from the local electrical power supply to the battery charger/conditioner.

4.6.5 The electrical system and its components shall be weatherproof, insulated, and protected from chafing, damage from road debris, and exposure to ground fires.

4.6.5.1 All wiring shall be coded to correspond with the wiring diagram provided with the vehicle.

4.6.5.2 Circuit protection shall be provided to protect the vehicle in the event of electrical overload.

4.6.6 Radio suppression of the electrical system shall be in accordance with SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or an equivalent radio suppression standard.

4.7 Vehicle Drive. Transmission of power from the power source(s) to the wheels of the vehicle shall be through an automatic or a semiautomatic gearbox.

4.7.1 The entire drivetrain shall be designed and rated by the component manufacturer as having the strength to slip the wheels of the static-loaded vehicle on a surface having a coefficient of friction of 0.8.

4.7.2 The transmission shall be approved by its manufacturer for the application.

4.7.3 A transmission cooling system shall be provided and designed so that the stabilized transmission oil temperature remains within the transmission manufacturer's prescribed limits under all operational conditions and at all ambient temperatures encountered at the operational airport.

4.7.4 A positive drive shall be provided to each wheel by means of a fully locked driveline in order to maximize traction on low-friction surfaces.

4.7.4.1 Positive drive either shall be permitted to be achieved by the use of automatic locking and torque proportioning differentials or be permitted to be selected manually by the seated driver by use of a single control while the vehicle is in motion.

4.7.4.2* Where a 10 × 8 vehicle is used, only 8 of the 10 wheels shall be required to be powered.

4.7.5 All-Wheel Drive.

4.7.5.1 All-wheel drive on these vehicles shall incorporate a drive to the front and rear axles that is engaged at all times during the intended airport service.

4.7.5.2 An interaxle differential shall be installed with automatic means or driver-selected means of differential locking.

4.7.6 All traction-increasing devices shall be operated by a single control for driving simplicity.

4.7.6.1 This requirement shall not apply to vehicles with a capacity of <1999 L (<528 gal).

4.7.7 Axle Capacity.

4.7.7.1 Front and rear axles shall have the gross axle weight rating (GAWR) capacity to carry the maximum imposed load under all intended operating conditions.

4.7.7.2 The variations in axle track shall not exceed 20 percent of the tire(s) sectional width at rated load.

4.8* Suspension. The suspension system shall be designed to allow the loaded vehicle to perform as follows:

- (1) Travel at the specified speeds over improved surface
- (2) Travel at moderate speeds over unimproved surface
- (3) Provide diagonally opposite wheel motion above ground obstacles without raising the remaining wheels from the ground, in accordance with Table 4.2.1.2(a) and Table 4.2.1.2(b)
- (4) Prevent damage to the vehicle caused by wheel movement

4.9 Rims, Tires, and Wheels.

4.9.1 Vehicles shall be required to meet the specified paved surface performance while still providing off-pavement performance compatible with the conditions encountered at the operational airport.

4.9.2* A tire selection shall be made that reflects the off-pavement performance requirements necessitated by the soil conditions encountered at the operational airport.

4.9.3* Only new tires shall be mounted on the vehicles.

4.9.4 All wheels on vehicles of more than 1999 L (528 gal) capacity shall be of the single-wheel type, with all rims, tires, and wheels of an identical size and the same tire tread design.

4.9.5 Rims, tires, and wheels shall be certified by their respective manufacturers as having the capacity to meet the specified performance.

4.9.6 Tires shall be certified by their respective manufacturers for not less than 42.9 km (25 mi) of continuous operation at 96.5 kph (60 mph) when inflated at the operational pressure.

4.10* Towing Connections. At least two large tow eyes or tow hooks (one at the front and one at the rear), capable of towing the vehicle on level ground without damage, shall be mounted on the truck and attached directly to the frame structure or where recommended by the vehicle manufacturer.

4.11 Brakes.

4.11.1* The braking system shall comply with FMVSS 121, *Brake Performance and Stability Testing* as follows:

- (1) No part of the brake chamber projects below the axle bowls.
- (2) The air system has the capacity for quick buildup from 0 kPa (0 psi) to release of spring brakes within 15 seconds.

4.11.2* Service brakes shall be of the all-wheel type with split circuits so that failure of one circuit does not cause total service brake failure.

4.11.2.1 The service brakes shall be capable of holding the fully loaded vehicle on a 50 percent grade.

4.11.2.2 For vehicles less than 6000 L (1585 gal), the service brakes shall stop the vehicle within 10.7 m (35 ft) at 32.2 kph (20 mph) and within 39.9 m (131 ft) at 64.4 kph (40 mph).

4.11.2.3 For vehicles greater than 6000 L (1585 gal), the service brakes shall stop the vehicle within 12.2 m (40 ft) at 32.2 kph (20 mph) and within 48.8 m (160 ft) at 64.4 kph (40 mph).

4.11.2.4 Stopping distances shall be accomplished on a dry, hard, approximately level roadway that is free from loose material and that has a roadway width equal to the vehicle width plus 1.2 m (4 ft) without any part of the vehicle leaving the roadway.

4.11.2.5 For each vehicle, the service brakes shall provide one power-assisted stop while the vehicle engine is inoperative for the stopping distances specified in 4.11.2.2 through 4.11.2.4.

4.11.3 The parking brake shall be capable of holding the fully loaded vehicle on a 20 percent grade without air or hydraulic assistance.

4.11.4 Brakes — Air System.

4.11.4.1 Reservoirs shall be equipped with drain valves and safety valves.

4.11.4.2 Provision shall be made for charging of air tanks with either a pull-away electrical connection used to power a vehicle-mounted complementary compressor or a pull-away air connection for charging of air tanks from an external air source.

4.11.4.3 Visual and audible low-air pressure warning devices that are visible and audible to the driver from inside the cab of the vehicle shall be provided.

4.12 Steering.

4.12.1 The chassis shall be equipped with power-assisted steering with direct mechanical linkage from the steering wheel to the steered axle(s) to allow manual control in the event of power-assist failure.

4.12.2 The power steering system shall have the capacity so that no more than 66.7 N (15 lbf) pull is needed on the steering wheel rim to turn the steering linkage from stop to stop with the fully loaded vehicle stationary on a dry, level, paved surface with the engine at idle.

4.12.3* The wall-to-wall turning diameter of the fully loaded vehicle shall be less than three times the vehicle length.

4.13 Cab. All interior crew and driving compartment door handles shall be designed and installed to protect against accidental or inadvertent opening.

4.13.1 Cab Interior.

4.13.1.1 The cab shall be fully enclosed (i.e., floor, roof, and four sides).

4.13.1.2 Seating for the crew shall be restricted to the cab.

4.13.1.3 The maximum number of crew seat positions provided in the cab designated by the manufacturer shall be labeled in the cab.

4.13.1.4 As a minimum, seat positions shall be provided, for the driver and for an additional crew member.

4.13.1.5 Three-point seat belts equipped with a single hand hookup shall be provided for each of the designated seating positions.

4.13.1.6 Space shall be provided for all instrument controls and equipment specified without hindering the crew.

4.13.1.7 Doors shall be provided on each side of the cab with steps and handrails to allow rapid entrance and exit from the cab while wearing full protective equipment.

4.13.1.8 Each door shall be equipped with a restraint device(s) to prevent the door from being sprung open by wind or jet blast.

4.13.2 Cab Visibility.

4.13.2.1 The cab shall meet the visibility requirements of 4.4.2.2.

4.13.2.2 Interior cab reflections from exterior and interior lighting shall be minimized.

4.13.2.3 The windshield shall be shatterproof safety glass.

4.13.2.4 All other windows shall be constructed of safety glass.

4.13.2.5 Where equipped with a primary turret having manual controls above the cab roof, the cab roof shall be designed with a quick access to the primary turret(s).

4.13.3 Cab Construction.

4.13.3.1 The cab shall be weatherproof.

4.13.3.2 The cab shall be fully insulated thermally and acoustically with a fire-resistant material.

4.13.3.3 The cab interior noise level at any seated position shall not exceed 85 dBA while the vehicle is being driven at 80.5 kph (50 mph) on a level, hard surface without warning devices operating.

4.13.3.4 While stationary and discharging water or foam from the high-volume turrets with exterior warning devices operating, the maximum noise level inside the cab shall be 90 dBA.

4.13.3.5 The cab shall be permitted to be of the unitized rigid body and frame structure type or a separate unit that is flexibly mounted on the main vehicle frame.

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

- (1) SAE J2420, *COE Frontal Strength Evaluation — Dynamic Loading Heavy Trucks*, and SAE J2422, *Cab Roof Strength Evaluation — Quasi-Static Loading Heavy Trucks*

- (2) ECE Regulation number 29, *Uniform Provisions Concerning the Approval of Vehicles with Regard to the Protection of the Occupants of the Cab of a Commercial Vehicle*

4.13.4 Instruments, Warning Lights, and Controls.

4.13.4.1 The minimum number of instruments, warning lights, and controls consistent with the operation of the vehicle, chassis, and firefighting system shall be provided.

4.13.4.1.1 All chassis instruments and warning lights shall be grouped on a panel in front of the driver.

4.13.4.1.2 All firefighting system instruments, warning lights, and controls shall be grouped by function to provide ready accessibility and high visibility for the driver as well as crew members.

4.13.4.2* All instruments and controls shall be illuminated.

4.13.4.3 Groupings of both the chassis and the firefighting system instruments, warning lights, and controls shall be removable as a unit or be accessible for servicing.

4.13.4.4* The following instruments and warning lights shall be provided as a minimum:

- (1) Speedometer/odometer
- (2) Engine tachometer(s)
- (3) Fuel level
- (4) Air pressure
- (5) Engine(s) temperature
- (6) Fire system pressure
- (7) Water tank level
- (8) Foam or tank level
- (9) Low-air pressure warning
- (10) Headlight beam indicator
- (11) Engine(s) oil pressure
- (12) Voltmeter(s)
- (13) Transmission oil temperature
- (14) Forward-looking infrared (FLIR) monitor

4.13.4.4.1 The components in 4.13.4.4(4), 4.13.4.4(6), 4.13.4.4(7), 4.13.4.4(8), and 4.13.4.4(9) shall not be applicable to a small commercial chassis.

4.13.4.5 The cab shall have all the following controls within reach of the driver for operation of the vehicle and the pump-system:

- (1) Accelerator pedal
- (2) Brake pedal
- (3) Parking brake control
- (4) Steering wheel, with directional signal control and horn
- (5) Transmission range selector
- (6) Pump control or selector
- (7) Foam control
- (8) Siren switch(es)
- (9) Bumper turret controls or ground sweep valve control, where specified
- (10) Undertruck valve control, where specified
- (11) Remote turret controls, where remote turret is provided
- (12) Light switches
- (13) Windshield wipers with delayed and multispeed capability and washer controls
- (14) Heater/defroster controls
- (15) Master electrical switch
- (16) Means of starting and stopping engine

- (17) Complementary agent pressurization control, where specified
- (18) Windshield deluge system switch, where specified

4.13.4.6* Where specified, a windshield deluge system shall be designed to flood the windshield with clear water and to be energized automatically whenever the system is operated.

4.13.4.7* Where specified, vehicles shall be equipped with the navigation system of a driver's enhanced vision system (DEVS).

4.13.4.7.1 The DEVS system shall meet or exceed the following requirements as outlined in FAA Advisory Circular AC No. 150/5210-19A:

- (1) Chapter 1, Section 2, Subsection b, Part (2) Navigation
- (2) Chapter 2, Full Sections 5–7, 16–19, 21
- (3) Chapter 2, Full Sections 16–19

4.13.4.7.2 Where specified, the DEVS navigation system as described in 4.13.4.7.1 shall include a tracking and onboard information system that meets or exceeds the following requirements as outlined in FAA Advisory Circular No. 150/5210-19A:

- (1) Chapter 1, Section 2, Subsection b, Part (3) Tracking
- (2)* Chapter 2, All

4.13.4.8* A low-visibility enhanced vision system shall be installed in the vehicle consisting of a FLIR system that meets or exceeds the following requirements as outlined in FAA Advisory Circular No. 150/5210-19A:

- (1) Chapter 1, Section 2, Subsection b, Part (1) Vision Enhancement
- (2) Chapter 2, Full Sections 6, 7, 10, and 12

4.13.4.9 FLIR.

4.13.4.9.1 The FLIR sensor shall be able to detect long wave (8 μ m to 12 μ m) infrared (IR) energy.

4.13.4.9.2 The sensor array resolution shall be a minimum of 640 horizontal pixels by 480 vertical pixels.

4.13.4.9.3 The camera shall have a high-contrast filter that will show low-contrast objects in a dynamic thermal scene.

4.13.4.9.4 The camera shall provide an industry standard composite (with automatic gain and level control) or digital video output.

4.13.4.9.5 The camera shall have a minimum horizontal (HFOV) and vertical field of view (VFOV) of 27 degrees (± 4 degrees) and 18 degrees (± 4 degrees), respectively.

4.13.5 Equipment.

4.13.5.1 The following equipment shall be provided in or on the cab, as applicable:

- (1) Heater/defroster
- (2) Driver's suspension seat with vertical, fore, and aft adjustment, with seat belt [The use of a nonsuspension driver's seat is permitted where recommended by the manufacturer; the vertical adjustment does not apply to commercial vehicles with a capacity of <1999 L (528 gal).]
- (3) Crew seats with individual retractable seat belts
- (4) Windshield washers
- (5) Windshield wipers
- (6) Siren
- (7) Horn

- (8) A means or provision that is designed to protect driver and crew from overhead glare and light from the sun
- (9) Outside rearview mirrors, as specified in 4.4.2.3
- (10) Interior lighting
- (11) Provisions for mounting at each crew seat position self-contained breathing apparatus (SCBA) of the type specified by the purchaser
- (12) Low-visibility FLIR meeting suggested specifications contained in Section D.4 or equivalent

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

- (1) The SCBA holder retains a pack and bottle combination for the published weight rating of the holder when subjected to the dynamic force pulse per SAE J2418, *Occupant Restraint System Evaluation — Frontal Impact Component-Level Heavy Trucks*.
- (2) If the SCBA unit is mounted in a seatback, the release mechanism is accessible to the user while seated.
- (3) Brackets that lock automatically either in the event of impact or when the parking brake is released, but are not locked at other times, are permitted.
- (4)* The SCBA holder retains the bottle when subjected to the deceleration pulse at 0, 30, 90, and 180 degrees with respect to the direction of bottle extraction and in the horizontal plane.
- (5) The SCBA holder retains the bottle when subjected to a deceleration pulse that exceeds 2 g for at least 60 ms in the vertical direction.
- (6) The deceleration pulse meets the SAE J2418 deceleration profile with an accuracy of ± 10 percent within the 35 ms to 95 ms range.
- (7) The deceleration pulse is measured on a rigid portion of the base of the test fixture.
- (8) The test component is retained in the holder during and after the dynamic test.
- (9) The force required to extract the bottle after each test is no more than 125 percent of the initial extraction force.
- (10) The SCBA holder is attached to the fixture in the same manner that it will be fastened to the seat or vehicle.
- (11) The test bottle does not move more than 7.6 m (3 in.) relative to the frame of the holder during each test.
- (12) The test fixture does not allow the holder frame to move more than 7.6 m (3 in.) relative to the base of the test sled.
- (13) Each holder bears a label affixed by the holder manufacturer certifying compliance to these specifications.

4.13.5.3 Equipment Mounting.

4.13.5.3.1 All equipment required to be used during an emergency response shall be securely fastened.

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

4.13.6 Signs visible from each seated position that state “Occupants must be seated and wearing a seat belt when apparatus is in motion” shall be provided.

4.13.7 Onboard Data Management and Communications Equipment. The purchaser shall specify what the contractor needs to provide in terms of onboard data management and communications equipment for the apparatus.

4.13.7.1 For each category of equipment listed in 4.13.7.5, the purchaser shall specify what equipment the contractor is to supply and install.

4.13.7.2 For each category of equipment listed in 4.13.7.5, the purchaser shall specify what purchaser-supplied equipment the contractor is to install.

4.13.7.3* For each category of equipment listed in 4.13.7.5, the purchaser shall specify what accommodations such as space, power, antenna bases, and so on the contractor is to provide to support purchaser-installed equipment.

4.13.7.4 For each category of equipment listed in 4.13.7.5, the purchaser shall specify if no equipment in that category is to be supplied or installed, or have any accommodations provided.

4.13.7.5 The purchaser shall provide the information identified in 4.13.7.1 through 4.13.7.4 for the following:

- (1)* MADAS
- (2) Mobile data terminals or other computer equipment
- (3) Traffic preemption equipment
- (4)* Vehicle data recorder
- (5)* V2X communications

4.13.8* If a lateral acceleration indicator is provided, it shall be adjustable for sensitivity and provide both visual and audio warning signals and warnings to the driver.

4.14 Body.

4.14.1 The body shall be constructed of materials that are of the lightest weight consistent with the strength necessary for off-pavement operation over rough terrain and exposure to excess heat, and body panels shall be removable where necessary to provide access to the interior of the vehicle.

4.14.2 Access doors shall be provided for those areas of the interior of the vehicle that are inspected frequently, including, but not limited to, the following:

- (1) Engine
- (2) Pump
- (3) Foam-proportioning system
- (4) Battery storage
- (5) Fluid reservoirs

4.14.3 Compartments for storage of equipment and tools to be carried on the vehicle shall have the following characteristics:

- (1) Be weather resistant
- (2) Be self-draining
- (3) Be lighted

4.14.4 A working deck that is reinforced and constructed of, or covered with, a slip-resistant material shall be provided and reinforced adequately to allow the crew to perform its duties in the primary turret area, cab hatch area, water tank top fill area and foam-liquid top fill area, and in other areas where access to complementary or installed equipment is necessary.

4.14.5 Handrails or bulwarks shall be provided where necessary for the safety and convenience of the crew.

4.14.5.1 Access handrails or handholds shall be provided at each entrance to a driving or crew compartment and at each position where steps or ladders for climbing are located.

4.14.5.2 Exterior access handrails shall be constructed of or covered with a slip-resistant, noncorrosive material.

4.14.5.3 Exterior access handrails shall be between 25.4 mm and 41.275 mm (1 in. and 1⅞ in.).

4.14.6 Steps or ladders shall be provided for access to the top fill area.

4.14.6.1 The lowermost step(s) shall be permitted to extend below the angle of approach or departure or ground clearance limits if it is designed to swing clear.

4.14.6.2 All other steps shall be rigidly constructed and constructed of, or covered with, a slip-resistant material.

4.14.6.3 The lowermost step(s) shall be no more than 558.8 mm (22 in.) above level ground when the vehicle is fully loaded.

4.14.6.4 Lighting shall be provided to illuminate steps and walkways.

4.14.7 A front bumper shall be mounted on the vehicle and secured to the frame structure.

4.14.8 Attachments shall be provided for all tools, equipment, and other items that the purchaser specifies to be furnished on the vehicle.

4.14.8.1 Equipment holders shall be attached and designed so that equipment remains in place under all operating conditions.

4.14.8.2 The equipment holders shall allow the equipment to be readily accessible and removable for use.

4.14.9* Each storage compartment identified by the vehicle manufacturer for use by the purchaser shall be labeled with tested weight.

4.14.10 Compartment loading shall not be exceeded as identified at the time of vehicle manufacture.

4.14.11 Provisions shall be made for mounting tools and equipment, as specified by the purchaser, on the truck.

4.14.12 Special tools for servicing the vehicle, fire suppression system, and any of the auxiliary equipment shall be identified specifically by the vehicle manufacturer and furnished as necessary by the vehicle manufacturer.

4.15 Firefighting Systems and Agents.

4.15.1 For ARFF purposes, vehicles using primary extinguishing agents shall be tested in accordance with all requirements of Chapters 1 through 3, and 27 through 29 of NFPA 460.

4.15.2 Vehicles designed to discharge complementary agents shall require the use of complementary agents that are compatible with the primary agent.

4.15.3* All components of the agent systems made of materials resistant to corrosion by the primary agent, primary agent/water solution, water, and, where specified, the complementary agent.

4.15.4 Combinations of high-pressure lines, valves, and quick disconnect fittings that allow for the in-service refilling of propellants without requiring the removal of the high-pressure vessels from the truck shall be permitted.

4.16 Agent Pump(s) and Pump Drive.

4.16.1 Agent Pump(s).

4.16.1.1 The water pump(s) shall be constructed of corrosion-resistant metals of the single-stage or multiple-stage centrifugal type agreed upon by the end user and manufacturer, and designed for emergency service.

4.16.1.1.1 Pumps shall be gravity primed from the vehicle tank.

4.16.1.1.2 The pump and piping system shall be designed to eliminate the entrapment of air.

4.16.1.2 All proportioning system components shall be made of materials resistant to corrosion by all primary agents.

4.16.1.3 Where discharging foam solution, the pumping system shall be capable of discharging at a rate equal to or exceeding the total requirements of the roof or boom-mounted turret(s), bumper turret or ground sweep nozzles, handline nozzles, and undertruck nozzles, where specified, discharging simultaneously at designed pressures.

4.16.2 Pump Drive.

4.16.2.1 The pump(s) drive shall allow operation of the pump(s) and simultaneous operation of the vehicle.

4.16.2.1.1 The pump(s) shall not be affected by changes in transmission ratios or the actuation of clutches in the vehicle drive.

4.16.2.1.2 The design of the drive system and controls shall prevent damage to the drive and minimize lurching of the vehicle when the vehicle drive is engaged during pumping operations.

4.16.2.1.3 The pump(s) drive system shall be capable of absorbing the maximum torque delivered by the engine to the pump(s) and withstanding the engagement of the pump(s) at all engine and vehicle speeds and under all operating conditions.

4.16.2.1.4 The operation of the pump(s) shall not, under any conditions, cause the engine to stall or cause more than a slight and momentary reduction in engine speed and consequent drop in pump pressure.

4.16.2.2 While pumping at rated capacity, the drive shall allow controlled vehicle operations at a minimum speed of 16.1 kph (10 mph) in forward direction and minimum speed of 8 kph (5 mph) in rearward direction.

4.16.2.2.1 During shifting from forward to rearward drive, the pumping system shall maintain the preset discharge pressure.

4.16.2.2.2 The pump(s) drive shall have the power capacity to provide the pump(s) discharge requirements of 4.16.1.3 while the vehicle is being propelled under all operating conditions where firefighting capability is needed.

4.16.2.3 If an independent engine is used to drive the pump(s), it shall operate with the same fuel and electrical system as the chassis engine

4.16.3 Tank-to-Pump Connections.

4.16.3.1 The tank-to-pump system shall be designed for flow at the pumping rates required by 4.16.1.3.

4.16.3.2 A drain shall be at the lowest point with a valve for draining all the liquid from the pumping system.

4.16.4 Discharge Connections. All couplings shall be specified by the purchaser to the standard for the airport.

4.16.5 Piping, Couplings, and Valves.

4.16.5.1 Union or rubber-gasketed fittings shall be provided where necessary to facilitate removal of piping.

4.16.5.2 Piping shall be provided with flexible couplings to minimize stress.

4.16.5.3 All valves shall be of the quarter-turn type and selected for ease of operation and freedom from leakage.

4.16.5.4 The tank-to-pump side of the pump piping shall be leak free.

4.16.5.5 All water and foam solution discharge piping, together with the agent pump(s), shall be tested at 50 percent above the system operating pressure.

4.16.5.6 Any 3 in. (75 mm) or larger intake valve to the water pump, except the tank-to-pump valve, shall be a slow-operating valve.

4.16.6 Overheat Protection. An automatic system with a visual alarm shall be provided to prevent overheating of the pumps while they are engaged and operating at zero discharge.

4.16.7 Pressure Relief System. A pressure relief system shall be provided to protect the system from damage.

4.16.8 Drains. A drainage system shall be provided appropriate for the design of the vehicle.

4.17 Water Tank.

4.17.1 Capacity.

4.17.1.1 A water tank shall have a usable capacity as specified in Table 4.2.1.2(a) and Table 4.2.1.2(b).

4.17.1.2 The rated capacity of the tank shall be equal to the usable capacity that can be pumped from the tank while the vehicle is parked on level ground.

4.17.1.3 The tank outlets shall be arranged to allow the use of at least 85 percent of the rated capacity with the vehicle positioned as follows:

- (1) On a 20 percent side slope
- (2) On a 30 percent ascending grade
- (3) On a 30 percent descending grade

4.17.2 Construction.

4.17.2.1 The tank shall be constructed to resist all forms of deterioration that could be caused by the water and the foam concentrate while affording the structural integrity necessary for off-road operation.

4.17.2.2 The tank shall have the following characteristics:

- (1) Be equipped with removable manhole covers over the tank discharge

- (2) Be designed to allow for internal and external inspection and service
- (3) Have longitudinal and transverse baffles
- (4) Have a minimum 63.5 mm (2½ in.) capacity drain connection installed at the bottom of the sump

4.17.2.3 Provisions shall be made for necessary overflow and venting.

4.17.2.3.1 Venting shall be sized to allow agent discharge at the maximum design flow rate without danger of tank collapse.

4.17.2.3.2 Vents shall be sized to allow rapid and complete filling without exceeding the internal pressure design limit of the tank.

4.17.2.3.3 Overflows shall be designed to prevent loss of water from the tank during maneuvering and to direct the discharge of overflow water directly to the ground.

4.17.2.4 The water tank shall have the following characteristics:

- (1) Be mounted in a manner that limits the transfer of the torsional strains from the chassis frame to the tank during off-pavement driving
- (2) Be separate and distinct from the crew compartment, engine compartment, and chassis
- (3) Be able to be removed as a unit
- (4) Be permitted to be an integral part of unitized rigid body construction

4.17.2.5 The water tank shall be equipped with at least one top fill opening of not less than 20.3 cm (8 in.) internal diameter.

4.17.2.5.1 The water tank top fill shall be equipped with an easily removable strainer of 6.4 mm (¼ in.) mesh construction.

4.17.2.5.2 The water tank top fill opening shall be equipped with a cap designed to prevent spillage.

4.17.2.6 For vehicles less than 1999 L (528 gal), the water tank shall be equipped with at least one top fill opening of not less than 127 mm (5 in.) internal diameter.

4.17.3 Tank Fill Connection(s).

4.17.3.1 A tank fill connection(s) shall be provided in a position where it can be reached easily from the ground.

4.17.3.2 All couplings shall be specified by the purchaser to the standard for the airport.

4.17.3.3 The connection(s) shall be provided with strainers of 6.4 mm (¼ in.) mesh.

4.17.3.4 The tank fill connection(s) shall be sized to allow filling of the water tank in 2 minutes at a pressure of 551.6 kPa (80 psi) at the tank intake connection.

4.17.3.5 The tank connections shall comply with the following:

- (1) Have check valves
- (2) Be constructed so that water is not lost from the tank when a connection or disconnection is made

4.18* Foam System.

4.18.1 Foam-Liquid Concentrate Tank(s).

4.18.1.1 The purchaser shall specify the percent concentrate foam system to be provided for it to have a working capacity sufficient for two tanks of water at the maximum tolerance specified in Section 28.2 of NFPA 460.

4.18.1.2 The tank(s) shall be designed for compatibility with the foam concentrate being used.

4.18.1.3 Tanks shall be designed to allow for internal and external inspection and service.

4.18.1.4 The tank outlets shall be located above the bottom of the sump and provide continuous foam-liquid concentrate to the foam proportioning system, with that system operating as specified in 4.18.4 and with the vehicle discharging two tank loads of usable water as specified in 4.17.1.

4.18.1.5 If separate from the water tank, the foam-liquid tank shall be mounted in a manner that limits the transfer of the torsional strains from the chassis frame to the tank during off-pavement driving.

4.18.1.5.1 The foam-liquid concentrate tank shall be removable as a unit.

4.18.1.5.2 Foam-liquid concentrate tanks used as an integral part of unitized rigid body construction shall be permitted.

4.18.1.5.3 A flexible tank shall be structurally supported to resist tearing independently of the fluid levels in either the water or foam tanks.

4.18.1.5.4 The structural support shall not be dependent on the fluid level in either the water tank or the foam tank.

4.18.1.6 A top fill trough shall have the following characteristics:

- (1) Be equipped with a mesh screen constructed of noncorrosive materials and container openers to allow emptying 18.9 L (5 gal) foam-liquid concentrate containers into the storage tank(s)
- (2) Be connected to the foam-liquid storage tank(s) with a fill line designed to introduce foam-liquid concentrate to minimize foaming within the storage tank

4.18.1.7 The tank fill connection(s) shall have the following characteristics:

- (1) Be provided in a position where it can be reached, but not exceed 1.5 m (5 ft), from the ground to allow the pumping of foam-liquid concentrate into the storage tank(s)
- (2) Be provided with strainers of 6.4 mm (¼ in.) mesh and have check valves or be constructed so that foam is not lost from the tank when a connection or disconnection is made

4.18.1.8 Where flexible tanks are used, the supply system shall have the following characteristics:

- (1) Be designed so that the flexible tanks are not subject to excess pressure
- (2) Be capable of delivering foam-liquid at a rate at least equal to or greater than the maximum discharge rate of the foam system

4.18.1.9 The tank(s) shall have the following characteristics:

- (1) Be vented to allow for filling without the buildup of pressure
- (2) Allow emptying of the tank at the maximum design flow rate without danger of collapse
- (3) Have the vent outlets directed to the ground to prevent spillage of foam-liquid concentrate on vehicle components

4.18.2 Foam Proportioning System Flushing. The foam-liquid concentrate system shall be arranged so that the entire piping system can be flushed readily with clear water.

4.18.3 Foam-Liquid Concentrate Piping.

4.18.3.1* The foam-liquid concentrate piping shall be of material resistant to corrosion by foam-liquid concentrates addressed in this standard.

4.18.3.1.1 Care shall be taken that combinations of dissimilar metals that produce galvanic corrosion are not selected or that such dissimilar metals are electrically insulated.

4.18.3.1.2 Where plastic piping is used, it shall be fabricated from unplasticized resins, unless it has been demonstrated that the stipulated plasticizer does not adversely affect the performance characteristics of the foam-liquid concentrates addressed in this standard.

4.18.3.1.3 The plastic pipe shall be permitted to be reinforced with glass fibers.

4.18.3.2 The foam-liquid concentrate piping shall be sized to allow the maximum required flow rate.

4.18.3.3 The foam-liquid concentrate piping shall be arranged to prevent water from entering the foam tank.

4.18.4 Foam Proportioning Systems.

4.18.4.1 The foam concentrate proportioning system shall provide a means of controlling the ratio of end-user-specified foam concentrate to the quantity of water in the foam solution being discharged from all orifices used for aircraft firefighting operations.

4.18.4.2 The proportioning system shall be accurate to provide for the discharge of finished foam within the range specified in Chapter 28 of NFPA 460.

4.18.4.3 Each nozzle shall have minimum foam discharge patterns and meet the discharge parameters described in Table 4.2.1.2(a).

4.18.4.4 If an input-based foam test system is specified with the vehicle it shall be one approved by the AHJ.

4.19 Premixed Foam Solutions.

4.19.1 Premixed — Pump System.

4.19.1.1* Where premixed solution in the main water tank is selected as the means of proportioning foam to water, the appropriate foam concentrate shall be used in accordance with the manufacturer specifications.

4.19.1.2 Where premixed solution is used, operation of the vehicle firefighting system shall conform to the requirements of Sections 4.16 and 4.17.

4.19.2 Premixed — Pressurized System.

4.19.2.1 Liquid Agent Container(s).

4.19.2.1.1 The storage container(s) for liquid agent(s) shall be marked, designed for pressurization, and constructed in accordance with the ASME *Boiler and Pressure Vessel Code*.

4.19.2.1.2 The material of construction shall be resistant to corrosion by the AFFF agent to be stored, or a lining material shall be provided.

4.19.2.1.3 An ASME-approved pressure relief valve and pressure gauge that indicates the internal pressure of the agent storage container at all times shall be provided on the container and set to prevent pressures in excess of the maximum allowable working pressure.

4.19.2.1.4 A readily accessible fill opening to allow ease in filling, and stirring if necessary, shall be provided.

4.19.2.1.4.1 The fill opening shall be in compliance with ASME or local codes and in no case be less than 76.2 mm (3 in.) in diameter.

4.19.2.1.4.2 Filling shall be accomplished without the removal of any of the extinguisher piping or any major component.

4.19.2.1.5* A means shall be provided to determine the contents of the container as a guide in recharging partial loads.

4.19.2.2 Propellant Gas.

4.19.2.2.1 The propellant gas shall be dry nitrogen or dry compressed air.

4.19.2.2.2 All propellant gas cylinders and valves shall be constructed and marked in accordance with U.S. Department of Transportation (DOT) requirements or regulations.

4.19.2.2.3 The design of the propellant source shall provide for replacement after each use.

4.19.2.2.3.1 Design of the propellant system shall provide for replacement of the high-pressure gas cylinder from the ground by a single person.

4.19.2.2.4 A pressure gauge that indicates the pressure of the propellant gas source at all times shall be provided.

4.19.2.2.5 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

4.19.2.2.6 The cylinder valve shall be capable of being opened by quick-acting control and permit remote operation.

4.19.2.2.7 The propellant gas supply shall be sized to provide the capability to expel the firefighting agent as well as to purge all piping and hose lines after use.

4.19.2.3 Pressure Regulation.

4.19.2.3.1 Pressure regulation shall be designed to reduce the cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the liquid agent container(s).

4.19.2.3.2 All pressure-regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

4.19.2.3.3 Pressure-regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

4.19.2.3.4 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

4.19.2.4 Piping and Valves.

4.19.2.4.1 All propellant piping and fittings shall have the following characteristics:

- (1) Conform to the appropriate ASME document
- (2) Be designed to withstand the working pressure of the system

4.19.2.4.1.1 The design of the piping and valving shall provide the desired flow of gas into the system and the minimum amount of restriction from the liquid agent container(s) to the hose connection.

4.19.2.4.1.2 Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

4.19.2.4.2 Provisions shall be made for the following:

- (1) Purging of all piping and hose of the liquid after use without discharging the liquid agent remaining in the container(s)
- (2) Depressurization of the liquid agent container(s) without the loss of the remainder of the liquid agent

4.19.2.4.3 Readily accessible drains shall be provided to allow complete draining of the system.

4.19.2.4.4 All valves shall be of the quarter-turn, quick-opening ball type.

4.19.2.4.4.1 A maximum of two operations, exclusive of the nozzle, shall be provided to charge the system.

4.19.2.4.4.2 Controls shall be arranged for simultaneous charging of the liquid agent and dry chemical systems.

4.19.2.4.4.3 Valves on the gas cylinder specified in 4.19.2.2.2 shall not be required to be of the quarter-turn, quick-opening ball type.

4.19.2.4.5 Identical quick-acting controls shall be provided to pressurize the liquid agent system from the cab of the vehicle and the unit.

4.19.2.4.6 All valves and piping shall be resistant to corrosion by the foam-liquid concentrate.

4.19.2.4.7 A check valve shall be provided in the gas piping to prevent the liquid agent from being forced back into the propellant gas line.

4.20 Turret Nozzles.

4.20.1 ARFF vehicles shall have at least one primary turret nozzle with a discharge rate tolerance of +10 percent $\pm$ 0 percent.

4.20.2 Turret nozzles with liquid flow rates of 2839 L/min (750 gpm) or more shall be of the dual discharge type and arranged to allow selection of either 50 percent or 100 percent of the turret's capacity.

4.20.3 If a turret nozzle is visible from the operator's position in all ranges of motion, an elevation and azimuth indication shall not be required.

4.20.4 The purchaser shall specify a manually operated or a power-assisted turret.

4.20.4.1 Where a manually operated turret is specified, the following shall apply:

- (1) Controls are in the cab.
- (2) Operation force is less than 133.4 N (30 lbf).
- (3) An indicator of turret elevation and azimuth is provided.

4.20.4.2 Where a power-assisted turret is specified, the following shall apply:

- (1) Controls are in the cab.
- (2) An indicator of roof turret elevation and azimuth is provided.
- (3) Where specified, a manual override or secondary control powered by an alternative source of all turret movement functions is provided.
- (4) Where specified, secondary controls are capable of operating the turret with a failed primary control system.
- (5) Where specified, the manual override for turret operation force is less than 133.4 N (30 lbf).

4.20.4.3 Where turret control is at the platform, operation forces shall be less than 222.4 N (50 lbf).

4.20.5 Turrets shall be capable of the following:

- (1) Being elevated at least 45 degrees above the horizontal
- (2) Discharging agent within 9.1 m (30 ft) in front of the vehicle at full output using a dispersed stream
- (3) Where a single turret is used on a vehicle, being rotated not less than 90 degrees to either side, with total traverse not less than 180 degrees
- (4) Where two turrets are used on a vehicle, stopping so that neither turret can interfere with the other turret
- (5) Providing access to turret controls for both foam and dry chemical turrets to the driver and crew members

4.20.6 If the boom-mounted turret is on a rotational base, it shall meet the following design and functional requirements:

- (1) The boom-mounted turret meets the requirements of 6.3.22, 6.4.1, and 6.4.12 while in the stowed position.
- (2) The vehicle achieves a 20 percent side slope, with the boom fully elevated and the nozzle rotated uphill at maximum horizontal rotation while discharging at maximum flow rate.
- (3) The vehicle is provided with an interlock or warning system and placards in full view of the driver/operator to provide the operational limitations during all phases of operation.
- (4) Flow rates are in accordance with Table 4.2.1.2(c) and Table 4.2.1.2(d) for major vehicles.
- (5) If the boom-mounted turret is intended to be the primary turret, it meets the primary water-foam agent turret discharge requirements of Table 4.2.1.2(c) and Table 4.2.1.2(d) for the applicable vehicle class while in the stowed position.
- (6) The boom-mounted turret meets the foam-quality standard of Chapters 1 through 3 and 27 through 29 of NFPA 460 for the applicable foam applicator and foam type.

- (7) The boom-mounted turret functions during ARFF operations without the need for outriggers or other ground contact stabilizers that would render the vehicle immobile or hinder its maneuverability.
- (8) The boom-mounted turret has a deployment time from the stowed position to the maximum height and starts the application of agent within 30 seconds.
- (9) The high rise, telescoping, or articulating movement of the boom is accomplished with not more than two adjacent lever controls.
- (10) The high rise, telescoping, or articulating movement of the boom is permitted to be manual or automated for preselected positioning of the elevation and reach.
- (11) If automated, these functions are provided with a manual override positioning capability.
- (12) The boom-mounted turret is capable of applying agent to any interior area of the most current wide-body jet, so as not to impede evacuation and for safety considerations of the vehicle operator.
- (13) The device is capable of positioning the nozzle within 0.6 m (2 ft) of ground level in front of the vehicle.
- (14) The device is capable of applying agent to the interior of the aircraft through cargo bay door openings, passenger doorways, and emergency exits on the type of aircraft being protected while the aircraft is in either the gear-up or gear-down landing position.
- (15) The boom-mounted turret has a range of motion so as to permit positioning of the nozzle to direct a firefighting agent stream at least 90 degrees to the longitudinal axis of the fuselage for interior fire extinguishment.
- (16) The turret/boom mechanism is capable of providing for horizontal movement along the aircraft of at least 30 degrees left and right of the vehicle centerline so as not to require repositioning or movement of the ARFF vehicle.
- (17) This horizontal rotation is accomplished without the deployment of stabilizers or outriggers that might cause a delay in positioning or emergency movement of the rescue vehicle.
- (18) The primary turret has backup systems to allow for override of the single-lever boom control and hydraulic system (or other power source) if the primary system becomes disabled.
- (19) The driver/operator is able to see the boom, as it is rising to its maximum height, from a seated position by means of a camera or direct line of sight.
- (20) A means of visually identifying the boom extension available is provided either by an external marking on the boom or a display in the cab visible to the vehicle operator.

4.20.6.1 If specified by the purchaser as the primary water-foam and dry chemical turret — that is, to function as a dual agent turret system — the device shall also be capable of meeting the agent discharge performance of Table 4.2.1.2(c) and Table 4.2.1.2(d) while in the bedded position.

4.20.6.2 An adjustable or dual flow rate nozzle shall be provided that will allow flow rates and patterns for interior aircraft firefighting. [See Table 4.2.1.2(c) and Table 4.2.1.2(d).]

4.20.6.3 Where specified, the boom-mounted turret shall be fitted with controls, accessories, and devices needed for a driver or another operator to remotely perform the interior aircraft and highest engine firefighting functions.

4.20.6.4 Where auxiliary agent lines are specified, they shall have the following characteristics:

- (1) Be capable of discharging either dry chemical, halocarbon agent, or approved equivalent through the nozzle while the device is extended out and up to its maximum operational reach
- (2) Meet the minimum auxiliary agent flow rate and pattern requirements of Table 4.2.1.2(c) and Table 4.2.1.2(d)

4.20.6.5 Where remote color optics are specified the following shall apply:

- (1) They are capable of permitting overall fire scene surveillance when fully extended and provide the driver/operator with the detail needed for placement of the piercing device on the aircraft hull for penetration.
- (2) The camera and associated lighting are designed and installed for exterior environmental operating conditions encountered by ARFF vehicles.
- (3) A monitor 178 mm (7 in.) or larger is cab-mounted and viewable from the driver/operator position.

4.20.6.6 Where a piercing nozzle/agent applicator is specified, it shall be movable in conjunction with the water-foam nozzle to allow placement of the nozzle control and be capable of the minimum water-foam flow rate and pattern requirements of Table 4.2.1.2(c) and Table 4.2.1.2(d).

4.20.6.7* The piercing nozzle shall be capable of a minimum flow rate of 946 L/min (250 gpm).

4.20.6.8 The nozzle system shall be constructed to direct or spray agent and water on both sides of the aircraft at the same time after the penetration is made.

4.20.6.9 Concept of delivery shall be multiple holes causing a spray that covers an area of at least 7.6 m (25 ft) along the length of the fuselage left and right of the penetration point.

4.20.6.10 The point of penetration shall be visible to the driver/operator either by direct line of sight or by remote optics for any piercing position on the aircraft as defined by the manufacturer.

4.20.6.11 The piercing nozzle shall be capable of piercing the aircraft fuselage over the wing area at angles up to 30 degrees left or right of the vehicle centerline in the event that the interior fire is located in this area.

4.20.6.12 The boom-mounted turret with piercing nozzle shall have the ability to perform a multi-axis, multifunction boom operation with penetration and agent flowing at the penetration point (above the windows and below the overhead stowage bins) of a single passenger deck aircraft in less than 45 seconds.

4.20.6.13 For devices designed to reach the second level of a multilevel passenger aircraft, the same function at the second level shall be achieved in less than 60 seconds.

4.20.7 If the boom-mounted turret is on a nonrotational base, it shall meet the following design and functional requirements:

- (1) The boom-mounted turret meets the requirements of 6.3.22, 6.4.1, and 6.4.12 while in the stowed position.
- (2) The vehicle achieves a 20 percent side slope with the boom fully elevated and the nozzle fully rotated uphill at maximum horizontal rotation while discharging at maximum flow rate.

- (3) If the nonrotational boom-mounted turret is the primary turret, its flow rates are to be in accordance with Table 4.2.1.2(c) and Table 4.2.1.2(d) for major vehicles.
- (4) If the nonrotational boom-mounted turret is the primary turret, it meets the primary water-foam agent turret discharge requirements of Table 4.2.1.2(c) and Table 4.2.1.2(d) for the applicable vehicle class while in the stowed condition.
- (5) The boom-mounted turret meets the foam quality standard of Chapter 28 of NFPA 460.
- (6) The boom-mounted turret functions during ARFF operations without the need for outriggers or other ground contact stabilizers that could render the vehicle immobile or hinder its maneuverability.
- (7) The boom-mounted turret has a deployment time from the bedded position to maximum height and start the application of agent within 30 seconds.
- (8) The boom-mounted turret is capable of applying agent through passenger doorways to interior areas of the type of aircraft being protected.
- (9) The device permits the operator to position the nozzle assembly so as to be able to discharge the agent in front of the vehicle at a level that permits the operator to see over the turret discharge.
- (10) The boom-mounted turret has a range of motion so as to permit positioning of the nozzle to direct a firefighting agent stream along the longitudinal axis of the fuselage or up to 90 degrees to the longitudinal axis for interior fire extinguishing.

4.21 Preconnected Handlines. Preconnected handlines shall be those handlines for discharging water or foam, or both, that are specified by the purchaser as intended for use as primary ARFF equipment and all other handlines that are installed on the vehicle shall not be considered as being preconnected handlines.

4.21.1 Preconnected handlines shall be those handlines for discharging water, foam, or both that are specified by the purchaser as intended for use as primary ARFF equipment.

4.21.2 Combined agent vehicles shall have at least one preconnected handline and nozzle for each agent.

4.21.2.1 Handlines and nozzles shall be permitted to be separate or twinned together for simultaneous agent discharge.

4.21.2.2 Handlines shall be permitted to be reeled handlines as specified in Table 4.2.1.2(a), Table 4.2.1.2(b), Table 4.2.1.2(c), and Table 4.2.1.2(d).

4.21.2.3 All other handlines that are installed on the vehicle shall not be considered to be preconnected handlines.

4.21.3 Each preconnected handline compartment shall be located so that the distance between the handline nozzle and the ground, step, or surface upon which the operator stands to initiate the pulling of the handline from the reel or top layer of collapsible hose is not more than 1.8 m (6 ft) above the surface.

4.21.4 Preconnected Reeled Handlines and Nozzles.

4.21.4.1 Handlines for reels shall have a minimum burst rating three times the nominal working pressure of the system and be able to discharge the flow required in Table 4.2.1.2(c) and Table 4.2.1.2(d) without unreeling the hose.

4.21.4.2 Each handline shall have the following characteristics:

- (1) Be equipped with a pistol grip shutoff-type nozzle designed to discharge both foam and water in accordance with the performance criteria in Table 4.2.1.2(c) and Table 4.2.1.2(d)
- (2) Meet the requirements of NFPA 1964

4.21.4.3 Each hose reel shall have the following characteristics:

- (1) Be designed and positioned to allow hose reel removal by a single person from any position in a 120 degree horizontal sector
- (2) Be designed to prevent the hose from unreeling when not desired
- (3) Have power rewind with manual override

4.21.4.4 The nozzle holder, friction brake, rewind controls, and manual valve control shall be accessible to the person using the hose reel.

4.21.4.5 The discharge control to each handline shall be adjacent to the handline and accessible to the person using the handline.

4.21.5 Preconnected Collapsible Handlines and Nozzles.

4.21.5.1 Collapsible handlines shall meet the requirements of NFPA 1961 and Table 4.2.1.2(c) and Table 4.2.1.2(d)

4.21.5.2 Each collapsible handline shall have the following characteristics:

- (1) Be equipped with a pistol grip shutoff-type nozzle designed to discharge foam and water in accordance with the performance criteria in Table 4.2.1.2(c) and Table 4.2.1.2(d)
- (2) Meet the requirements of NFPA 1964

4.21.5.3 Hose storage areas shall have the following characteristics:

- (1) Be fabricated from noncorrosive material and designed to drain
- (2) Be smooth and free from all projections that might damage the hose
- (3) Have no other equipment mounted or located where it can obstruct the removal of the hose

4.21.5.4 The discharge control to each handline shall be adjacent to the handline and accessible to the person using the handline.

4.22 Turret, Ground Sweep, and Undertruck Nozzles.

4.22.1* Where a bumper turret or ground sweep nozzle(s) is provided, the controls shall be mounted inside the cab within reach of the driver and a crew position.

4.22.2 The turret shall have a horizontal rotation of 180 degrees and vertical travel of +45 degrees/-20 degrees.

4.22.3 Where specified, undertruck nozzles shall be mounted under the truck and controlled from the cab to protect the bottom of the vehicle and the inner sides of the wheels and tires with foam solution discharged in a spray pattern.

4.22.4 Turrets, handlines, and ground sweeps shall discharge foam having the quality specified in Chapters 1 through 3, and 27 through 29 of NFPA 460.

4.22.5 Measurement of the expansion ratio and 25 percent drainage times shall be in accordance with the procedures outlined in Chapter 29 of NFPA 460.

4.23 Complementary Agent System. Where specified, the vehicle shall be equipped with a complementary agent system.

4.23.1 Dry Chemical Container. The dry chemical container shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, or equivalent, and so stamped.

4.23.1.1 All piping and fittings shall conform to the appropriate ASME, or equivalent, code to withstand the working pressure of the system.

4.23.1.1.1 The design of the piping and valving shall provide the desired flow of gas into the system and the minimum amount of restriction from the chemical container(s) to the hose connection.

4.23.1.1.2 Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

4.23.1.2 Provisions shall be made for purging all piping and hose of dry chemical after use without discharging the dry chemical remaining in the dry chemical container(s).

4.23.1.2.1 Provisions also shall be made for the depressurization of the dry chemical container(s) without the loss of the remainder of the dry chemical.

4.23.1.2.2 A pressure gauge shall be provided that indicates the internal pressure of the agent storage container(s) at all times.

4.23.1.3 The system shall have the following characteristics:

- (1) Be designed to ensure fluidization of the dry chemical at the time of operation
- (2) Include a manual operating feature where any design includes the movement of the chemical container(s) to fluidize the contents

4.23.1.4 A check valve shall be provided in the gas piping to prevent the extinguishing agent from being forced back into the propellant gas line.

4.23.1.5 A means of pressure relief conforming to appropriate ASME codes shall be provided for the dry chemical container and piping to prevent overpressurization in the event of a malfunction in the propellant gas regulator system or in the event the container is involved in a severe fire exposure.

4.23.1.6* The fill opening in the dry chemical container shall have the following characteristics:

- (1) Be located so that it is easily accessible for recharging and necessitates a minimum amount of time and effort to open and close
- (2) Allow for filling to be accomplished without the removal of any of the extinguisher piping or any major component

4.23.1.7 Identical quick-acting controls shall be provided to pressurize the dry chemical agent system from the cab of the vehicle and at the handline.

4.23.1.8 The pressure container shall be designed to allow hydrostatic testing.

4.23.2 Dry Chemical Propellant.

4.23.2.1 The propelling agent shall be dry nitrogen, dry air, argon, or carbon dioxide.

4.23.2.2 All propellant gas cylinders and valves shall be designed, constructed, and marked in accordance with U.S. DOT, or equivalent, requirements or regulations.

4.23.2.3 The propellant gas supply shall be sized to provide the capability to expel the firefighting agent, as well as to purge all piping and hose lines after each use.

4.23.2.4 The design of the propellant source shall provide for quick and easy replacement after each use.

4.23.2.5 A pressure gauge to indicate the pressure on the propellant gas source at all times shall be provided.

4.23.2.6 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

4.23.3 Dry Chemical Pressure Regulation.

4.23.3.1 Pressure regulation shall be designed to reduce the cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the dry chemical container(s).

4.23.3.2 All pressure-regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

4.23.3.3 Pressure-regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

4.23.3.4 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

4.24 Halogenated Agent.

4.24.1 Halogenated Agent Container.

4.24.1.1 The storage container shall be designed, constructed, and marked in accordance with the ASME *Boiler and Pressure Vessel Code*, or equivalent.

4.24.1.1.1 Where specified, a reserve kit shall be provided with the delivery of the truck.

4.24.1.2 The material of construction shall be resistant to corrosion by the halogenated agent to be stored.

4.24.1.3 A readily accessible charge coupling for filling shall be provided.

4.24.1.3.1 Filling shall be accomplished without the removal of any of the extinguisher piping or any major component.

4.24.1.3.2 A pressure gauge shall be provided that indicates the internal pressure of the agent storage containers at all times.

4.24.1.4 A means shall be provided to determine the contents of the container as a guide in recharging partial loads and to prevent overfilling of the tank.

4.24.2 Halogenated Agent Propellant Gases.

4.24.2.1 Selection of the propellant gases shall follow the recommendations of the firefighting agent manufacturer.

4.24.2.2 All propellant gas cylinders and valves shall be designed, constructed, and marked in accordance with U.S. DOT regulations.

4.24.2.3 Pipes and valves connected to the halogenated agent container shall be designed to withstand the working pressure of the system.

4.24.2.4 The propellant gas cylinder(s) shall be provided with the capability to expel firefighting agents and to purge all piping and hose lines after use.

4.24.2.5 The propellant cylinder(s) shall be readily accessible for replacement.

4.24.2.6 A pressure gauge shall be provided to indicate the pressure of the propellant gas source at all times.

4.24.2.7 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

4.24.2.8 A check valve shall be provided in the gas piping to prevent the liquid agent from being forced back into the propellant gas line.

4.24.3 Halogenated Agent Pressure Regulation.

4.24.3.1 An ASME-approved, or equivalent, pressure relief valve shall be provided on the container and set to prevent pressures in excess of the maximum allowable working pressure.

4.24.3.2 Pressure regulation shall be designed to reduce the normal cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the halogenated agent container(s).

4.24.3.3 All pressure-regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

4.24.3.4 Pressure-regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

4.24.3.5 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

4.24.4 Halogenated Agent Delivery Piping and Valves.

4.24.4.1 All piping, couplings, and valves shall be sized for flow with minimal restriction and pressure loss.

4.24.4.1.1 Material for all piping, couplings, and valves shall be selected to avoid corrosive and galvanic action.

4.24.4.1.2 Piping shall be mounted and provided with flexible couplings to minimize stress.

4.24.4.2 All valves shall have the following characteristics:

- (1) Be of the quarter-turn type
- (2) Be selected for ease of operation and freedom from leakage

4.24.4.3 All discharge piping shall be tested at 50 percent above the system operating pressure.

4.24.4.4 Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

4.24.4.5 Provisions shall be made for the following:

- (1) Purging all piping and hose of the halogenated agent after use, without discharging the halogenated agent remaining in the container(s)
- (2) Venting of the halogenated agent container without loss of the remainder of the liquid agent

4.24.4.6 Identical quick-acting controls shall be provided to pressurize the halogenated agent system from the cab of the vehicle and at the handline.

4.24.4.7* All seals within the halogenated agent system and all seals from other systems that can come in contact with the halogenated agent during discharge shall be of a compatible seal material.

4.25 Dry Chemical Turret.

4.25.1 Auxiliary Agent Discharge. Where specified, a turret shall have an auxiliary agent discharge mounted parallel to the foam solution discharge, or entrained within the foam solution discharge stream.

4.25.1.1 The dry chemical turret performance shall be in accordance with Table 4.2.1.2(c) and Table 4.2.1.2(d).

4.25.1.2 Where entrained dry chemical discharge is specified for water tank capacity under 1999 L (528 gal), the dry chemical flow rate shown in parentheses in Table 4.2.1.2(c) and Table 4.2.1.2(d) shall be used.

4.25.1.3 The dry chemical system shall be designed so that the operator can select to discharge both the primary and the complementary agent systems separately or simultaneously.

4.25.2 Complementary Agent Handlines.

4.25.2.1 Handlines for complementary agents shall have a minimum burst pressure rating three times the nominal working pressure of the system and in accordance with the performance criteria in Table 4.2.1.2(c) and Table 4.2.1.2(d).

4.25.2.1.1 The complementary agent handline shall be equipped with a nozzle that allows going from a fully open to a fully closed position in a single, simple movement.

4.25.2.1.2 Nozzle construction shall be of nonferrous metal or stainless steel.

4.25.2.2 Multiple agent handlines and nozzles shall be designed so that each agent can be discharged separately or simultaneously, parallel or entrained.

4.25.2.2.1 The barrels shall be linked together to provide coordinated application by one operator.

4.25.2.2.2 Each reel shall be designed and positioned to allow hose line removal by a single person from any position in a 120 degree horizontal sector.

4.25.2.2.3 Each reel shall be equipped with a friction brake to prevent the hose from unreeling when not desired.

4.25.2.2.4 A power rewind with manual override shall be provided.

4.25.2.2.5 The nozzle holder, friction brake, rewind controls, and manual valve control shall be accessible to the person using the hose reel.

4.25.2.2.6 A backup hand crank shall be provided and stored on the vehicle.

4.25.2.2.7 The discharge control to each handline shall be adjacent to the handline and accessible to the person using the handline.

4.26 Lighting and Electrical Equipment.

4.26.1* Lighting equipment shall be installed in conformity with local road regulations, where practicable, and shall include the following:

- (1) Headlights with upper and lower driving beams where a control switch that is readily accessible to the driver is provided for beam selection
- (2) In addition to dual taillights and dual stop lights, a minimum of one additional stop light located high up on the rear of the vehicle
- (3) Self-canceling turn signals, front and rear, with a steering column-mounted control, and a visual and audible indicator, and a four-way flasher switch
- (4) Reflectors, marker, and clearance lights furnished to describe the overall length and width of the vehicle
- (5) Engine compartment lights, nonglare type, arranged to illuminate both sides of the engine, with individual switches located in the engine compartment.
- (6) Service lighting for all areas described in 4.14.2(1), 4.14.2(2), and 4.14.2(3), as well as for the engine compartment
- (7) Lighting for all top-deck working areas
- (8) At least one backup light and an audible alarm with a minimum of 97 dBA that meet SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*, installed in the rear of the body

4.26.2* A warning siren shall be provided on the vehicle that meets the requirements of SAE J1849, *Emergency Vehicle Sirens*.

4.26.2.1 The siren shall be mounted to allow maximum forward sound projection and protected from foam dripping from the turret or water splashed up by the tires.

4.26.2.2 The siren unit shall consist of the following functions as a minimum: public address, wail, and yelp.

4.26.2.3 A selector switch shall be mounted within reach of the driver that will allow the operation of the vehicle's horn and the siren from the horn button in the steering wheel.

4.26.2.4 A certificate of compliance shall be provided with the vehicle from the siren manufacturer.

4.26.3 A horn shall be mounted at the front part of the vehicle, with the control positioned so that it is readily accessible to the driver.

4.26.4 Exterior Emergency Warning Lights.

4.26.4.1 A master switch for all exterior emergency warning lights shall be provided in the cab within easy reach of the driver.

4.26.4.2 Emergency warning light(s) shall be mounted on the top of the vehicle and visible for 360 degrees in a horizontal plane.

4.26.4.2.1 The emergency warning light(s) shall be mounted so as to also be visible from the air.

4.26.4.2.2 The purchaser shall provide the vehicle manufacturer with the color of the light(s) and indicate whether the emergency warning lights be LED flasher type, rotating beacon type, or strobe type.

4.26.4.3 Two alternating flashing emergency warning lights shall be mounted at the rear of the vehicle as far apart as practicable.

4.26.4.3.1 These lights shall not be mounted any higher than 1828.8 mm (72 in.) above ground level.

4.26.4.3.2 The purchaser shall provide the vehicle manufacturer with the color of the light and desired flash pattern.

4.26.4.4 Two alternating flashing emergency warning lights shall be mounted at the front of the vehicle as far apart as practicable.

4.26.4.4.1 These lights shall not be mounted any higher than 1828.8 mm (72 in.) above ground level.

4.26.4.4.2 The purchaser shall provide the vehicle manufacturer with the color of the light and indicate whether the emergency warning lights are to be LED flasher type, sealed beam type, or strobe type.

4.26.4.5 The complete emergency warning light system shall require no more than a combined total of 12 volt 40 amps or equivalent for other voltages.

4.26.5 Radios.

4.26.5.1 Provisions shall be made for mounting radios.

4.26.5.1.1 Operation of the radios shall be from the cab.

4.26.5.1.2 Radios shall be mounted to allow quick servicing or replacement.

4.26.5.2 The purchaser shall specify all necessary radios and frequencies that are to be provided.

4.26.6 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.

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

4.27 Application. Where any part of a line voltage electrical system is provided as a fixed installation, the applicable requirements of this chapter shall apply.

Chapter 5 Aircraft Interior Access Vehicle (NFPA 414)

5.1 General.

5.1.1 The firefighting vehicle capabilities contained in this chapter are considered to be the minimum acceptable for performance of AIAVs.

5.1.2 Aircraft interior access vehicles (AIAVs) for ARFF intended to transport personnel and equipment to the scene of an aircraft emergency for the purpose of rescuing occupants and conducting rescue and firefighting operations shall meet the minimum design, performance, and acceptance requirements of this chapter.

5.1.3 The features and components that, when assembled, produce an efficient and capable AIAV shall meet the requirements of this chapter.

5.1.4 Unless stated, other requirements identified in 4 and 6 of this standard shall not apply to this chapter.

5.2 AIAV Vehicle Requirements.

5.2.1 AIAV Cab.

5.2.1.1 The AIAV cab shall provide a minimum seating for two firefighters.

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

5.2.1.3 The cab shall be fully enclosed (i.e., floor, roof, and four sides).

5.2.1.4 Seating for the crew shall be restricted to the cab.

5.2.1.5 The maximum number of crew seat positions provided in the cab designated by the manufacturer shall be labeled in the cab.

5.2.1.6 As a minimum, seat positions shall be provided, for the driver and for an additional crew member.

5.2.1.7 Three-point seat belts equipped with a single hand hookup shall be provided for each of the designated seating positions.

5.2.1.8 Space shall be provided for all instrument controls and equipment specified without hindering the crew.

5.2.1.9 Doors shall be provided on each side of the cab with steps and handrails to allow rapid entrance and exit from the cab while wearing full protective equipment.

5.2.1.10 Each door shall be equipped with a restraint device(s) to prevent the door from exceeding its intended range of motion.

5.2.1.11 Cab Visibility.

5.2.1.11.1 The cab shall meet the visibility requirements of 4.4.2.2.

5.2.1.11.2 Interior cab reflections from exterior and interior lighting shall be minimized.

5.2.1.11.3 The windshield shall be shatterproof safety glass.

5.2.1.11.4 All other windows shall be constructed of safety glass.

5.2.1.11.5 Resources for docking platform driver/operator visibility shall be provided.

5.2.1.12 Cab Construction.

5.2.1.12.1 The cab shall be weatherproof.

5.2.1.12.2 The cab shall be fully insulated thermally and acoustically with a fire-resistant material.

5.2.1.12.3 The cab interior noise level at any seated position shall not exceed 85 dBA while the vehicle is being driven at 80.5 kph (50 mph) on a level, hard surface without warning devices operating.

5.2.1.12.4 While stationary and discharging water or foam from the high-volume turrets with exterior warning devices operating, the maximum noise level inside the cab shall be 90 dBA.

5.2.1.12.5 The cab shall be permitted to be of the unitized rigid body and frame structure type or a separate unit that is flexibly mounted on the main vehicle frame.

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

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

5.2.2 Equipment. The following equipment shall be provided in or on the cab, as applicable:

- (1) Heater/defroster
- (2) Driver's suspension seat with vertical, fore, and aft adjustment, with seat belt [The use of a nonsuspension driver's seat is permitted where recommended by the manufacturer; the vertical adjustment does not apply to commercial vehicles with a capacity of <1999 L (<528 gal).]
- (3) Crew seats with individual retractable seat belts
- (4) Windshield washers
- (5) Windshield wipers
- (6) Siren
- (7) Horn
- (8) A means or provision that is designed to protect driver and crew from overhead glare and light from the sun
- (9) Outside rearview mirrors, as specified in 4.4.2.3
- (10) Interior lighting

5.2.3 SCBA Mounting. Where SCBA holders are mounted within a driving or crew compartment, they shall comply with the following:

- (1) The SCBA holder retains a pack and bottle combination for the published weight rating of the holder when subjected to the dynamic force pulse per SAE J2418, *Occupant Restraint System Evaluation — Frontal Impact Component-Level Heavy Trucks*.
- (2) If the SCBA unit is mounted in a seatback, the release mechanism is accessible to the user while seated.
- (3) Brackets that lock automatically either in the event of impact or when the parking brake is released, but are not locked at other times, are permitted.
- (4)* The SCBA holder retains the bottle when subjected to the deceleration pulse at 0, 30, 90, and 180 degrees with

respect to the direction of bottle extraction and in the horizontal plane.

- (5) The SCBA holder retains the bottle when subjected to a deceleration pulse that exceeds 2 g for at least 60 ms in the vertical direction.
- (6) The deceleration pulse meets the SAE J2418 deceleration profile with an accuracy of ± 10 percent within the 35 ms to 95 ms range.
- (7) The deceleration pulse is measured on a rigid portion of the base of the test fixture.
- (8) The test component is retained in the holder during and after the dynamic test.
- (9) The force required to extract the bottle after each test is not more than 125 percent of the initial extraction force.
- (10) The SCBA holder is attached to the fixture in the same manner that it will be fastened to the seat or vehicle.
- (11) The test bottle does not move more than 7.6 m (3 in.) relative to the frame of the holder during each test.
- (12) The test fixture does not allow the holder frame to move more than 7.6 m (3 in.) relative to the base of the test sled.
- (13) Each holder bears a label affixed by the holder manufacturer certifying compliance to these specifications.

5.2.4 Equipment Mounting.

5.2.4.1 All equipment required to be used during an emergency response shall be securely fastened.

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

5.3 AIAV Body.

5.3.1 Compartments shall be provided to store tools and equipment conforming to manufacturers' load specifications.

5.3.2 Outriggers/stabilizers shall be provided for vehicle stability.

5.4 AIAV Aircraft Access/Egress.

5.4.1* The vehicle shall provide access from ground level to aircraft door sill heights at least to the lower aircraft door sills of the largest aircraft operating at the airport.

5.4.2* The aircraft access system shall not be configured as a ladder.

5.4.3 Access ramps/stairs shall not exceed a vertical angle of 40 degrees. [SAE AIR6133: 5, Table 4]

5.4.4 The stepping surface to the docking platform shall have a minimum width of 1.07 m (42 in.).

5.4.5 A handrail shall comply with the following:

- (1) A handrail shall be provided on each side of the access extending from the docking platform to the bottom of the access
- (2) The height of the handrail measured from the stepping surface shall be a minimum of 0.76 m (30 in.)

5.4.6 Lighting shall be provided to fully illuminate the stepping surfaces at 5 fc (53 lx).

5.4.7 Step strength shall be at least 1221 kg/m² (250 lb/ft²) at any point. [SAE AIR6133: 6.1, Table 5]

5.4.8 Stepping surfaces of access ramps/stairs shall be slip resistant and have the following characteristics:

- (1) Be nonskid both wet and dry
- (2) Have a coefficient of friction not less than 0.5
- (3) Be resistant to the collection of water and snow
- (4) Allow water and snow that does collect to be easily removed
- (5) Be resistant to the catching of narrow shoe heels on small contact areas
- (6) Be resistant to deformation by narrow shoe heels on small contact areas

[SAE AIR6133: 6.2.1]

5.5 AIAV Docking Platform.

5.5.1 General. The docking platform of the vehicle shall be sized to allow a Type A aircraft door to be fully opened and stowed, allowing firefighters and their equipment access to the aircraft.

5.5.1.1 The vehicle shall have a horizontal gap control of at least 10 degrees to either side of the leading edge of the docking platform.

5.5.1.2 The docking platform floor strength shall be designed to support 140 kg (308 lb) at any point. [SAE AIR6133: 6.1, Table 5]

5.5.1.3 The docking platform and lift system shall be designed for a bearing load of 317 kg/m² (65 lb/ft²). [SAE AIR6133: 6.1, Table 5]

5.5.1.4 The docking process itself shall be done without causing damage to the vehicle or the fuselage.

5.5.2* Handrails.

5.5.2.1 Handrails shall be provided as required.

5.5.2.2 The height of the handrails measured from the platform surface shall be a minimum of 0.91 m (36 in.).

5.5.3 Docking Platform Controls.

5.5.3.1 The vehicle shall have the ability to control the docking platform from inside the vehicle cab and on the docking platform.

5.5.3.2 The vehicle docking platform shall be able to be controlled by one person using either set of controls.

5.5.3.3 The controls shall be designed such that continuous, deliberate pressure on the control is necessary for activation and continuous operation and such that relief of that pressure will cause control to return to neutral position.

5.5.3.4 All safety-relevant functions of the staircase (e.g., movement of the staircase body) shall be carried out with a two-function control (deadman type).

5.6 AIAV Performance Requirements.

5.6.1 The access vehicle shall have off-pavement driving capabilities.

5.6.2* The vehicle's clearance circle diameter of the fully loaded vehicle shall be less than three times the maximum overall length of the vehicle.

5.6.3 The vehicle shall pass a 5 degree tilt test with stairs fully extended and loaded to the manufacturer's recommended maximum weight capacity.

5.6.4* From a 1.5 degree horizontal side slope, the vehicle shall have the ability to auto-level the stairs and docking platform to horizontal.

5.7 AIAV Safety Requirements.

5.7.1 Docking Platform.

5.7.1.1 The docking platform shall provide a method to prevent a sudden drop of the docking platform in the event of a vertical lift system failure.

5.7.1.2 The docking platform shall have a device warning the operator that the leading edge of the docking platform is within 152 mm (6 in.) of the aircraft fuselage.

5.7.1.3 The vehicle shall be designed so that the docking platform can be manually lowered and evacuated in the event of power failure.

5.7.1.4 There shall be a method to keep the vehicle from moving with passengers on the stairs or platform.

5.7.1.5 To verify the safety of the requirement in 5.5.1.3, a 317 kg/m² (65 lb/ft²) weight shall be applied to the docking platform for a period of 4 hours, with no platform drift.

5.7.2 Placards and Signs. A placard indicating vehicle traveling height, weight, and speed limitations shall be displayed within sight of the driver.

5.7.3 Gross Vehicle Weight (GVW). The actual gross vehicle weight of a fully loaded vehicle shall not exceed the manufacturer's gross vehicle weight rating as recorded on the vehicle information data plate.

5.7.4 Approvals. Manufacturer's application approvals shall be provided for all major and safety critical components of the chassis.

5.7.5 Wind Stability Requirements. The AIAV shall be stable when exposed to wind blasts up to 75 km/h (40 knots) without cautions and/or restrictions (without outriggers and/or stabilizers) and up to 120 km/h (65 knots) with adequate precautions and/or restrictions (with outriggers and/or stabilizers).
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5.7.6 Lighting and Electrical Equipment.

5.7.6.1 Installation.

5.7.6.1.1 Lighting equipment shall be installed in conformity with local road regulations, where practicable.

5.7.6.1.2 Lighting equipment installation shall also include the following:

- (1) Headlights with upper and lower driving beams are provided, along with a control switch for beam selection that is accessible to the driver.
- (2) Dual taillights and dual stop lights are provided.
- (3) A minimum of one additional stop light is located high up on the rear of the vehicle.

- (4) Self-canceling turn signals, front and rear, with a steering-column-mounted control and a visual and audible indicator is provided, along with a four-way flasher switch.
- (5) Reflectors and marker and clearance lights are furnished to describe the overall length and width of the vehicle.
- (6) Engine compartment lights, nonglare type, are provided and arranged to illuminate both sides of the engine, with individual switches located in the engine compartment.
- (7) Service lighting are provided for all areas described in 4.14.2(1), 4.14.2(2), and 4.14.2(3), as well as for the engine compartment.
- (8) Lighting for all top-deck working areas are provided.
- (9) At least one backup light and an audible alarm with a minimum of 97 dBA that meet SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*, is installed in the rear of the body.

5.7.6.2 A warning siren shall be provided that has a sound output of not less than 95 dBA at 30.5 m (100 ft) when measured directly ahead of the siren and not less than 90 dBA at 30.5 m (100 ft) when measured at 45 degrees on either side.

5.7.6.2.1 The siren shall be mounted to allow maximum forward sound projection and protected from foam dripping from the turret or water splashed up by the tires.

5.7.6.2.2 The siren unit shall consist of the following functions as a minimum: public address, wail, and yelp.

5.7.6.2.3 A selector switch shall be mounted within reach of the driver that will allow the operation of the vehicle's horn and the siren from the horn button in the steering wheel.

5.7.6.3 A horn shall be mounted at the front part of the vehicle, with the control positioned so that it is readily accessible to the driver.

5.7.7 Exterior Emergency Warning Lights.

5.7.7.1 A master switch for all exterior emergency warning lights shall be provided in the cab within easy reach of the driver.

5.7.7.2 Emergency warning light(s) shall be mounted on the top of the vehicle and visible for 360 degrees in a horizontal plane.

5.7.7.2.1 The emergency warning light(s) shall be mounted so as to also be visible from the air.

5.7.7.2.2 The purchaser shall provide the vehicle manufacturer with the color of the light(s) and indicate whether the emergency warning lights be LED flasher type, rotating beacon type, or strobe type.

5.7.7.3 Two alternating flashing emergency warning lights shall be mounted at the rear of the vehicle as far apart as practicable.

5.7.7.3.1 These lights shall not be mounted any higher than 1828.8 mm (72 in.) above ground level.

5.7.7.3.2 The purchaser shall provide the vehicle manufacturer with the color of the light and indicate whether the emergency warning lights are to be the LED flasher type, sealed beam type, or strobe type.

5.7.7.4 Two alternating flashing emergency warning lights shall be mounted at the front of the vehicle as far apart as practicable.

5.7.7.4.1 These lights shall not be mounted any higher than 1828.8 mm (72 in.) above ground level.

5.7.7.4.2 The purchaser shall provide the vehicle manufacturer with the color of the light and indicate whether the emergency warning lights are to be LED flasher type, sealed beam type, or strobe type.

5.7.7.5 The complete emergency warning light system shall require no more than a combined total of 12 volt 40 amps or equivalent for other voltages.

5.7.8 Radios.

5.7.8.1 Provisions shall be made for mounting radios.

5.7.8.1.1 Operation of the radios shall be from the cab.

5.7.8.1.2 Radios shall be mounted to allow quick servicing or replacement.

5.7.8.2 The purchaser shall specify all necessary radios and frequencies that are to be provided.

5.7.9 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.

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

5.7.11 Operator's Manual.

5.7.11.1 Operating instructions shall include all information required for operation of the vehicle, vehicle components, fire-fighting systems, and integral vehicular options.

5.7.11.2 The location and function of all controls and instruments shall be covered by illustrations and descriptions.

5.7.11.3 These instructions, as a minimum, also shall include the following:

- (1) Complete description of the vehicle and special equipment
- (2) Preparation for use of the vehicle upon receipt
- (3) Daily maintenance and mission readiness checks to be performed by the operator
- (4) Periodic operator inspection

5.7.12 Towing Connections. At least two large tow eyes or tow hooks (one at the front and one at the rear), capable of towing the vehicle on level ground without damage, shall be mounted on the truck and attached directly to the frame structure or where recommended by the vehicle manufacturer.

5.7.13 Reflective Striping. A graphic design meeting the reflectivity requirements of this subsection shall be permitted to replace all or part of the required striping, provided the design or combination thereof covers a minimum of the same perimeter length required in 4.3.4.5.

5.8 AIAV Acceptance Criteria.

5.8.1* Driver Vision Measurement.

5.8.1.1 Test equipment shall consist of a plumb bob, a tape measure, and a protractor or an inclinometer.

5.8.1.2 The vehicle shall be tested in its fully loaded condition, with tires inflated to their recommended operating pressure.

5.8.1.3 The driver's range of visibility shall be determined as follows:

- (1) Adjust the driver's seat to its mid position with respect to height, weight, and fore and aft adjustments.
- (2) Place a structure on the seat cushion for locating an eye height of 806.5 mm (31¾ in.) and a position of 304.8 mm (12 in.) forward from the seat back. Place the seat back in a vertical position.
- (3) Establish the features that limit the upward and downward line of vision that are located directly in front of the driver's seat.
- (4) Measure and record the angle above the horizon at which upward vision is obstructed from the eye height point established in 5.8.1.3(2).
- (5) Establish the lowest possible line of vision below the horizon directly in front of the eye height point and project this line forward of the cab until it intersects with the ground. Project this line of vision by using a light beam, or, if the windshield is removed, use a string line. Measure and record the distance from this intersection with the ground and the front face of the bumper at the front of the truck.
- (6) Stretch a line from the eye height point laterally across the cab in order to establish and ochroid the 90 degree line of vision to the left and right of the straight ahead position. Note obstructions within these angles.

5.8.1.4 The recorded values for the distance at which the line of vision meets the ground in front of the truck and the angle of vision above the horizon shall equal or exceed the vehicle's specification.

5.8.1.5 Obstacles within the 90 degree horizontal line of vision to the right or left shall not create an obstruction of more than 7 degrees per obstruction.

5.8.2 Radio Suppression.

5.8.2.1 Test equipment shall be in accordance with SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or the equivalent standard being used.

5.8.2.2 The vehicle shall be configured with all standard electrical features mounted and operational.

5.8.2.2.1 During the tests, all vehicle engines shall be operated at idle.

5.8.2.2.2 All vehicle-mounted electrical devices functioning at the crash site shall be turned on with the following stipulations:

- (1) All vehicle lighting is on.
- (2) All heating, defrosting, and air-conditioning systems, or as many systems as possible, are on with their respective fans adjusted to the maximum speed setting.
- (3) Complementary power-generating devices (where applicable) are running.
- (4) Intermittent warning devices, such as hazard flashers, warning buzzers, and horns, are turned off.

5.8.2.3 The vehicle shall be tested in accordance with SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or the equivalent standard being used.

5.8.2.4 The results of the test shall be evaluated in accordance with SAE J551/1, *Performance Levels and Methods of Measurement*

of *Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or the equivalent standard being used.

5.8.3 Service/Emergency Brake Test.

5.8.3.1 Instrumentation shall consist of the following:

- (1) Calibrated fifth-wheel-type speed measuring device that is accurate to within ± 0.8 kph (± 0.5 mph) or ± 0.5 percent of the actual vehicle speed
- (2) Ground speed readout device controlled by the fifth wheel
- (3) Trigger device that detects brake pedal movement
- (4) Strip chart recording distance traveled, vehicle speed, and the point at which actuation of the brake system occurs

5.8.3.2 The vehicle shall be tested in its fully loaded condition with the brakes adjusted and the tires inflated to the vehicle manufacturer's specifications.

5.8.3.2.1 The brakes shall have been burnished to ensure repeatable results.

5.8.3.3 The service and emergency brake stopping distances shall be determined in the following manner:

- (1) While traveling down the center of the lane established by the width of the vehicle plus 1.2 m (4 ft), attain a speed slightly above the desired test speed and release the throttle.
- (2) With the strip chart recorder running, at the instant that the vehicle reaches the desired test speed, actuate the brake pedal as if in a panic stop and continue applying the brakes until the vehicle comes to a complete stop. While stopping, modulate the brake pedal as necessary to maintain vehicle control. Record the distance traveled from the time that the brake pedal is applied to the time that the vehicle comes to rest.
- (3) Observe whether or not the vehicle leaves the established lane during the brake stop.
- (4) Repeat 5.8.3.3(1) through 5.8.3.3(3) for a total of five stops from each test speed.
- (5) Repeat 5.8.3.3(1) through 5.8.3.3(4) to obtain results at speeds of 32.2 kph (20 mph) and 64.4 kph (40 mph).
- (6) Disable the front service brakes and repeat 5.8.3.3(1) through 5.8.3.3(4) at a test speed of 64.4 kph (40 mph).
- (7) Reconnect the front service brakes and disable the rear service brakes and repeat 5.8.3.3(1) through 5.8.3.3(4) at a test speed of 64.4 kph (40 mph).

5.8.3.3.1 Items 5.8.3.3(6) and 5.8.3.3(7) shall not be applicable to commercial chassis.

5.8.3.4 Each of the recorded stops shall be within the specified distance without any part of the vehicle leaving the established test lane.

5.8.4 Service/Park Brake Grade Holding Test.

5.8.4.1 Test equipment shall consist of the following:

- (1) Load cell accurate to within ± 227 kg (± 500 lb) (applicable only to the alternate drawbar method)
- (2) Variable load dynamometer sled (applicable only to the alternate drawbar method)

5.8.4.2 The vehicle shall be tested in its fully loaded condition with the brakes adjusted and the tires inflated to the vehicle manufacturer's specifications.

5.8.4.3 The brakes shall have been burnished to ensure repeatable results.

5.8.4.4 The capability of the vehicle's parking brake to hold the vehicle stationary on a 20 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test.

5.8.4.5 If an actual 20 percent grade is available, the tests shall be conducted as follows:

- (1) Drive the vehicle in a forward direction onto the 20 percent grade, stop, and set the parking brake.
- (2) Shift the transmission to neutral, release the service brakes, and verify that there is no wheel rotation.
- (3) Repeat 5.8.4.5(1) and 5.8.4.5(2) with the vehicle facing the opposite direction.

5.8.4.6 If an actual 20 percent grade is not available, the tests shall be conducted as follows:

- (1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
- (2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
- (3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the parking brake until a 20 percent equivalent drawbar is generated. A 20 percent equivalent drawbar load is determined as follows:
 - (a) A 20 percent grade — 11.31 degree angle
 - (b) The loaded vehicle weight $\times \sin 11.31$ degrees (0.196), which equals the necessary drawbar pull to simulate holding on a 20 percent grade
 - (c) The area of the load cell, determined at the time of the test
 - (d) The load cell reading, in kPa (psi), that simulates a 20 percent grade, calculated by the following:

[5.8.4.6]

$$\text{load cell reading} = \frac{\sin 11.31 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

5.8.4.7 The capability of the vehicle's service brake to hold the vehicle stationary on a 50 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test.

5.8.4.8 If an actual 50 percent grade is available, the tests shall be conducted as follows:

- (1) Drive the vehicle in a forward direction onto the 50 percent grade, apply the service brakes, and shift the transmission to neutral.
- (2) Verify there is no wheel rotation.
- (3) Repeat 5.8.4.8(1) and 5.8.4.8(2) with the vehicle facing the opposite direction.

5.8.4.9 If an actual 50 percent grade is not available, the tests shall be conducted as follows:

- (1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.

- (2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
- (3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the service brakes until a 50 percent equivalent drawbar is generated. A 50 percent equivalent drawbar load is determined as follows:
 - (a) A 50 percent grade — 26.57 degree angle
 - (b) The loaded vehicle weight $\times$ sin 26.57 degrees (0.447), which equals the necessary drawbar pull to simulate holding on a 50 percent grade
 - (c) The area of the load cell, determined at the time of the test
 - (d) The load cell reading, in kPa (psi), that simulates a 50 percent grade, calculated by the following:

[5.8.4.9]

$$\text{load cell reading} = \frac{\sin 26.57 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

- (4) Repeat 5.8.4.9(1) through 5.8.4.9(3) with a drawbar force applied in the rearward direction.

5.8.4.10 The capability of the vehicle's service brake to hold the vehicle stationary on a 20 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test.

5.8.4.11 If an actual 20 percent grade is available, the tests shall be conducted as follows:

- (1) Drive the vehicle in a forward direction onto the 20 percent grade, apply the service brakes, and shift the transmission to neutral.
- (2) Verify that there is no wheel rotation.
- (3) Repeat 5.8.4.11(1) and 5.8.4.11(2)

5.8.4.12 If an actual 20 percent grade is not available, the tests shall be conducted as follows:

- (1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
- (2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
- (3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the service brakes until a 20 percent equivalent drawbar is generated. A 20 percent equivalent drawbar load is determined as follows:
 - (a) A 20 percent grade — 11.31 degree angle
 - (b) The loaded vehicle weight $\times$ sin 11.31 degrees (0.196), which equals the necessary drawbar pull to simulate holding on a 20 percent grade
 - (c) The area of the load cell, determined at the time of the test
 - (d) The load cell reading, in kPa (psi), that simulates a 20 percent grade, calculated by the following:

[5.8.4.12]

$$\text{load cell reading} = \frac{\sin 11.31 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

- (4) Repeat 5.8.4.12(1) through 5.8.4.12(3) with a drawbar force applied in the rearward direction.

5.8.4.13 The brakes shall lock the wheels and hold the vehicle stationary on both the 20 percent and 50 percent grade or the brakes shall generate an equivalent drawbar pull, with the vehicle pointed either uphill or downhill.

5.8.5 Steering Control Test. Vehicle's steering system shall be fully operational, with the steering linkage stops adjusted within the manufacturer's specified production tolerance limits.

5.8.5.1 Test equipment shall consist of a steering wheel and a torque meter or a spring scale.

5.8.5.2 The vehicle shall be tested in a fully loaded condition with tires inflated to their operating pressure.

5.8.5.3 The vehicle shall be tested as follows:

- (1) Set the road wheels in the straight-ahead position; engage neutral, and release the brakes, ensuring that there is no vehicle movement.
- (2) With the engine at idle speed, measure and record the force applied to the steering rim that is necessary to turn the steering linkage from stop to stop.

5.8.5.4 The measured force shall not exceed the manufacturer's design specifications.

5.8.6 Vehicle Clearance Circle Test.

5.8.6.1 A tape measure, markers or a marking device, and a calculator shall be required.

5.8.6.2 The vehicle's steering system shall be fully operational, with the steering linkage stops adjusted within the manufacturer's specified production tolerance limits.

5.8.6.3 The vehicle shall be tested as follows:

- (1) Drive the vehicle to the end of steering travel, making a left or right turn as necessary, in at least one complete circle to fully "settle" the wheels into their steady-state condition.
- (2) Slowly drive the vehicle in the full cramp turn.
- (3) Stop the vehicle in three locations around the turning circle, applying the brake smoothly and gradually.
- (4) At each stop, mark the outermost projected point of the vehicle on the ground.
- (5) Measure and record the straight line distances between the marks for each of the stop locations (length 1, length 2, and length 3).
- (6) Calculate the vehicle clearance circle radius (R) as follows:

[5.8.6.3]

$$R = \frac{(\text{length } 1)(\text{length } 2)(\text{length } 3)}{4 [S (S - \text{length } 1) (S - \text{length } 2) (S - \text{length } 3)]^{1/2}}$$

where:

$$S = (\text{length } 1 + \text{length } 2 + \text{length } 3) / 2$$

- (7) Repeat 5.8.6.3(1) through 5.8.6.3(6) while turning the vehicle in the opposite direction.

5.8.6.4 The vehicle's clearance circle diameter (2R) shall be less than three times the maximum overall length of the vehicle.

5.8.7 To verify the safety of the docking platform requirement in 5.5.1.3, a 317 kg/m² (65 lb/ft²) weight shall be applied for a period of 4 hours, with no platform drift.

Chapter 6 ARFF Apparatus — Acceptance Criteria (NFPA 414)

6.1 General.

6.1.1 Quality Assurance. The manufacturer shall provide quality assurance certification documents for the manufacturing processes of each vehicle.

6.1.2 Compliance with the requirements of this standard shall be verified by the following methods:

- (1) Component manufacturer's certification
- (2) Prototype vehicle tests
- (3) Operational tests

6.1.3 Prototype vehicle tests shall be conducted by the manufacturer in accordance with the standardized procedures found in Section 6.3.

6.1.3.1 The manufacturer shall ensure that the performance requirements have been achieved with the design.

6.1.3.2 Calculated performance capability shall not be substituted for an actual prototype test.

6.1.4 Operational tests shall be performed either at the airport or at the manufacturer's facility as specified in Section 6.4.

6.1.5 The manufacturer of the vehicle shall demonstrate to the purchasing authority or its designee the care and maintenance and operational capability of the vehicle.

6.1.6 Operational tests shall be performed on every vehicle built.

6.1.7* Each manufacturer shall have in place a procedure for the frequency of calibration or cause for calibration of tools and testing devices.

6.2 Component Manufacturer's Certification.

6.2.1 Manufacturer certification shall comply with both of the following:

- (1) Incorporate documentation for any new technology
- (2) Certify that any of the components on the following list are fitted for use on all ARFF vehicles:
 - (a) Engine
 - (b) Transmission
 - (c) Axles
 - (d) Transfer case
 - (e) Wheels
 - (f) Tires
 - (g) Handline hose with couplings attached
 - (h) Premixed storage container
 - (i) Premixed system pressure-relief valve
 - (j) Propellant gas cylinder
 - (k) Propellant gas cylinder regulating device
 - (l) Complementary agent storage container
 - (m) Complementary agent pressure-relief device
 - (n) Water tank
 - (o) Foam tank
 - (p) Hydrostatic pressure test

6.2.2 The cooling system shall be certified by the engine manufacturer to satisfy all conditions at all ambient temperatures encountered at the airport for both the engine and the transmission.

6.2.3 The brake system shall be certified by the vehicle manufacturer to satisfy the service brake, emergency brake, and grade-holding performance requirements for the corresponding class of vehicle.

6.2.4 Where the vehicle is equipped with an air brake system, the vehicle manufacturer shall provide itemized, certified data relative to the air system as follows:

- (1) Total reservoir capacity
- (2) Total required volume (12 times the total combined brake chamber volume at full stroke)
- (3) Quick buildup system capacity
- (4) Quick buildup system pressure needed to release the spring brakes

6.3 Prototype Vehicle Tests. Where the vehicle is fitted with a boom-mounted turret, the test shall be conducted with the boom-mounted turret in the stowed position.

6.3.1 When a new model or vehicle type is designed, each variant of the vehicle shall be tested to all prototype and operational tests as specified in Sections 6.3 and 6.4.

6.3.2 If sub-system changes are made to a current vehicle model, the vehicle shall be tested to the applicable prototype and operational tests related to that area of the vehicle as specified in 6.3.2.1 through 6.3.2.5.

6.3.2.1 Changes in engine horsepower of 3 percent or greater shall require the following tests:

- (1) Pump and roll on 40 percent grade
- (2) Gradeability
- (3) Acceleration
- (4) Top speed
- (5) Agent discharge pumping
- (6) Dual pumping discharge
- (7) Pump and maneuver
- (8) Primary turret flow

6.3.2.2 Changes in drive train components, including transmission, transfer case, water pump drive, axles, or brake system components, shall require the following tests:

- (1) Pump and roll on 40 percent grade
- (2) Gradeability
- (3) Service/emergency brake
- (4) Service/parking brake holding
- (5) Side slope
- (6) Weight/weight distribution
- (7) Acceleration
- (8) Top speed
- (9) Brake operational
- (10) Agent discharge pumping
- (11) Pump and maneuver
- (12) Primary turret flow

6.3.2.3 Changes in chassis/suspension components, including cab, steering system, suspension supplier, suspension rating, or suspension type, shall require the following tests:

- (1) Cornering stability
- (2) Vehicle dimensions
- (3) Driver vision

- (4) Electrical charging system
- (5) Radio suppression
- (6) Body and chassis flexibility
- (7) Steering control
- (8) Vehicle clearance circle
- (9) Warning siren
- (10) Cab interior noise
- (11) Side slope
- (12) Weight/weight distribution
- (13) Brake operational
- (14) Air system/air compressor

6.3.2.4 Changes to the water pump shall require the following tests:

- (1) Pump and roll on 40 percent grade
- (2) Agent pump(s)/tank vent discharge
- (3) Primary turret flow rate
- (4) Handline nozzle flow rate
- (5) Ground sweep/bumper turret flow rate
- (6) Undertruck nozzle
- (7) Dry chemical turret flow rate and range
- (8) Agent discharge pumping
- (9) Dual pumping system
- (10) Foam concentration
- (11) Primary turret flow

6.3.2.5 Changes in primary firefighting systems, including water tank design, piping layout, pressure relief system, foam mixing system, discharge(s), control systems, or secondary agent systems shall require the following tests:

- (1) Rated water and foam tank capacity
- (2) Agent pump(s)/tank vent discharge
- (3) Water tank fill and overflow
- (4) Flushing system
- (5) Primary turret flow rate
- (6) Primary turret pattern
- (7) Primary turret control force measurement
- (8) Primary turret articulation
- (9) Handline nozzle flow rate
- (10) Handline nozzle pattern
- (11) Ground sweep/bumper turret flow rate
- (12) Ground sweep/bumper turret pattern
- (13) Undertruck nozzle
- (14) Foam concentration/foam quality
- (15) Propellant gas
- (16) Pressure regulation
- (17) AFFF premix piping and valves
- (18) Pressurized agent purging and venting
- (19) Complementary agent handline flow rate and range
- (20) Dry chemical turret flow rate and range
- (21) Side slope
- (22) Weight/weight distribution
- (23) Acceleration
- (24) Agent discharge pumping
- (25) Dual pumping system
- (26) Foam concentration
- (27) Primary turret flow
- (28) Piercing/penetrating nozzle

6.3.3 Adding a boom-mounted turret to a vehicle shall deem it as a new model and require all prototype tests.

6.3.4 Unless otherwise stated for testing, if the vehicle is fitted with a boom-mounted turret, the test shall be conducted with the boom-mounted turret in the stowed position.

6.3.5* The prototype vehicle tests shall be completed in the vehicle's largest capacity configuration.

6.3.6* Rated Water and Foam Tank Capacity Test.

6.3.6.1 Test equipment shall consist of the following:

- (1) Calibrated sight gauge
- (2) Liquid volume measuring device accurate to within ± 1.0 percent
- (3) Alternative: A stopwatch and a scale capable of measuring the total vehicle weight accurate to within ± 1.0 percent

6.3.6.2 The rated water and foam tank capacity shall be determined as follows:

- (1) Park the vehicle on level ground.
- (2) If necessary, attach a calibrated site gauge to both the water tank and the foam tank.
- (3) Fill the water piping up to a level even with the bottom of the tank. Do not record the water quantity used.
- (4) While filling both tanks with a liquid volume measuring device, correlate and record the amount of water added to each tank with the site gauge calibrations. When the tanks are filled to the top, record the total liquid capacity for each tank.
- (5) Alternative: After completion of (3), record the weight of the vehicle. Fill the water tank and foam tank and record the weight of the vehicle.
- (6) Add dye to the foam tank.
- (7) Set the agent system to discharge at the specified foam solution rate, and adjust the system discharge pressure to the recommended pressure.
- (8) Starting with tanks that are completely full, discharge at maximum rate through the primary turret(s) until the agent pump(s) shows a drop in discharge pressure, and then stop immediately. Verify that dye is apparent in the discharge stream throughout the test. Record the discharge time if using the weight measurement method.
- (9) Alternative: Record the weight of the vehicle after discharging. Calculate the pump-out capacity of the water tank using the weight of the water plus the foam discharged, the foam proportioning rate, and the discharge time, as previously verified.
- (10) Measure the amount of liquid remaining in both tanks and convert to liters (gallons) using the conversion established in 6.3.6.2(5). Subtract the amount remaining from the total capacity to determine the amount pumped out. Record the total amount of liquid pumped out of the tanks.
- (11) Refill the water tank only (not the foam tank). Discharge the water tank as in 6.3.6.2(8). Verify that dye is apparent throughout the test. Measure and record the additional amount of liquid discharged from the foam tank. Fill the water tank and discharge as many times as necessary to eliminate all usable liquid from the foam tank.
- (12) Total and record the amount of liquid discharged from the foam tank from the time of initial fill.
- (13) Refill both tanks and repeat 6.3.6.2(6) through 6.3.6.2(11) with the vehicle parked in the following attitudes:
 - (a) 20 percent side slope, left side up
 - (b) 20 percent side slope, right side up
 - (c) 30 percent slope, ascending
 - (d) 30 percent slope, descending

- (14) After pumping on a slope, with the vehicle in each of the four slope conditions, return the vehicle to level ground to measure the water volume discharged.
- (15) Divide the volume of liquid discharged from each tank on the four slope conditions by 0.85 and record.

6.3.6.3 The rated or usable water tank capacity shall be the lesser of the volumes calculated in 6.3.6.2(10) or 6.3.6.2(14).

6.3.6.4 The rated or usable foam tank capacity shall be the lesser of the volumes calculated in 6.3.6.2(12) and 6.3.6.2(14).

6.3.7* Cornering Stability.

6.3.7.1 A calibrated speedometer and a means of indicating steering wheel angle shall be required.

6.3.7.2 The vehicle shall be tested in its fully loaded condition.

6.3.7.3 A speed as outlined in Table 4.2.1.2(a) and Table 4.2.1.2(b) shall be obtained and maintained for one full revolution of the circle in accordance with SAE J2181, *Steady State Circular Test Procedures for Trucks and Buses*, as follows:

- (1) Slowly drive the vehicle around the 30.5 m (100 ft) radius circle while keeping the centerline of the front of the vehicle directly over the marked line.
- (2) Establish a reference position on the steering wheel position indicator at a slow speed.
- (3) Gradually increase the speed until the maximum speed is reached.
- (4) Record the maximum speed and the corresponding position of the steering wheel.
- (5) Repeat 6.3.7.3(1) through 6.3.7.3(4) while driving the vehicle in the opposite direction.

6.3.7.4 The speed achieved shall be in accordance with Table 4.2.1.2(a) and Table 4.2.1.2(b).

6.3.7.5 A double lane change test shall be conducted as follows:

- (1) The vehicle shall be driven through the cones at a 40 kph (25 mph) speed in two directions.
- (2) This test shall be accomplished for all prototype first article vehicles only.
- (3) The vehicle shall be fully loaded and equipped for this test.

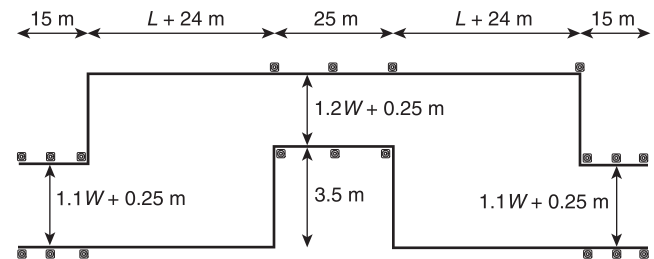
6.3.7.5.1 Test Conditions. Wind speed shall be ≤ 3 m/s (≤ 6.7 mph).

6.3.7.5.2 Test Surface. The test surface shall be a large uniform paved surface that is hard and level with a slope of ≤ 2 percent in all directions with a coefficient of friction of ≥ 0.7 and shall be dry, clean of debris, and large enough to ensure test area safety.

6.3.7.5.3 Test Track Dimensions. The double lane change test track dimensions shall be as shown in Figure 6.3.7.5.3, and traffic cones shall mark the corners as shown in Figure 6.3.7.5.3.

6.3.7.5.4 Test Procedure. The test procedure shall be as follows:

- (1) The operator shall drive through the first section, keeping the speed as steady as possible while driving the entire test track.
- (2) The operator shall repeat the test at various speed increments until one of the following occurs:



L – Overall vehicle length

W – Vehicle width

■ – Traffic cone

For U.S. units, 1 m = 3.23 ft.

FIGURE 6.3.7.5.3 Lane Change Test Course.

- (a) The maximum speed for the test as specified in Table 4.2.1.2(a) and Table 4.2.1.2(b) is completed.
- (b) The limit of the vehicle's stability is attained.
- (c) It becomes impossible to cross the test track without knocking the traffic cones down.
- (3) The parameters and the vehicle's behavior during the test shall be recorded.
- (4) The test shall be repeated in the opposite direction.
- (5) The entire test shall be repeated by a different driver.

6.3.7.5.5 Data Documentation. The following data from the test shall be documented:

- (1) Characteristics of the test surface and the test dimensions
- (2) Test number
- (3) Direction of test
- (4) Speed of test
- (5) Vehicle behavior
- (6) Number and position of the cones knocked down

6.3.7.6 The vehicle shall demonstrate the ability to traverse the "J" turn test in both directions on smooth, level pavement without the brakes being applied.

6.3.8* Vehicle Dimensions.

6.3.8.1 Test equipment shall consist of a tape measure and an electronic angle following device.

6.3.8.2 The vehicle shall be tested in its fully loaded condition with tires inflated to their recommended operating pressure.

6.3.8.3 The following vehicle dimensions shall be measured in accordance with their definitions, with the vehicle positioned on the flat pad:

- (1) Angle of approach
- (2) Angle of departure
- (3) Interaxle clearance angle
- (4) Underbody clearance
- (5) Underaxle clearance

6.3.8.4 Linear dimensions shall be rounded down to the nearest 12.7 mm ($\frac{1}{2}$ in.), and angular dimensions shall be rounded down to the nearest $\frac{1}{2}$ degree.

6.3.9* Driver Vision Measurement.

6.3.9.1 Test equipment shall consist of a plumb bob, a tape measure, and a protractor or an inclinometer.

6.3.9.2 The vehicle shall be tested in its fully loaded condition, with tires inflated to their recommended operating pressure.

6.3.9.3 The driver's range of visibility shall be determined as follows:

- (1) Adjust the driver's seat to its mid position with respect to height, weight, and fore and aft adjustments.
- (2) Place a structure on the seat cushion for locating an eye height of 806.5 mm (31¾ in.) and a position 304.8 mm (12 in.) forward from the seat back. Place the seat back in a vertical position.
- (3) Establish the features that limit the upward and downward line of vision that are located directly in front of the driver's seat.
- (4) Measure and record the angle above the horizon at which upward vision is obstructed from the eye height point established in 6.3.9.3(2).
- (5) Establish the lowest possible line of vision below the horizon directly in front of the eye height point and project this line forward of the cab until it intersects with the ground. Project this line of vision by using a light beam, or, if the windshield is removed, use a string line. Measure and record the distance from this intersection with the ground and the front face of the bumper at the front of the truck.
- (6) Stretch a line from the eye height point laterally across the cab in order to establish and record the 90 degree line of vision to the left and right of the straight ahead position. Note obstructions within these angles.

6.3.9.4 The recorded values for the distance at which the line of vision meets the ground in front of the truck and the angle of vision above the horizon shall equal or exceed the vehicle's specification.

6.3.9.5 Obstacles within the 90 degree horizontal line of vision to the right or left shall not create an obstruction of more than 7 degrees per obstruction.

6.3.10* Pump and Roll on a 40 Percent Grade.

6.3.10.1 Test equipment shall consist of the following:

- (1) Calibrated speedometer
- (2) Vehicle-equipped pump pressure gauge
- (3) Load cell accurate to within ±227 kg (±500 lb) (applicable only to the alternate drawbar method)
- (4) Variable load dynamometer sled (applicable only to the alternate drawbar method)

6.3.10.2 The vehicle shall have had its primary turret(s) discharge rate and pressure verified, with vehicle in its fully loaded condition with tires inflated to their recommended operating pressure, prior to beginning this test to ensure that the turret(s) discharges at or above the minimum rate specified.

6.3.10.3 The capability of the vehicle to ascend, stop, start, and continue ascent on a 40 percent grade without interruption in the discharge rate shall be demonstrated either on an actual grade or by means of an equivalent drawbar test as follows:

- (1) Fill both the water and foam tanks with water.
- (2) Set the agent system to discharge in the foam mode and set the system discharge pressure for optimum performance.
- (3) Position the vehicle at the bottom of a 40 percent grade and initiate discharge at full output through the primary turret nozzles in the direction of travel.

- (4) Initiate the vehicle's ascent of the grade and achieve a speed of at least 1.6 kph (1 mph). During the ascent, bring the vehicle to a stop and resume the ascent at a speed of at least 1.6 kph (1 mph) without interruption in the discharge stream. Record the vehicle speed and any variation in discharge pressure.
- (5) If an actual 40 percent grade is not available, repeat 6.3.10.3(1) through 6.3.10.3(4) with the vehicle coupled to a 40 percent grade equivalent drawbar load determined as follows:
 - (a) A 40 percent grade — 21.8 degree angle
 - (b) The loaded vehicle weight × sin 21.8 degrees (0.371), which equals the necessary drawbar pull to simulate ascending a 40 percent grade
 - (c) The area of the load cell, which can be determined at the time of the test
 - (d) The load cell reading, in kPa (psi), that simulates a 40 percent grade, which can be calculated by the following:

[6.3.10.3]

$$\text{load cell reading} = \frac{\sin 21.8 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

6.3.10.4 The vehicle shall negotiate the grade or drawbar pull smoothly while maintaining an operating pressure of at least 50 percent of the specified design pressure for the primary turret(s) at speeds of at least 1.6 kph (1 mph).

6.3.11* Electrical Charging System.

6.3.11.1 Test instrumentation shall consist of the following:

- (1) A laboratory-quality voltmeter with a scale range compatible with the design voltage of the vehicle's electrical system
- (2) The scale on the voltmeter graduated to allow reading voltages with a ±0.1 volt accuracy
- (3) A laboratory-quality ammeter with a scale range compatible with the anticipated electrical load present on the vehicle
- (4) The ammeter graduated to allow reading current flow within a ±3 percent accuracy
- (5) Confirmation that the tachometer is installed in the vehicle.

6.3.11.2 The test vehicle shall be tested with the following:

- (1) A fully charged set of batteries
- (2) Fully operational electric and charging systems
- (3) Testing temperature ranges of 10°C to 32.2°C (50°F to 90°F)

6.3.11.3 Electrical System Performance Tests.

6.3.11.3.1 The fire apparatus low voltage electrical system shall be tested as required by this section, and its subsections.

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

6.3.11.3.3 Test Sequence.

6.3.11.3.3.1* The three tests defined in 6.3.11.3.3.2 through 6.3.11.3.3.4(D) shall be performed in the order in which they appear.

(A) Before each test, the batteries shall be fully charged until the voltage stabilizes at the voltage regulator set point and the lowest charge current is maintained for 10 minutes.

(B) Failure of any of these tests shall require a repeat of the sequence.

6.3.11.3.3.2 Reserve Capacity Test.

(A) The engine shall be started and kept running until the engine and engine compartment temperatures are stabilized at normal operating temperatures and the battery system is fully charged.

(B) The engine shall be shut off, and the minimum continuous electrical load shall be activated for 10 minutes.

(C) All electrical loads shall be turned off prior to attempting to restart the engine.

(D) The battery system shall then be capable of restarting the engine.

(E) Failure to restart the engine shall be considered a test failure of the battery system.

6.3.11.3.3.3 Alternator Performance Test at Idle.

(A) The minimum continuous electrical load shall be activated with the engine running at idle speed.

(B) The engine temperature shall be stabilized at normal operating temperature.

(C) The battery system shall be tested to detect the presence of battery discharge current.

(D) The detection of battery discharge current shall be considered a test failure.

6.3.11.3.3.4 Alternator Performance Test at Full Load.

(A) The total continuous electrical load shall be activated with the engine running up to the engine manufacturer's governed speed.

(B) The test duration shall be a minimum of 2 hours.

(C) Activation of the load management system shall be permitted during this test.

(D) An alarm sounded by excessive battery discharge, as detected by the warning system required in 10.3.4, or a system voltage of less than 11.8 V dc for a 12 V nominal system, 23.6 V dc for a 24 V nominal system, or 35.4 V dc for a 42 V nominal system for more than 120 seconds shall be considered a test failure.

6.3.11.3.4 Low Voltage Alarm Test.

6.3.11.3.4.1 The following test shall be started with the engine off and the battery voltage at or above 12 V for a 12 V nominal system, 24 V for a 24 V nominal system, or 36 V for a 42 V nominal system.

6.3.11.3.4.2 With the engine shut off, the total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates.

6.3.11.3.4.3 The battery voltage shall be measured at the battery terminals.

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

6.3.11.3.4.5 The battery system shall then be able to restart the engine.

6.3.11.3.4.6 Failure to restart the engine shall be considered a test failure.

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

- (1) Documentation of the electrical system performance tests
- (2) A written electrical load analysis, including the following:
 - (a) The nameplate rating of the alternator
 - (b) The alternator rating under the conditions specified in 10.3.2
 - (c) Each of the component loads specified in 10.3.3 that make up the minimum continuous electrical load
 - (d) Additional electrical loads that, when added to the minimum continuous electrical load, determine the total continuous electrical load
 - (e) Each individual intermittent electrical load

6.3.11.4 The electrical system performance shall be compared as follows:

- (1) Against the specification at engine idle
- (2) Also at 50 percent of engine rpm

6.3.11.5 The measured voltage of the batteries shall remain above 13 volts (for a 12-volt system) and 26 volts (for a 24-volt system) at all times while the alternator is running.

6.3.12* Radio Suppression.

6.3.12.1 Test equipment shall be in accordance with SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or the equivalent standard being used.

6.3.12.2 The vehicle shall be configured with all standard electrical features mounted and operational.

6.3.12.2.1 During the tests, all vehicle engines shall be operated at idle.

6.3.12.2.2 All vehicle-mounted electrical devices functioning at the crash site shall be turned on with the following stipulations:

- (1) All vehicle lighting shall be on.
- (2) All heating, defrosting, and air-conditioning systems, or as many systems as possible, shall be on with their respective fans adjusted to the maximum speed setting.
- (3) Complementary power-generating devices (where applicable) shall be running.
- (4) Intermittent warning devices, such as hazard flashers, warning buzzers, and horns, shall be turned off.

6.3.12.3 The vehicle shall be tested in accordance with SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or the equivalent standard being used.

6.3.12.4 The results of the test shall be evaluated in accordance with SAE J551/1, *Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)*, or the equivalent standard being used.

6.3.13* Gradeability Test.

6.3.13.1 Test equipment shall consist of the following:

- (1) Load cell accurate to within ± 227 kg (± 500 lb) (applicable only to the alternate drawbar method)
- (2) Variable load dynamometer sled (applicable only to the alternate drawbar method)

6.3.13.2 The vehicle shall be tested in its fully loaded condition with tires inflated to their recommended operating pressure.

6.3.13.3 The capability of the fully loaded vehicle to ascend a 50 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 50 percent grade is not available, then the vehicle shall be coupled to a 50 percent equivalent drawbar load, determined as follows:

- (1) A 50 percent grade — 26.57 degree angle
- (2) The loaded vehicle weight $\times \sin 26.57$ degrees (0.447), which equals the necessary drawbar pull to simulate ascending a 50 percent grade
- (3) The area of the load cell, determined at the time of the test
- (4) The load cell reading, in kPa (psi), that simulates a 50 percent grade, which can be calculated by the following:

[6.3.13.3]

$$\text{load cell reading} = \frac{\sin 26.57 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

6.3.13.4 The vehicle shall negotiate the grade or draw pull smoothly.

6.3.14* Body and Chassis Flexibility Test.

6.3.14.1 Test equipment shall consist of two to four 355.6 mm (14 in.) ramps with flat tops large enough for the tire footprint and graduated on both sides to allow the vehicle to ascend and descend.

6.3.14.2 The vehicle shall be tested in its fully loaded condition with tires inflated to their recommended operating pressure.

6.3.14.3 The vehicle shall be tested as follows:

- (1) Drive the fully loaded vehicle onto 355.6 mm (14 in.) blocks as follows:
 - (a) For a 4 $\times$ 4, positioned under the diagonally opposite front and rear wheels.
 - (b) For a 6 $\times$ 6, positioned under the diagonally opposite wheel positions that correspond to axle 1 and axle 3.
 - (c) For an 8 $\times$ 8, positioned under the diagonally opposite wheel positions that correspond to axle 1 and axle 4.
- (2) With the vehicle in the position given in 6.3.14.3(1), take the following steps:

- (a) Inspect the vehicle to ensure that there are no sheet metal interferences and that all moving parts are free to function.
- (b) Demonstrate all systems to ensure that they function, including discharge from all orifices.
- (3) Switch the blocks to the opposite sides of the truck and repeat 6.3.14.3(1) and 6.3.14.3(2).

6.3.14.4 No moving part shall interfere with another.

6.3.14.4.1 If component contact should occur, it shall in no way damage the component or detract from the vehicle's ability to carry out its mission.

6.3.14.4.2 No clearance shall be permitted between any tire and its supporting surface.

6.3.15* Service/Emergency Brake Test.

6.3.15.1 Instrumentation shall consist of the following:

- (1) Calibrated fifth-wheel-type speed measuring device that is accurate to within ± 0.8 kph (± 0.5 mph) or ± 0.5 percent of the actual vehicle speed
- (2) Ground speed readout device controlled by the fifth wheel
- (3) Trigger device that detects brake pedal movement
- (4) Strip chart recording distance traveled, vehicle speed, and the point at which actuation of the brake system occurs

6.3.15.2 The vehicle shall be tested in its fully loaded condition with the brakes adjusted and the tires inflated to the vehicle manufacturer's specifications.

6.3.15.2.1 The brakes shall have been burnished to ensure repeatable results.

6.3.15.3 The service and emergency brake stopping distances shall be determined in the following manner:

- (1) While traveling down the center of the lane established by the width of the vehicle plus 1.2 m (4 ft), attain a speed slightly above the desired test speed and release the throttle.
- (2) With the strip chart recorder running, at the instant that the vehicle reaches the desired test speed, actuate the brake pedal as if in a panic stop and continue applying the brakes until the vehicle comes to a complete stop. While stopping, modulate the brake pedal as necessary to maintain vehicle control. Record the distance traveled from the time that the brake pedal is applied to the time that the vehicle comes to rest.
- (3) Observe whether or not the vehicle leaves the established lane during the brake stop.
- (4) Repeat 6.3.15.3(1) through 6.3.15.3(3) for a total of five stops from each test speed.
- (5) Repeat 6.3.15.3(1) through 6.3.15.3(4) to obtain results at speeds of 32.2 kph (20 mph) and 64.4 kph (40 mph).
- (6) Disable the front service brakes and repeat 6.3.15.3(1) through 6.3.15.3(4) at a test speed of 64.4 kph (40 mph).
- (7) Reconnect the front service brakes and disable the rear service brakes and repeat 6.3.15.3(1) through 6.3.15.3(4) at a test speed of 64.4 kph (40 mph).

6.3.15.3.1 Items 6.3.15.3(6) and 6.3.15.3(7) shall not be applicable to commercial chassis.

6.3.15.4 Each of the recorded stops shall be within the specified distance without any part of the vehicle leaving the established test lane.

6.3.16* Service/Parking Brake Grade Holding Test.

6.3.16.1 Test equipment shall consist of the following:

- (1) Load cell accurate to within ± 227 kg (± 500 lb) (applicable only to the alternate drawbar method)
- (2) Variable load dynamometer sled (applicable only to the alternate drawbar method)

6.3.16.2 The vehicle shall be tested in its fully loaded condition with the brakes adjusted and the tires inflated to the vehicle manufacturer's specifications.

6.3.16.2.1 The brakes shall have been burnished to ensure repeatable results.

6.3.16.3 The capability of the vehicle's parking brake to hold the vehicle stationary on a 20 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 20 percent grade is available, the tests shall be conducted as follows:

- (1) Drive the vehicle in a forward direction onto the 20 percent grade, stop, and set the parking brake.
- (2) Shift the transmission to neutral, and release the service brakes and verify that there is no wheel rotation.
- (3) Repeat (1) and (2) with the vehicle facing the opposite direction.

6.3.16.3.1 If an actual 20 percent grade is not available, the tests shall be conducted as follows:

- (1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
- (2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
- (3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the parking brake until a 20 percent equivalent drawbar is generated. A 20 percent equivalent drawbar load is determined as follows:
 - (a) A 20 percent grade — 11.31 degree angle
 - (b) The loaded vehicle weight $\times \sin 11.31$ degrees (0.196), which equals the necessary drawbar pull to simulate holding on a 20 percent grade
 - (c) The area of the load cell, determined at the time of the test
 - (d) The load cell reading, in kPa (psi), that simulates a 20 percent grade, calculated by the following:

$$[6.3.16.3.1]$$

$$\text{load cell reading} = \frac{\sin 11.31 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

6.3.16.4 The capability of the vehicle's service brake to hold the vehicle stationary on a 50 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 50 percent grade is available, the tests shall be conducted as follows:

- (1) Drive the vehicle in a forward direction onto the 50 percent grade, apply the service brakes, and shift the transmission to neutral.

- (2) Verify there is no wheel rotation.
- (3) Repeat 6.3.16.4(1) and 6.3.16.4(2) with the vehicle facing the opposite direction.

6.3.16.4.1 If an actual 50 percent grade is not available, the tests shall be conducted as follows:

- (1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
- (2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
- (3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the service brakes until a 50 percent equivalent drawbar is generated. A 50 percent equivalent drawbar load is determined as follows:
 - (a) A 50 percent grade — 26.57 degree angle
 - (b) The loaded vehicle weight $\times \sin 26.57$ degrees (0.447), which equals the necessary drawbar pull to simulate holding on a 50 percent grade
 - (c) The area of the load cell, determined at the time of the test
 - (d) The load cell reading, in kPa (psi), that simulates a 50 percent grade, calculated by the following:

$$[6.3.16.4.1]$$

$$\text{load cell reading} = \frac{\sin 26.57 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

- (4) Repeat 6.3.16.4.1(1) through 6.3.16.4.1(3) with a drawbar force applied in the rearward direction.

6.3.16.5 The capability of the vehicle's service brake to hold the vehicle stationary on a 20 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 20 percent grade is available, the tests shall be conducted as follows:

- (1) Drive the vehicle in a forward direction onto the 20 percent grade, apply the service brakes, and shift the transmission to neutral.
- (2) Verify that there is no wheel rotation.
- (3) Repeat 6.3.16.5(1) and 6.3.16.5(2) with the vehicle facing the opposite direction.

6.3.16.5.1 If an actual 20 percent grade is not available, the tests shall be conducted as follows:

- (1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
- (2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
- (3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the service brakes until a 20 percent equivalent drawbar is generated. A 20 percent equivalent drawbar load is determined as follows:
 - (a) A 20 percent grade — 11.31 degree angle
 - (b) The loaded vehicle weight $\times \sin 11.31$ degrees (0.196), which equals the necessary drawbar pull to simulate holding on a 20 percent grade
 - (c) The area of the load cell, determined at the time of the test

- (d) The load cell reading, in kPa (psi), that simulates a 20 percent grade, calculated by the following:

[6.3.16.5.1]

$$\text{load cell reading} = \frac{\sin 11.31 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

- (4) Repeat 6.3.16.5.1(1) through 6.3.16.5.1(3) with a drawbar force applied in the rearward direction.

6.3.16.6 The brakes shall lock the wheels and hold the vehicle stationary on both the 20 percent and 50 percent grade (or the brakes shall generate an equivalent drawbar pull), with the vehicle pointed either uphill or downhill.

6.3.17* Steering Control Test.

6.3.17.1 Test equipment shall consist of a steering wheel and a torque meter or a spring scale.

6.3.17.2 The vehicle shall be tested in a fully loaded condition with tires inflated to their operating pressure.

6.3.17.3 The vehicle shall be tested as follows:

- (1) Set the road wheels in the straight-ahead position; engage neutral, and release the brakes, ensuring that there is no vehicle movement.
- (2) With the engine at idle speed, measure and record the force applied to the steering rim that is necessary to turn the steering linkage from stop to stop.

6.3.17.4 The measured force shall not exceed the manufacturer's design specifications.

6.3.18* Vehicle Clearance Circle Test.

6.3.18.1 A tape measure, markers or a marking device, and a calculator shall be required.

6.3.18.2 The vehicle's steering system shall be fully operational, with the steering linkage stops adjusted within the manufacturer's specified production tolerance limits.

6.3.18.3 The vehicle shall be tested as follows:

- (1) Drive the vehicle to the end of steering travel, making a left or right turn as necessary, in at least one complete circle to fully "settle" the wheels into their steady-state condition.
- (2) Slowly drive the vehicle in the full cramp turn.
- (3) Stop the vehicle in three locations around the turning circle, applying the brake smoothly and gradually.
- (4) At each stop, mark the outermost projected point of the vehicle on the ground.
- (5) Measure and record the straight line distances between the marks for each of the stop locations (length 1, length 2, and length 3).
- (6) Calculate the vehicle clearance circle radius (R) as follows:

[6.3.18.3]

$$R = \frac{(\text{length } 1)(\text{length } 2)(\text{length } 3)}{4 [S (S - \text{length } 1) (S - \text{length } 2) (S - \text{length } 3)]^{1/2}}$$

where:

$$S = (\text{length } 1 + \text{length } 2 + \text{length } 3)/2$$

- (7) Repeat 6.3.18.3(1) through 6.3.18.3(6) while turning the vehicle in the opposite direction.

6.3.18.4 The vehicle's clearance circle diameter ($2R$) shall be less than three times the maximum overall length of the vehicle.

6.3.18.5 The vehicle shall be tested in a fully loaded condition with tires inflated to their operating pressure.

6.3.19* Agent Pump(s)/Tank Vent Discharge Test.

6.3.19.1 Test equipment shall consist of a liquid level measuring device accurate to within ± 1.0 percent.

6.3.19.2 Each discharge nozzle on the vehicle shall have been individually verified as discharging at a flow rate at or above the minimum rate specified when the agent system is operated at the recommended pressure.

6.3.19.3 The test shall be conducted as follows:

- (1) Fill the water tank and the foam tank to the top.
- (2) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.
- (3) Set the agent system pressure relief to the recommended pressure.
- (4) Engage the agent pumps, and operate them at maximum pumping speed with all discharge outlets closed.
- (5) Simultaneously initiate discharge of the primary turret(s), primary handlines, ground sweeps/bumper turret, and undertruck nozzles. After approximately 75 percent of the contents from the water tank has been discharged, simultaneously stop discharge through all nozzle outlets. Record the time of discharge.
- (6) Measure and then add together the total amount of liquid discharged from the water tank and the foam tank. Calculate the average discharge rate using the discharge time from 6.3.19.3(5).
- (7) Calculate the quantity of liquid used from the foam tank as a percentage of the total liquid discharged.

6.3.19.4 The measured total discharge rate shall be equal to at least the sum of the minimum specified discharge rates of the nozzles used during the test.

6.3.19.5 The calculated average foam concentration shall be within the tolerance permitted in Section 28.2 of NFPA 460.

6.3.20* Water Tank Fill and Overflow Test.

6.3.20.1 Instrumentation shall consist of calibrated mechanical or electronic pressure measuring devices with an accuracy of ± 3 percent and a stopwatch.

6.3.20.2 The water tank shall be empty, and the water tank fill and vent system shall be fully operational for this test.

6.3.20.3 The water tank fill and vent system shall be tested as follows to verify that the tank can be filled in 2 minutes or less:

- (1) Park the vehicle on level ground.
- (2) Attach one pressure measuring device at the inlet to the tank fill piping, and attach the other pressure measuring device to the tank body or an extension of the tank body.
- (3) Simultaneously initiate flow to the tank and start the stopwatch. The water supply pressure shall be maintained at 551.6 kPa (80 psi) throughout the test.
- (4) At the moment water begins to flow from the overflow piping, stop the watch and record the elapsed time.

- (5) While maintaining a 551.6 kPa (80 psi) supply pressure and an overflow condition, record the internal tank pressure. After recording this pressure, shut off the water supply.

6.3.20.4 The results of this test shall be evaluated as follows:

- (1) The time to fill the tank to the overflow condition shall be 2 minutes or less.
- (2) The internal tank pressure shall not exceed the tank design pressure.

6.3.21* Flushing System Test.

6.3.21.1 No special instrumentation shall be required for this test.

6.3.21.2 The vehicle's agent system and flushing system shall be fully operational for this test.

6.3.21.3 The vehicle's flushing system shall be tested as follows:

- (1) Fill the water tank and foam tank with clean water, and add dye to the foam tank.
- (2) Discharge agent through each discharge orifice on the vehicle while operating in the foam mode until dye is present in the discharge stream.
- (3) Mark the liquid level in the foam tank.
- (4) Set the agent system in the flush mode, and discharge through each discharge orifice until clear water is present in the discharge stream.
- (5) Shut the agent system down, and drain the piping.
- (6) Recheck the foam tank level.

6.3.21.4 Failure to develop a clear water stream through each nozzle shall be considered evidence that the flushing system is not working.

6.3.21.5 There shall be no evidence of feedback of clear water into the foam tank.

6.3.22* Primary Turret Flow Rate Test.

6.3.22.1 Test equipment shall consist of the following:

- (1) Calibrated sight gauge
- (2) Liquid volume measuring device accurate to within ± 1.0 percent
- (3) Calibrated pressure gauge, if not already provided on the truck
- (4) Alternative: A stopwatch and a scale capable of measuring total vehicle weight accurate to within ± 1.0 percent of the scale capacity

6.3.22.2 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

6.3.22.3 The primary turret discharge rate shall be determined as follows:

- (1) Set the primary turret pattern for straight stream operation
- (2) Fill the water tank completely
- (3) Engage the pump, and operate it at design speed
- (4) Open the turret flow control valve
- (5) If necessary, at this stage perform the following procedures:
 - (a) If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.

- (b) If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes.

- (c) Read and record the tank volume in liters (gallons) when the watch is stopped after allowing flow for at least 1 minute.

- (d) Determine the flow rate in L/min (gal/min) by dividing the difference in gallons by the time of discharge.

- (e) If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch, and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge and calculate the flow rate.

- (6) Reset the primary turret pattern to the dispersed setting and repeat 6.3.22.3(2) through 6.3.22.3(5).

- (7) Reset the primary turret to the half flow rate setting (if applicable) and repeat 6.3.22.3(1) through 6.3.22.3(6).

6.3.22.4 The measured turret flow rates shall equal to the specified flow in Table 4.2.1.2(c) or Table 4.2.1.2(d) rate within a tolerance of ± 10 percent/ -0 percent.

6.3.23 Primary Turret Pattern Test. The primary turret pattern test shall be conducted in accordance with the requirements of Chapter 29 of NFPA 460.

6.3.23.1 The primary turret pattern ranges shall equal the specified distances in Table 4.2.1.2(c) or Table 4.2.1.2(d).

6.3.24* Primary Turret Control Force Measurement.

6.3.24.1 Test equipment shall consist of a spring scale that can be attached to the end of the turret control handle or a torque measuring device that can be attached to the rotational axis of the turret.

6.3.24.2 The water tank shall be filled prior to starting the test.

6.3.24.2.1 The water tank shall have been verified that the vehicle pump system is capable of operating at design flow and pressure.

6.3.24.2.2 The test shall be conducted with the primary turret at the full flow rate setting.

6.3.24.2.3 The turret power-assist system, if applicable, shall be fully operational.

6.3.24.3 The test shall be conducted as follows:

- (1) Set the turret pattern control for straight stream, and, where applicable, engage the power assist.
- (2) Engage the pump, and operate it at design speed.
- (3) Open the turret flow control valve.
- (4) Using a spring scale attached to the end of the turret aiming handle, rotate the turret to the right and to the left, recording the needed force for each direction. Again, using the spring scale attached to the end of the turret aiming handle, elevate and depress the turret, and record the force needed to elevate and depress.
- (5) Repeat 6.3.24.3(2) through 6.3.24.3(4) with the pattern control set at the maximum dispersed position after refilling the water tank as necessary.

6.3.24.4 The forces recorded shall not exceed the forces specified in 4.20.4.

6.3.25* Primary Turret Articulation Test.

6.3.25.1 The test equipment shall consist of a tape measure, a level, and an electric angle following device.

6.3.25.2 The water tank shall be filled prior to the test.

6.3.25.2.1 The turret power-assist system, if applicable, should be fully operational.

6.3.25.3 The test shall be conducted as follows:

- (1) With the turret pointed ahead, raise the turret barrel to the maximum elevated position. With a level held horizontal at the vertical rotation axis, measure the angle between the level and the turret barrel with the protractor and record.
- (2) Rotate the primary turret barrel to the right and left to the angle needed.
- (3) Place a marker 9.1 m (30 ft) in front of the vehicle. Aim the turret straight ahead with the rate control at full flow, with the pattern control in the maximum dispersed position and with the turret in the maximum depressed position. When water discharges, observe whether water strikes the marker or strikes closer to the vehicle.

6.3.25.4 Turret articulation shall be considered as passing if the measurements meet or exceed the specifications.

6.3.26* Handline Nozzle Flow Rate Test.

6.3.26.1 Test equipment shall consist of the following:

- (1) Calibrated sight gauge
- (2) Liquid volume measuring device accurate to within ± 1.0 percent
- (3) Calibrated pressure gauge, if not already provided on the truck
- (4) Alternative: A stopwatch and a scale capable of measuring total vehicle weight accurate to within ± 1.0 percent

6.3.26.2 The vehicle's pumping system shall be verified to be capable of operating at full rate.

6.3.26.3 The handline nozzle flow rate shall be determined as follows:

- (1) Set the handline nozzle pattern for straight stream operation
- (2) Fill the water tank completely
- (3) Engage the pump and operate it at design speed
- (4) Open the handline nozzle flow control valve
- (5) If necessary, at this stage perform the following procedures:
 - (a) If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.
 - (b) If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes.
 - (c) Read and record the tank volume in liters (gallons) when the watch is stopped after allowing flow for at least 5 minutes.
 - (d) Determine the flow rate in L/min by dividing the difference in gallons by the time of discharge.
 - (e) If an open-top calibrated tank is used, discharge through the nozzle until the pressure stabilizes, and then simultaneously direct the stream into the tank while starting the stopwatch.
 - (f) Stop the stopwatch when the tank is full and remove or shut off the nozzle.

- (g) Determine the flow rate by dividing the tank volume in liters (gallons) by the fill time in minutes.
 - (h) If a scale is used, record the vehicle weight prior to discharge.
 - (i) Start a stopwatch and discharge water at stabilized pressure for 1 minute.
 - (j) Record the vehicle weight after discharge and calculate flow rate.
- (6) If the nozzle is the non-air-aspirated type, repeat 6.3.26.3(2) through 6.3.26.3(5) with the nozzle pattern setting in the fully dispersed position.

6.3.26.4 The measured handline nozzle flow rates shall equal the specified flow rate in Table 4.2.1.2(c) or Table 4.2.1.2(d) within a tolerance of $+10$ percent/ -0 percent.

6.3.27 Handline Nozzle Pattern Test. The handline nozzle pattern test shall be conducted in accordance with the requirements of Chapters 1 through 3, and 27 through 29 of NFPA 460.

6.3.27.1 The handline nozzle pattern ranges shall equal the specified distances in Table 4.2.1.2(c) or Table 4.2.1.2(d).

6.3.28* Ground Sweep/Bumper Turret Flow Rate Test.

6.3.28.1 Test equipment shall consist of the following:

- (1) Calibrated sight gauge
- (2) Liquid volume measuring device accurate to within ± 1.0 percent
- (3) Calibrated pressure gauge, if not already provided on the truck
- (4) Alternative: A stopwatch and a scale capable of measuring total vehicle weight accurate to within ± 1.0 percent

6.3.28.2 The vehicle's pumping system shall be verified to be capable of operating at full rate.

6.3.28.3 The ground sweep/bumper turret discharge rate shall be determined as follows:

- (1) Set the ground sweep/bumper turret pattern for straight stream operation.
- (2) Fill the water tank completely.
- (3) Engage the pump and operate it at design speed.
- (4) Open the ground sweep/bumper turret flow control valve.
- (5) If necessary, at this stage perform the following procedures:
 - (a) If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.
 - (b) If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. Read and record the tank volume in liters (gallons) when the watch is stopped after allowing flow for at least 1 minute. Determine the flow rate in L/min by dividing the difference in gallons by the time of discharge.
 - (c) If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch, and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge, and calculate the flow rate.
- (6) If the ground sweep/bumper turret is the non-air-aspirated type, repeat 6.3.28.3(2) through 6.3.28.3(5)

with the nozzle pattern setting in the fully dispersed position.

6.3.28.4 The measured flow rates shall equal the specified flow rate within a tolerance of +10 percent/−0 percent.

6.3.29 Ground Sweep/Bumper Turret Pattern Test. The ground sweep/bumper turret pattern test shall be conducted in accordance with the requirements of Chapters 1 through 3, and 27 through 29 of NFPA 460.

6.3.30* Undertruck Nozzle Test.

6.3.30.1 Markers shall be available for use in defining the pattern boundaries.

6.3.30.2 The vehicle's pump system shall be verified to be capable of operating at full rate.

6.3.30.2.1 The agent tanks shall be filled with water and foam, respectively.

6.3.30.3 The test shall be conducted as follows:

- (1) Set the agent system to operate in the foam mode.
- (2) Engage the agent pump and operate it at design speed.
- (3) Open the undertruck nozzles to discharge simultaneously, and continue to discharge until a definite pattern outline is apparent.
- (4) Close the discharge and mark and record the boundaries of the pattern.

6.3.30.4 The pattern shall be considered acceptable if the foam spray covers the outline created by the vehicle on the ground and wets the inside of all tires.

6.3.30.5 The flow rate of the undertruck nozzles shall meet the flow rate specified in Table 4.2.1.2(c) or Table 4.2.1.2(d).

6.3.31* Foam Concentration/Foam Quality Test.

6.3.31.1 The test equipment described in Chapters 1 through 3, and 27 through 29 of NFPA 460 shall be used for this test.

6.3.31.2 Each discharge nozzle on the vehicle shall have been individually verified as discharging at a flow rate within the tolerance specified.

6.3.31.2.1 The agent system shall have been verified as capable of operating at full rate.

6.3.31.3 The test shall be conducted as follows:

- (1) Fill the water tank and the foam tank to the top, and refill as necessary throughout the test.
- (2) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.
- (3) Set the agent system pressure relief to the recommended pressure.
- (4) Engage the agent pumps, and operate them at maximum pumping speed with all discharge outlets closed.
- (5) Test each foam delivery system first for the individual nozzle/flow rate specified in the following list and then for a total combined simultaneous discharge in accordance with Chapters 1 through 3, and 27 through 29 of NFPA 460:
 - (a) Primary turret(s) full rate
 - (b) Primary turret(s) half rate
 - (c) Ground sweep/bumper turret
 - (d) Handline nozzles

(e) Undertruck nozzles

6.3.31.4 The foam concentrations measured shall fall within the permitted tolerances specified in Chapters 1 through 3, and 27 through 29 of NFPA 460 for each nozzle and for the combined simultaneous discharge.

6.3.31.4.1 The foam expansion and drainage time measurements shall equal or exceed those specified in Chapters 1 through 3, and 27 through 29 of NFPA 460 for each nozzle.

6.3.32* Warning Siren Test.

6.3.32.1 Test equipment shall consist of the following:

- (1) Sound level meter that meets the requirements of ANSI S1.4, *Specification for Sound Level Meters*, for Type 1 or S1A meters and has been calibrated by a certified testing laboratory within the previous 12 months
- (2) Tape measure

6.3.32.2 The capability of the warning siren on the vehicle to project sound forward and to the sides shall be determined as follows:

- (1) Set the sound level meter to the A-weighting network, "fast" meter response, and position the meter directly ahead of the vehicle at a distance of 30.5 m (100 ft) from the front bumper, with the microphone at ear level of a 95th percentile male.
- (2) Energize the siren and record the meter reading.
- (3) Repeat 6.3.32.2(1) and 6.3.32.2(2) with the sound level meter 30.5 m (100 ft) from the vehicle, first at a position 45 degrees to the right and then at 45 degrees to the left of the longitudinal centerline of the vehicle.

6.3.32.3 The recorded noise level shall equal or exceed the specifications.

6.3.33* Propellant Gas.

6.3.33.1 Test equipment shall consist of a calibrated scale or load cell with an accuracy of ± 1.0 percent.

6.3.33.2 The vehicle extinguishing agent piping system shall be operational.

6.3.33.2.1 The agent tank(s) shall be empty.

6.3.33.2.2 The propellant gas tank(s) shall be fully charged to the rated pressure.

6.3.33.2.3 A means of lifting the agent tanks for weighing without loss of agent shall be provided.

6.3.33.2.4 As an alternative, the extinguishing agent tank(s) shall be permitted to be tested outside of the vehicle.

6.3.33.2.5 Where the alternative in 6.3.33.2.4 is used, the test shall be conducted with the agent tank(s) and related piping, fittings, valves, hose, and nozzle(s) in the same configurations in which they are installed on the vehicle.

6.3.33.3 The test for each of the extinguishing agents shall be conducted in the following manner:

- (1) Weigh the empty tank(s) and record as tare weight.
- (2) Using the manufacturer's recommended filling procedure, charge the tank(s) with the manufacturer's recommended extinguishing agent to the upper fill weight/volume tolerance. Reweigh and record this as gross filled weight.

- (3) Ensure that all fill caps are tightened, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
- (4) Pressurize the agent tank(s) using the manufacturer's recommended procedure.
- (5) Simultaneously, fully open all discharge nozzles, and keep open until only the pressurizing gas is expelled.
- (6) Shut down the propellant gas supply.
- (7) Reweigh the agent tank(s) and record this as post-discharge weight.
- (8) Calculate and record the total agent discharged as follows: Gross filled weight – post-discharge weight = total agent discharge

6.3.33.4 There shall be a supply of propellant gas to purge all discharge lines as evidenced by the emission from each nozzle of gas only.

6.3.34* Pressure Regulation.

6.3.34.1 Test equipment shall consist of a calibrated pressure gauge or transducer capable of reading the recommended tank top discharge pressure and possessing an accuracy of ± 34.5 kPa (± 5.0 psi).

6.3.34.2 The vehicle extinguishing agent system shall be piped to all discharge outlets with the tank(s) empty.

6.3.34.2.1 The propellant gas tank(s) shall be fully charged and at pressure.

6.3.34.2.2 A means for mounting a pressure gauge or transducer somewhere between the downstream (low-pressure) side of the regulator and the agent tank top shall be provided.

6.3.34.2.3 As an alternative, the extinguishing agent tank(s) shall be permitted to be tested outside of the vehicle.

6.3.34.2.4 Where the alternative in 6.3.34.2.3 is used, the test shall be conducted with the agent tank(s) and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

6.3.34.3 The test for each of the extinguishing agents shall be conducted in the following manner:

- (1) Using the manufacturer's recommended filling procedure, charge the tank(s) with the manufacturer's recommended extinguishing agent to the upper fill weight/volume tolerance.
- (2) Install a pressure gauge or transducer between the downstream (low-pressure) side of the regulator and the agent tank top.
- (3) Ensure that all fill caps are tightened, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings are tight.
- (4) Pressurize the agent tank(s) using the manufacturer's recommended procedure. Record the agent tank pressure.
- (5) Simultaneously, fully open all discharge nozzles, and keep open until only the pressurizing gas is expelled.
- (6) During agent discharge, monitor agent tank pressure and record at 5-second or shorter intervals.
- (7) Once the gas point has been reached for all discharge nozzles, shut down the gas supply.

6.3.34.4 The pressure regulation system shall be capable of maintaining pressure throughout the discharge.

6.3.34.4.1 At no time shall pressure fall below or exceed the design range specified by the manufacturer.

6.3.35* AFFF Premix Piping and Valves.

6.3.35.1 Test equipment shall consist of the following:

- (1) Calibrated scale or load cell with an accuracy of ± 1.0 percent
- (2) Stopwatch

6.3.35.2 All vehicle foam discharge piping shall be operational, and the premix tank shall be empty.

6.3.35.2.1 The propellant gas tank(s) shall be fully charged and within pressure.

6.3.35.2.2 A means of lifting the agent tank(s) for weighing without loss of agent shall be provided.

6.3.35.2.3 As an alternative, the system shall be permitted to be tested outside of the vehicle.

6.3.35.2.4 Where the alternative in 6.3.35.2.3 is used, the test shall be conducted with the premix tank and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

6.3.35.3 The test shall be conducted in the following manner:

- (1) Weigh the empty premix tank and record as tare weight.
- (2) Using the manufacturer's recommended filling procedure, charge the tank with water or premix solution. Reweigh and record as gross filled weight.
- (3) Ensure that all fill caps are tightened, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
- (4) Pull all handline hose from the reel(s) or hose compartment(s).
- (5) Pressurize the system using the manufacturer's recommended procedure.
- (6) Simultaneously, start the stopwatch and fully open the turret(s), undertruck nozzles, and handline(s).
- (7) After discharging for at least 30 seconds, simultaneously stop the stopwatch and close the turret(s), undertruck nozzles, and handline(s). Record the elapsed time on the stopwatch as discharge time.
- (8) Following the manufacturer's instructions, shut off the propellant gas supply, and blow down the system.
- (9) Reweigh the premix tank and record this as post-discharge weight.
- (10) Add the recommended flow rates from each discharge nozzle and record this sum as the designed total flow rate.
- (11) Calculate the actual total flow rate (TFR) as follows:

[6.3.35.3]

$$\text{TFR} = \frac{\text{gross filled weight} - \text{post-discharge weight}}{(\text{density}) \times \frac{(\text{elapsed time in seconds})}{60}}$$

6.3.35.4 The actual TFR shall equal the specified flow rate designed within a tolerance of +10 percent/–0 percent.

6.3.36* Pressurized Agent Purging and Venting.

6.3.36.1 No special test equipment or instrumentation shall be required to conduct the test(s).

6.3.36.2 The vehicle extinguishing agent system(s) shall be fully operational.

6.3.36.2.1 The agent tank(s) shall be fully charged with the manufacturer's recommended agent.

6.3.36.2.2 The propellant gas tank(s) shall be fully charged to the rated pressure.

6.3.36.2.3 As an alternative, the extinguishing agent tank(s) shall be permitted to be tested outside of the vehicle.

6.3.36.2.4 Where the alternative in 6.3.36.2.3 is used, the test shall be conducted with the fully charged agent tank(s) and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

6.3.36.3 The test for each of the pressurized extinguishing agent systems shall be conducted in the following manner:

- (1) Pressurize the agent tank(s) using the manufacturer's recommended procedure.
- (2) Pull all hose from the reel(s) or compartment(s).
- (3) Fully open all discharge devices.
- (4) After approximately 5 seconds to 20 seconds, close all discharge devices.
- (5) Purge all discharge lines, and vent the agent tank(s) using the manufacturer's recommended procedure.

6.3.36.4 Any agent beyond the tank outlet shall be purged from the discharge piping and hose as evidenced by the discharge from each nozzle of gas only.

6.3.36.4.1 The depressurization or venting of the agent tank shall allow only minimal quantities of agent to escape.

6.3.37* Complementary Agent Handline Flow Rate and Range.

6.3.37.1 Test equipment shall consist of the following:

- (1) Calibrated scale or load cell with an accuracy of ± 1.0 percent
- (2) Stopwatch
- (3) Tape measure or other device for measuring distance
- (4) Calibrated anemometer
- (5) Pan containing at least 0.09 m^2 (1 ft^2) of motor or aviation gasoline
- (6) Agent tank (if equipped with an agent tank) with a liquid level gauge with accuracy of $\pm 1.13 \text{ kg}$ (2.5 lb)

6.3.37.2 All vehicle agent piping shall be operational.

6.3.37.2.1 The agent tank shall be empty.

6.3.37.2.2 The propellant gas tank(s) shall be fully charged and within pressure.

6.3.37.2.3 A means of lifting the agent tank(s) for weighing without loss of agent shall be provided.

6.3.37.2.4 As an alternative, the system shall be permitted to be tested outside of the vehicle.

6.3.37.2.5 Where the alternative in 6.3.37.2.4 is used, the test shall be conducted with the agent tank and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

6.3.37.3 The test shall be conducted in the following manner:

- (1) Using the manufacturer's recommended agent and filling procedure, charge the agent tank.

- (2) If weight discharged will be based on liquid level gauge readings, record liquid level gauge reading in 9 kg (20 lb) increments, based on weighing of agent supply cylinder, as tank is initially filled.
- (3) Ensure that all fill caps are tightened, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
- (4) Pull all handline hose from the reel(s).
- (5) Pressurize the system using the manufacturer's recommended procedure, and open all handline nozzles until agent flow is observed. Close the nozzles.
- (6) Activate system and purge handline of air by opening the handline nozzle for approximately 1 second.
- (7) Weigh or note weight based on liquid level gauge reading, and record the agent tank as the "initial weight."
- (8) Position the handline nozzles at least 6.1 m (20 ft) from the fire pan so that they can be discharged onto a flat grade with no stream obstructions. Ignite the fuel.
- (9) Position one of the handline nozzles (nozzle 1) 0.9 m to 1.2 m (3 ft to 4 ft) above ground level while simultaneously starting the stopwatch and fully open the nozzle discharging agent onto the fire.
- (10) After at least 50 percent of the contents of the tank has been discharged, shut down the nozzle and stop the stopwatch. Record the time as "elapsed discharge time no. 1."
- (11) Reweigh the agent tank, and record as "weight after first discharge."
- (12) If a second nozzle (nozzle 2) is provided, repeat 6.3.37.3(1) through 6.3.37.3(8).
- (13) While holding the two handline nozzles in a fixed horizontal position 0.9 m to 1.2 m (3 ft to 4 ft) above ground level, simultaneously start the stopwatch and fully open both nozzles.
- (14) After at least 50 percent of the contents of the tank has been discharged, simultaneously shut down both nozzles, and stop the stopwatch. Record the time as "elapsed discharge time no. 2."
- (15) Reweigh the agent tank, and record as "weight after second discharge."
- (16) Calculate the flow rate (FR) from nozzle 1 as follows:

[6.3.37.3a]

$$\text{FR} = \frac{\text{initial weight (test 1)} - \text{initial weight (test 2)}}{(\text{elapsed discharge time no. 1})}$$

- (17) Calculate the flow rate (FR) from nozzle 2 as follows:

[6.3.37.3b]

$$\text{FR} = \frac{\text{weight after first discharge} - \text{weight after second discharge}}{2 \times (\text{elapsed discharge time no. 2})}$$

- (18) If nozzle 2 is of a different configuration, repeat the fire test for this nozzle.

6.3.37.4 Test results shall be evaluated as follows:

- (1) The flow rate from each nozzle must meet the requirement.
- (2) When discharged simultaneously, the flows from nozzle 1 and nozzle 2 must be within 10 percent of each other.

6.3.38* Dry Chemical Turret Flow Rate and Range.**6.3.38.1** Test equipment should consist of the following:

- (1) Calibrated scale or load cell with an accuracy of ± 1.0 percent
- (2) Stopwatch
- (3) Tape measure or other device for measuring distance
- (4) Calibrated anemometer

6.3.38.2 All dry chemical discharge piping shall be operational.**6.3.38.2.1** The dry chemical tank shall be empty.**6.3.38.2.2** The propellant gas tank(s) shall be fully charged to the rated pressure.**6.3.38.2.3** A means of lifting the agent tank(s) for weighing without loss of agent shall be provided.**6.3.38.2.4** As an alternative, the system shall be permitted to be tested outside of the vehicle.**6.3.38.2.5** Where the alternative in 6.3.38.2.4 is used, the test shall be conducted with the agent tank and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.**6.3.38.3** The test shall be conducted in the following manner:

- (1) Using the manufacturer's recommended agent and filling procedure, charge the tank.
- (2) Ensure that all fill caps are tightened, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
- (3) Pressurize the system using the manufacturer's recommended procedure, and open the turret discharge valve until agent is observed. Close the valve.
- (4) Weigh and record the agent tank as the "initial test weight."
- (5) Position the dry chemical turret so that it can be discharged onto a flat grade with no stream obstructions. Position the turret to obtain maximum straight stream reach.
- (6) Simultaneously, start the stopwatch and fully open the turret.
- (7) During discharge, place markers at the far point where dry chemical strikes the ground (range marker) and at either side of the widest part of the pattern (width markers), following these procedures:
 - (a) The operator(s) placing the markers shall wear safety equipment for this task.
 - (b) The agent manufacturer's material safety data sheet shall be consulted.
- (8) After discharging at least 75 percent of the contents of the tank, simultaneously stop the stopwatch and shut down the turret while recording the elapsed time in seconds as discharge time.
- (9) Measure the distance from the turret to the range marker and record as the far point range.
- (10) Measure the distance between the width markers and record as the pattern width.
- (11) Reweigh the agent tank and record as the weight after discharge.

- (12) Calculate the flow rate (FR) as follows:

[6.3.38.3]

$$FR = \frac{\text{initial test weight} - \text{weight after discharge}}{\text{elapsed discharge time}}$$

6.3.38.4 The discharge flow rate shall equal the requirements in Table 4.2.1.2(c) or Table 4.2.1.2(d)**6.3.39* Cab Interior Noise Test.****6.3.39.1** Test equipment shall consist of a sound level meter that meets the requirements of ANSI S1.4, *Specification for Sound Level Meters*, for Type 1 or S1A meters.**6.3.39.1.1** The sound level meter shall have been calibrated by a certified testing laboratory within the previous 12 months.**6.3.39.2** The vehicle shall be tested in its fully loaded condition with tires inflated to their recommended inflation pressure.**6.3.39.2.1** The cab doors, windows, and hatch openings shall be closed during this test.**6.3.39.2.2** The vehicle shall be driven long enough to bring the drivetrain components up to their operating temperatures prior to starting the test.**6.3.39.2.3** Thermostatically controlled shutters or cooling fans, or both, shall be allowed to function.**6.3.39.2.4** The vehicle agent system(s), the communications system, and the audible warning system and emergency warning system shall be inactive during this test.**6.3.39.3** The interior noise level of the cab shall be determined as follows:

- (1) Set the sound level meter to the A-weighting network, "fast" meter response, and position the meter adjacent to the driver's ear.
- (2) Bring the vehicle up to a road speed of 80.5 kph (50 mph) and maintain that speed while recording the noise measurements.
- (3) Repeat 6.3.39.3(1) and 6.3.39.3(2) until four readings have been taken, bringing the vehicle to rest between each measurement. If any of the noise measurements differ from the others by more than 2 dBA, they should be replaced by another measurement, since they could be the result of extraneous ambient noises or equipment/measurement error.
- (4) Average the four readings.

6.3.39.4 The average of the recorded noise readings shall be less than or equal to the cab interior noise level specification specified in 4.13.3.3.**6.3.40 J Turn.****6.3.40.1** Test equipment shall consist of a means of digitally recording vehicle speed at 100 Hz.**6.3.40.2** The vehicle shall be tested in its fully loaded condition.**6.3.40.3** The J Turn track dimensions shall meet the dimensions shown in Figure 6.3.40.3.

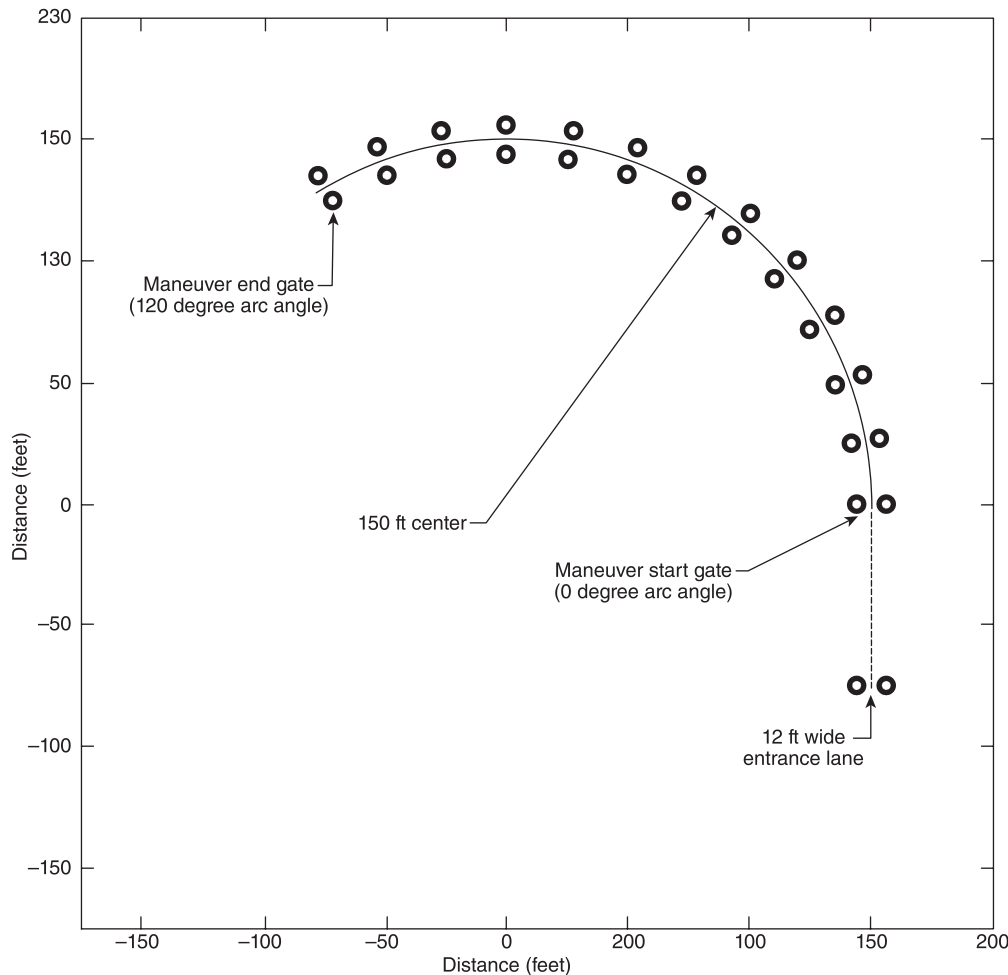


FIGURE 6.3.40.3 J Turn Track Dimensions.

6.3.40.4 Test Procedure. The test procedure for the J Turn track shall be as follows:

- (1) The vehicle shall enter the track at a minimum speed of 30 mph (48 kph).
- (2) The vehicle shall be driven through the course maintaining vehicle speed.
- (3) Vehicle speed shall be recorded at 100 Hz as the vehicle drives through the track.
- (4) If any outside cones are knocked down, the test shall not be counted.
- (5) The average speed of the vehicle through the track shall be in accordance with Table 4.2.1.2(a) and Table 4.2.1.2(b).

6.4* Operational Tests.

6.4.1 Vehicle Testing, Side Slope.

6.4.1.1 This test shall be accomplished on every vehicle prior to the vehicle being delivered to the end user.

6.4.1.1.1 It shall be accomplished with all requested equipment placed and installed as ordered by the end user.

6.4.1.1.2 The tilt-table angle shall be recorded on a metal data plate affixed to the left door of the vehicle.

6.4.1.1.3 The data plate shall list the following items:

- (1) Vehicle empty weight
- (2) Maximum gross weight
- (3) Special equipment installed prior to test
- (4) Front and rear axle weights with weight distribution calculation

6.4.1.1.4 The actual tilt-table angle achieved in the test shall be recorded on the plate for left and right directions.

6.4.1.1.4.1* The test shall be conducted on a tilt-table facility meeting the following SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, requirements:

- (1) The tilt table shall have a high-friction, ridged surface to provide enough traction force at the tire/table interface to keep the tires from sliding sideways.
- (2) The vehicle shall be restrained and tilted until the vehicle tilt or side slope angle can be positively determined.

6.4.1.2 The vehicle shall be tested in its fully loaded condition with tires inflated to their recommended operating pressure.

6.4.1.2.1 A ballast that is fastened in each seat shall be used in place of the crew for safety.

6.4.1.2.2 The water and foam tanks overflows and vents shall be capped during the test to reduce the amount of water leakage during the test.

6.4.1.3 Where the vehicle is fitted with a boom-mounted turret, an additional test shall be performed as follows:

- (1) Tilt the vehicle on a table or position the vehicle on a 20 percent grade.
- (2) Elevate the boom to the highest elevation.
- (3) Position the turret nozzle uphill at maximum horizontal rotation and discharge the agent at maximum flow rate for the class of vehicle being tested.

6.4.1.4 The side slope capability of the vehicle shall be determined in accordance with SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, and as follows:

- (1) Tilt the vehicle on a table to the angle specified for the vehicle being tested.
- (2) Once the vehicle is positioned at the required angle, check the vehicle restraints to ensure that no tension is applied.

6.4.1.5 The vehicle shall be considered to meet its side slope requirement if the vehicle can stand by itself on the grade without the use of the safety restraints.

6.4.1.6 If the vehicle slides and any of the wheels are in contact with the vertical constraining surface rail during the test, the truck shall be repositioned and the test repeated so the truck does not gain an advantage provided by the vertical constraining surface.

6.4.2* Weight/Weight Distribution.

6.4.2.1 Instrumentation for the weight and weight distribution test shall be limited to in-ground or portable scales.

6.4.2.1.1 The accuracy of the scales shall be ± 1.0 percent of the scale capacity.

6.4.2.2 The vehicle shall be tested in its fully loaded condition.

6.4.2.2.1 Ballast shall be used for the crew, agent, and equipment as necessary.

6.4.2.3 The total weight of the vehicle and weight distribution shall be determined as follows:

- (1) Determine the total weight of the vehicle by driving the fully loaded vehicle onto the scale(s).
- (2) Determine the individual axle loadings by measuring the weight on each axle at the ground. Since the total vehicle weight is more accurately reflected by the single weight measurement in 6.4.2.3(1), correct the individual axle loads proportionately, as necessary, so that their total equals the total vehicle weight. Subtract the lightest loaded axle weight from the heaviest loaded axle weight, and divide the difference by the weight of the heaviest axle.
- (3) Determine individual tire loadings by measuring the weight on each tire at the ground. Make proportionate corrections to the individual tire loads so that their total equals the load on the respective axle. Determine the average tire weight for each axle by adding the right-hand and left-hand tire weights for each axle and dividing by 2. Subtract the lightest loaded tire weight from the heaviest

loaded tire weight for each axle, and divide the difference by the average tire load for that axle.

6.4.2.4 The data shall be evaluated on the following basis:

- (1) The total weight of the vehicle must be less than or equal to the vehicle manufacturer's gross vehicle weight rating.
- (2) The difference between the heaviest loaded axle and the lightest loaded axle must be less than or equal to the maximum difference permitted in the specification.
- (3) The difference between the tire weights on any given axle must be less than or equal to the maximum difference permitted in the specification.
- (4) The data must be supplied showing each axle weight, difference in weight between axles, and the percentage difference between axles.

6.4.3* Acceleration.

6.4.3.1 Ambient temperatures at the test site shall be -17.8°C to 43.3°C (0°F to 110°F), and elevations shall include heights up to 609.6 m (2000 ft) unless otherwise specified by the purchaser.

6.4.3.2 Instrumentation shall consist of both a fifth wheel device, or equivalent, designed to measure and record (at least visibly, as a minimum) vehicle speed and time from the time the vehicle begins to move until it reaches a predetermined top speed; and a secondary, GPS-based speed-measuring device to verify.

6.4.3.3 The vehicle shall be tested in its fully loaded condition with the engine and the transmission at their operating temperatures.

6.4.3.3.1 The tires shall be inflated to the manufacturer's recommended pressure.

6.4.3.4 The test shall be conducted in the following manner:

- (1) Start the test with the vehicle at rest, the engine at idle, and the transmission in gear.
- (2) Simultaneously, start the stopwatch and accelerate the vehicle, and continue accelerating to a wide-open throttle condition.
- (3) At the moment the vehicle reaches 80.5 kph (50 mph), stop the watch and record the elapsed time.
- (4) To compensate for wind conditions and slope, repeat the test in the opposing direction. Record and average a minimum of three readings in each of the two directions.

6.4.3.5 The average acceleration time to 80.5 kph (50 mph) shall be less than or equal to the requirements specified in Table 4.2.1.2(a) and Table 4.2.1.2(b).

6.4.4* Top Speed.

6.4.4.1 Instrumentation shall consist of both the vehicle's speedometer as installed by the manufacturer at the time of delivery and a secondary, GPS-based speed-measuring device to verify speed.

6.4.4.2 The vehicle shall be tested in its fully loaded condition with the engine and the transmission at their operating temperatures.

6.4.4.2.1 The tires shall be inflated to the manufacturer's recommended pressure.

6.4.4.3 The test shall be conducted in the following manner:

- (1) Accelerate the vehicle to the speed specified in Table 4.2.1.2(a) and Table 4.2.1.2(b).
- (2) To compensate for wind conditions and slope, repeat the test in the opposing direction.
- (3) If the specified speed cannot be achieved in one of the directions, repeat 6.4.4.3(1) and 6.4.4.3(2), accelerating the vehicle to its maximum speed in each direction; record the speeds and average the two numbers.

6.4.4.4 The test shall be considered successful if the average top speed equals or exceeds 104.6 kph (65 mph).

6.4.5* Brake Operational Test.

6.4.5.1 Instrumentation shall consist of the vehicle's speedometer, as installed by the manufacturer; a secondary, GPS-based speed-measuring device to verify speed; and a tape measure.

6.4.5.2 The vehicle shall be tested in its fully loaded condition with the brakes adjusted to the manufacturer's recommended tolerances.

6.4.5.2.1 The tires shall be inflated to the vehicle manufacturer's recommended inflation pressure.

6.4.5.2.2 The vehicle's stopping distance shall have been certified by the vehicle manufacturer.

6.4.5.3 The test shall be conducted in the following manner:

- (1) Maintain a constant speed of 32.2 kph (20 mph) while driving down the centerline of the test site.
- (2) Apply the brakes as if in a panic stop until the vehicle comes to rest.
- (3) Measure and record the distance from the outer edge of the vehicle to the centerline of the lane.
- (4) Repeat 6.4.5.3(1) through 6.4.5.3(3) at a constant speed of 64.4 kph (40 mph).

6.4.5.4 The distance measured shall not exceed one-half the vehicle width plus 0.6 m (2 ft).

6.4.6 Air System/Air Compressor Test.

6.4.6.1 Instrumentation shall consist of the vehicle's air system pressure gauge(s), as installed by the manufacturer, and a stopwatch.

6.4.6.2 The vehicle's air system shall be fully operational for this test.

6.4.6.2.1 The manufacturer previously shall have established the ratio of actual to required reservoir capacity and the spring brake release pressure.

6.4.6.2.2 The test shall be conducted with the transmission in neutral and the parking brakes set.

6.4.6.3 The test shall be conducted as follows:

- (1) Using the brake pedal, bleed off the air reservoir system pressure to a level below 586 kPa (85 psi) as indicated on the cab-mounted air gauge(s).
- (2) Accelerate the engine to its wide-open throttle condition.
- (3) When the air pressure indicator reaches 586 kPa (85 psi), start the stopwatch. If more than one air pressure indicator is installed on the vehicle, start the stopwatch when the first indicator registers 586 kPa (85 psi).

- (4) Continue building air pressure with the engine at wide-open throttle until 689.5 kPa (100 psi) registers on all air pressure indicators, stop the watch, and record the time.
- (5) Using the brake pedal, bleed off the air reservoir system pressure to 0 kPa (0 psi), as indicated on the cab-mounted air gauge(s).
- (6) Accelerate the engine to a wide-open throttle condition.
- (7) When the wide-open throttle condition is reached, simultaneously start the stopwatch.
- (8) Continue building air pressure with the engine at wide-open throttle until the previously established spring brake release pressure has been reached in the quick buildup system; stop the watch and record the time.

6.4.6.4 The results shall be evaluated as follows:

- (1) The time needed for a buildup of 586 kPa to 689.5 kPa (85 psi to 100 psi) shall be within 25 seconds of the permitted time, as calculated for larger reservoir capacities.
- (2) The quick buildup time shall be within 15 seconds.

6.4.7* Agent Discharge Pumping Test.

6.4.7.1 No test equipment shall be required.

6.4.7.2 The vehicle's agent system shall be fully operational with all primary handlines deployed for this test.

6.4.7.3 The simultaneous discharge of all nozzles shall be tested as follows:

- (1) Fill both the water tank and the foam (or dyed water) tank completely with water and foam, respectively.
- (2) Set the agent system to operate in the foam mode, set the system pressure for optimum performance, and engage the agent pumps. Simultaneously, operate the pumps of vehicles with multiple pumps during this test.
- (3) Initiate discharge first through the primary turret and then through the ground sweeps (or optional bumper turret), primary handlines, and undertruck nozzles until all are discharging simultaneously in a straight stream. As each nozzle is turned on, observe the range along with the system pressure.
- (4) Continue to discharge until the system pressure has stabilized with all nozzles discharging.

6.4.7.4 Since measurements of actual flow rates are not accurately obtained in the field, the system shall be considered to have met the agent discharge pumping test requirement in accordance with the procedures of 6.4.7.3, provided the nozzle ranges show no signs of deterioration as additional nozzles are engaged and the agent system pressure does not fluctuate by more than 10 percent where the primary turret flowing by itself is compared with the combined discharge pressure.

6.4.7.5 Foam (or dyed water) shall be evident in the discharging stream from all nozzles at all times.

6.4.8* Dual Pumping System Test.

6.4.8.1 No special instrumentation shall be required for this test.

6.4.8.2 The vehicle's agent system shall be fully operational for this test.

6.4.8.3 The ability of a vehicle equipped with a dual pumping system to provide foam solution to all nozzles when only one system is active shall be tested as follows:

- (1) Fill both the water tank and the foam tank completely with water, and add dye or foam concentrate to the foam tank.
- (2) Set the agent system to operate in the foam mode, and set the system pressure for optimum performance.
- (3) Set the primary turret(s) discharge rate in the half flow rate setting.
- (4) Initiate discharge first through the primary turret(s) (at half rate) and then through the ground sweep nozzles (or alternate bumper turret), the primary handline nozzles, and the undertruck nozzles, first with one pump operating, and then the other.

6.4.8.4 A foam or dye solution discharge stream shall be present at each nozzle tested when either pump is engaged.

6.4.9* Pump and Maneuver Test.

6.4.9.1 No test equipment shall be required.

6.4.9.2 The vehicle's agent system shall be fully operational for this test.

6.4.9.3 The positive pump and maneuver capability, along with the smooth engagement of the pump, shall be tested as follows:

- (1) Fill both the water tank and the foam tank completely with water, and add dye or foam concentrate to the foam tank.
- (2) With the vehicle being driven at 32.2 kph (20 mph), engage and disengage the pump(s) without damage to the pump or pump drive system.
- (3) Bring the vehicle to a stop, and prepare the primary turrets and ground sweeps (or optional bumper turret) for discharging.
- (4) Place the agent selector in the foam mode, and set the agent system pressure relief to relieve at the recommended pressure for optimum performance.
- (5) Initiate discharge through the primary turrets and ground sweeps/bumper turret nozzles, and drive the vehicle in a forward and reverse direction at speeds ranging up to 8 kph (5 mph). Stop and start the vehicle, and change direction from forward to reverse while operating through this speed range without interrupting the discharge flow rate or range. Engage and disengage the pumps during the test.
- (6) Repeat 6.4.9.3(5) both on and off the road.

6.4.9.4 During the test, there shall be no indication of proportioning, pressure, or flow rate instability.

6.4.9.5 The operation of the pump shall not cause the engine to stall.

6.4.9.6 Engagement of the pump or vehicle drive shall be accomplished without introducing any vehicle dynamics such as severe lurching.

6.4.9.7 Dye or foam solution shall be evident while discharging from all nozzles.

6.4.10* Hydrostatic Pressure Test.

6.4.10.1 Test equipment shall consist of the following:

- (1) Hydraulic pressure gauge with a scale adequate for monitoring a pressure equal to 1½ times the agent system pressure of the vehicle
- (2) Pressure charging device capable of developing a pressure equal to 1½ times the agent system pressure of the vehicle and sustaining it for 15 minutes or longer
- (3) Miscellaneous plates or caps to isolate the tank-to-pump side of the agent system, as necessary, from the hydrostatic test pressure

6.4.10.2 The vehicle's agent system shall be fully assembled at the time of the test.

6.4.10.2.1 Because it is sometimes desirable to perform the hydrostatic pressure test before the body is completely assembled and firefighting system controls are in place, the agent system shall not be required to be fully operational during the hydrostatic portion of the test.

6.4.10.3 The water and foam concentrate or foam solution discharge piping shall be tested as follows:

- (1) Isolate all tank-to-pump piping components that cannot tolerate the hydrostatic test pressures from the discharge piping and pump(s) by installing temporary plates or caps between these items and the discharge piping. Include the agent pumps in the test.
- (2) Close all discharge nozzles and seal any bypass lines from the pressure piping to the agent tanks.
- (3) Connect a pressure charging device (e.g., electric motor-driven water pump or hand pump) into the discharge piping.
- (4) Activate the pressure charging device, fill the agent pumps and discharge piping with water, and pressurize to at least 1½ times the maximum recommended agent system operating pressure.
- (5) Close the supply line from the pressure charging system, thereby sealing the discharge piping in a pressurized condition.
- (6) Maintain the test pressure for at least 15 minutes without degradation.
- (7) If leaks exist that cause the pressure to drop, repair the leaks and repeat the test.
- (8) On completion of the hydrostatic test, disconnect the charging device and reassemble the tank-to-pump piping.
- (9) Fill the agent tanks and piping with water, and inspect the tank-to-pump piping for leaks after the agent system has been operated in the foam mode.

6.4.10.4 No pressure decay shall be permitted during the 15-minute test.

6.4.10.5 No discharge or tank-to-pump piping water leaks shall be permitted during or after agent system operation.

6.4.11* Foam Concentration Test.

6.4.11.1 The test equipment described in Chapters 1 through 3, and 27 through 29 of NFPA 460 shall be used for this test.

6.4.11.2 Each discharge nozzle on the vehicle shall have been individually verified as discharging at a flow rate within the tolerance specified.

6.4.11.2.1 The agent system shall have been verified as capable of operating at full rate.

6.4.11.3 The test shall be conducted as follows:

- (1) Fill the water and foam tank to the top and refill as necessary throughout the test.
- (2) Set the foam proportioning system to proportion foams at the concentration specified and set the agent selector for the foam mode.
- (3) Set the agent system pressure relief to the recommended pressure.
- (4) Engage the agent pumps and bring them up to maximum pumping speed with all discharge outlets closed.
- (5) Test each foam delivery system in accordance with Chapters 1 through 3, and 27 through 29 of NFPA 460 for the individual nozzle/flow rate as follows:
 - (a) Primary turret(s) full rate
 - (b) Primary turret(s) half rate
 - (c) Ground sweep/bumper turret
 - (d) Handline nozzles
 - (e) Undertruck nozzles

6.4.11.4 The foam concentrations measured shall fall within the permitted tolerances specified in Chapters 1 through 3, and 27 through 29 of NFPA 460 for each nozzle.

6.4.12* Primary Turret Flow Rate Test.

6.4.12.1 A stopwatch shall be required for this test.

6.4.12.2 The agent system shall be fully operational.

6.4.12.2.1 The agent system pressure shall be set in accordance with the manufacturer's recommendations.

6.4.12.2.2 The water tank shall be filled completely.

6.4.12.3 The test shall be conducted as follows:

- (1) Simultaneously initiate discharge through the primary turret(s) at the maximum flow rate and start the stopwatch.
- (2) Continue discharging until the pump cavitates, as indicated by a significant drop in discharge pressure, and stop the watch when this occurs. Record the elapsed time.
- (3) Divide the rated water tank capacity, in liters (gallons), by the elapsed discharge time to determine the average discharge rate.

6.4.12.4 The average measured discharge rate shall be in agreement with the nominal discharge rate specified.

6.4.12.4.1 The total elapsed discharge time shall be no less than 1 minute nor greater than 2 minutes.

6.4.13 Piercing Nozzle Testing.

6.4.13.1* The manufacturer shall demonstrate the ability to penetrate a sandwiched metal sample of two pieces of 0.090 5052 grade soft aluminum material with the piercing nozzle in under 3 seconds.

6.4.13.2* The manufacturer shall demonstrate the ability to penetrate a sandwiched metal sample of two pieces of 0.090 2024-T3 grade aircraft aluminum with the piercing nozzle in under 3 seconds.

Chapter 7 Fire Apparatus — General Requirements (NFPA 1901/1906)

7.1 Administration.

7.1.1* Scope. Chapters 7 through 27 define the minimum requirements for the design, performance, and testing of new automotive fire apparatus and trailers designed to be used under emergency conditions to transport personnel and equipment and to support the suppression of fires and mitigation of other hazardous situations, including wildland fires.

7.1.2 Purpose. This purpose of Chapters 7 through 27 is to specify the minimum requirements for new automotive fire apparatus and trailers that will be safe and reliable when maintained and used within design parameters.

7.1.3 Application.

7.1.3.1* Chapters 7 through 27 shall apply to new fire apparatus that meet the following criteria:

- (1) Have 10,001 lb (4501 kg) or greater gross vehicle weight rating (GVWR) or are trailers intended to be towed by fire apparatus under emergency response conditions
- (2) Are designed for use under emergency conditions to transport personnel and equipment and to support the suppression of fires and mitigation of other hazardous situations, including wildland fires
- (3) Are contracted for on or after January 1, 2024

7.1.3.2 Nothing shall prevent the use of the standard prior to January 1, 2024, or for vehicles with less than 10,001 lb (4501 kg) gross vehicle weight rating (GVWR), if the purchaser and the contractor both agree.

7.1.4* Retroactivity. This standard shall not be applied retroactively.

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

7.1.5.1 The technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

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

7.1.6 Units of Measure.

7.1.6.1* In Chapters 7 through 27, values for measurement in U.S. customary units shall be followed an equivalent in SI units.

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

7.2 General.

7.2.1 All fire apparatus shall comply with the following chapters:

- (1) Chapter 1, "Administration"
- (2) Chapter 2, "Referenced Publications"
- (3) Chapter 3, "Definitions"
- (4) Chapter 7, "General Requirements"
- (5) Chapter 8, "Fire Apparatus — Requirements by Type"
- (6) Chapter 9, "Chassis and Vehicle Components"

- (7) Chapter 10, “Low Voltage Electrical Systems and Warning Devices”
- (8) Chapter 11, “Driving and Crew Areas”
- (9) Chapter 12, “Body, Compartments, and Equipment Mounting”

7.3 Requirements by Apparatus Type.

7.3.1 Table 7.3.1 shows the required chapters that shall apply to the construction of each type of fire apparatus.

7.3.2 In addition to the types of fire apparatus listed in 7.3.1, other types of fire apparatus shall be permitted by combining the requirements for the components to be used in the apparatus as defined in Section 7.6 with the requirements listed in Section 7.2.

7.4 Responsibility of the Purchaser.

7.4.1* It shall be the responsibility of the purchaser to specify the details of the apparatus in addition to the requirements in NFPA 1900 needed by the manufacturer to build the apparatus, including:

- (1) Requirements not uniquely specified in NFPA 1900, such as the type of apparatus desired.
- (2) Any features of the apparatus desired in addition to, or in excess of, the requirements in NFPA 1900.

- (3) Identification of any crew seats as either designated primary seating positions or designated secondary seating positions.

7.4.2 After acceptance of the fire apparatus, the purchaser shall be responsible for ongoing training of personnel to develop and maintain proficiency regarding the proper and safe use of the apparatus and the associated equipment.

7.5 Responsibility of the Contractor. The requirements of 7.5.1 through 7.5.2 shall apply to contractors for structural fire apparatus.

7.5.1 The contractor shall provide a detailed description of the apparatus, a list of equipment to be furnished, and other construction and performance details to which the apparatus shall conform.

7.5.1.1 The detailed description of the apparatus shall include, but shall not be limited to, estimated in-service weight, wheelbase, turning clearance radius, principal dimensions, angle of approach, angle of departure, transmission, axle ratios, and, if applicable, the rated capacity of the aerial device.

7.5.1.2 The contractor’s detailed description shall include a statement specifically describing each aspect of the delivered apparatus that will not be fully compliant with the requirements of this standard.

Table 7.3.1 Chapter Requirements by Apparatus

Chapter	Pumper Fire Apparatus	Initial Attack Fire Apparatus	Mobile Water Supply Fire Apparatus	Aerial Fire Apparatus	Quint Fire Apparatus	Special Service Fire Apparatus	Mobile Foam Fire Apparatus	Wildland Fire Suppression Apparatus	Wildland Mobile Water Supply Apparatus	Wildland Crew Carrier Apparatus
13. Fire Pumps and Associated Equipment	Required	Required	If specified	If specified	Required	If specified	Required	If specified	If specified	N/A
14. Auxiliary Pumps and Associated Equipment	If specified	If specified	If specified	If specified	If specified	If specified	If specified	N/A	N/A	N/A
15. Pumps for Wildland Firefighting and Associated Equipment	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Required	Required	N/A
16. Ultra-High Pressure Fire Pumps and Associated Equipment	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	N/A
17. Water Tanks	Required	Required	Required	If specified	Required	If specified	If specified	Required	Required	N/A
18. Foam Proportioning Systems	If specified	If specified	If specified	If specified	If specified	If specified	Required	If specified	If specified	N/A
19. Compressed Air Foam Systems (CAFS)	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	N/A
20. Aerial Devices	If specified	If specified	N/A	Required	Required	If specified	If specified	N/A	N/A	N/A
21. Line Voltage Electrical Systems	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified
22. Command and Communications	If specified	If specified	If specified	If specified	If specified	If specified	If specified	N/A	N/A	N/A
23. Air Systems	If specified	If specified	If specified	If specified	If specified	If specified	If specified	N/A	N/A	N/A
24. Winches	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified
25. Trailers	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified
26. Vehicle Protection Systems	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified	If specified
27. Wildland Fire Crew Carrier Apparatus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Required

7.5.1.3 The purpose of these contractor specifications shall be to define what the contractor intends to furnish and deliver to the purchaser.

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

7.6 Fire Apparatus Components. All components installed on structural fire apparatus shall be installed in accordance with the applicable manufacturer's installation instructions.

7.7 Legal Requirements. The apparatus shall comply with all applicable federal and state or provincial laws and regulations.

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

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

7.8.2 The certification organization shall not be owned or controlled by manufacturers or vendors of the product that is being tested.

7.8.3 The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

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

7.8.5 There shall be no conditional, temporary, or partial certification of test results.

7.8.6* Forms or data sheets shall be provided and used during the testing.

7.8.7 Programs shall be in place for training, proficiency testing, and performance verification of any staff involved with certification.

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

7.9 Manufacturer Certification of Test Results. Where this standard requires the results of tests or the performance of a component to be certified by the manufacturer, the manufacturer shall meet the requirements of this section.

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

7.9.2 There shall be no conditional, temporary, or partial certification of test results.

7.9.3 The manufacturer shall have the facilities and equipment necessary to conduct the required testing, a program for the calibration of all instruments, and procedures to ensure the proper control of all testing.

7.9.4* Forms or data sheets shall be provided and used during the testing.

7.9.5 Programs shall be in place for training, proficiency testing, and performance verification of any personnel involved with certification.

7.9.6 An official of the company that manufactures or installs the product shall designate in writing who is qualified to witness tests and certify results.

7.9.7 Certification documentation shall be delivered with the apparatus, including results of the certification tests.

7.10 Personnel Protection.

7.10.1* Guards, shields, or other protection shall be provided where necessary to prevent injury of personnel by hot, moving, or rotating parts during nonmaintenance operations.

7.10.1.1 One safety sign FAMA02, which warns of rotating shaft hazards, shall be located on the frame rail on each side of a vehicle and any other place where a rotating shaft hazard is present.

7.10.1.2 One safety sign FAMA05, which warns of fan hazards, shall be visible to personnel at each approach to spinning fans.

7.10.2 Electrical insulation or isolation shall be provided where necessary in order to prevent electrical shock from onboard electrical systems.

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

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

7.10.4.1 Apparatus built for sale in the United States shall employ safety signage that complies with ANSI/NEMA Z535.4.

7.10.4.2 Apparatus built for sale outside the United States shall employ safety signage that complies with either ANSI/NEMA Z535.4 or ISO 9244.

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

7.11 Controls and Instructions.

7.11.1 Illumination shall be provided for controls, switches, instruction plates, labels, gauges, and instruments necessary for the operation of the apparatus and the equipment provided on it, except drain controls and associated plumbing where located below the truck body.

7.11.1.1 If external illumination is provided, it shall be a minimum of 5 fc (50 lx) on the face of the device.

7.11.1.2 If internal illumination is provided, it shall be a minimum of 4 fL (14 cd/m²).

7.11.2* All required signs, instruction plates, and labels shall comply with all of the following:

- (1) Be permanent in nature
- (2) Be securely attached
- (3) Meet the requirements of 7.10.4 and UL 969, *Standard for Marking and Labeling Systems*

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

7.11.2.2 The exterior mounted labels relating to safety or critical operational instructions shall be reflective or illuminated as required by 7.11.1.

7.11.3 The centerline of any gauge or visual display required by Chapters 7 through 31 shall be no more than 84 in. (2130 mm) vertically above the ground (with vehicle at in-service weight) or the platform that is designed to serve as the operator's standing position.

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

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

7.12 Onboard Data Management and Communications Equipment. The purchaser shall specify what the contractor needs to provide in terms of onboard data management and communications equipment for the apparatus.

7.12.1 For each category of equipment listed in 7.12.5, the purchaser shall specify what equipment the contractor is to supply and install.

7.12.2 For each category of equipment listed in 7.12.5, the purchaser shall specify what purchaser-supplied equipment the contractor is to install.

7.12.3* For each category of equipment listed in 7.12.5, the purchaser shall specify what accommodations such as space, power, antenna bases, or other accommodations the contractor is to provide to support purchaser-installed equipment.

7.12.4 For each category of equipment listed in 7.12.5, the purchaser shall specify if no equipment in that category is to be supplied or installed, or have any accommodations provided.

7.12.5 The purchaser shall provide the information identified in 7.12.1 through 7.12.4 for the following:

- (1) Radio communication equipment
- (2) Mobile data terminals or other computer equipment
- (3) Traffic preemption equipment
- (4)* Vehicle data recorder
- (5)* V2X communications
- (6) Digital alert warning system (DAWS)

7.12.6* A DAWS, if provided, shall meet the requirements of NFPA 950.

7.13 Component Protection.

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

7.13.2 The types of equipment described in 7.13.1 shall be furnished with protective looms, grommets, or other devices at each point where they pass through body panels or structural members or wherever they lie against a sharp metal edge.

7.13.3 A through-the-frame connector shall be permitted to be used in place of protective looms or grommets.

7.14 Vehicle Stability.

7.14.1* Stability Control System

7.14.1.1 The apparatus shall be equipped with a stability control system in any configuration for which it is commercially available.

7.14.1.2 The stability control system shall have, at a minimum, a steering wheel position sensor, a vehicle yaw sensor, a lateral accelerometer, and individual wheel brake controls.

7.14.2 Apparatus completed in two or more stages shall not exceed the incomplete vehicle manufacturer's maximum allowable vertical center of gravity.

7.14.3 Rollover Stability.

7.14.3.1 Structural fire apparatus not equipped with a stability control system and all wildland fire apparatus shall meet either of the following:

- (1)* The apparatus shall remain stable in both directions in accordance with Table 7.14.3.1 when tested on a tilt table in accordance with SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*.
- (2) The calculated or measured vertical center of gravity (VCG) divided by the rear axle track width shall not exceed the applicable criterion in Table 7.14.3.1.

7.14.3.2 Certification shall be by one of the following methods:

- (1) Performing a tilt-table test on the completed apparatus
- (2) Calculating the point at which the apparatus will tip based on centers of gravity, suspension geometry, suspension compliance, and tire compliance
- (3) Comparing the apparatus design to a previously certified substantially similar apparatus
- (4) Demonstrating that the calculated or measured center of gravity (CG) divided by the rear axle track width does not exceed the value in Table 7.14.3.1

Table 7.14.3.1 Rollover Stability Requirements

Vehicle	Tilt Criteria (degrees)	VCG/Track (percentage)
Wildland fire apparatus ≤33,000 lb (15,000 kg) GVWR	30	75
Wildland fire apparatus >33,000 lb (15,000 kg) GVWR	27	80
Structural fire apparatus not equipped with a stability control system	26.5	80

7.14.3.3 Certification shall be delivered with the fire apparatus.

7.14.3.4 A previously certified apparatus shall be considered substantially similar if it includes a chassis with the same or higher CG height, the same or narrower rear axle track width, the same or greater water tank size and CG height, the same type of front and rear suspension, and the same type and size of aerial device.

7.14.3.5 For purposes of certification the apparatus shall be loaded with fuel, water, firefighting agents, hose, ladders, a weight of 250 lb in each seating position, and weight equivalent to the miscellaneous equipment allowance.

7.14.3.6 If the apparatus is designed to meet a specified higher equipment loading or larger hose bed capacity or to carry additional ground ladders, these greater loads shall be accounted for in the testing, calculating, or measuring.

7.14.3.7 The weight added to the fire apparatus for certification, calculation, or measurement shall be distributed to approximate typical in-service use of the fire apparatus while not exceeding the manufacturer's published individual compartment weight ratings.

7.14.4 Weight Distribution.

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

7.14.4.2 The front axle loads shall not be less than the minimum axle loads specified by the chassis manufacturer under full load and all other loading conditions.

7.14.5 Load Distribution.

7.14.5.1* The apparatus manufacturer shall calculate the load distribution for the apparatus.

7.14.5.2 The apparatus manufacturer shall deliver the load distribution plan with every fire apparatus.

7.14.5.3 The manufacturer shall design the fire apparatus to comply with the gross axle weight ratings (GAWR), the overall gross vehicle weight rating (GVWR), and the chassis manufacturer's load balance guidelines.

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

7.14.6* Each tire shall be equipped with a visual indicator or monitoring system that indicates tire pressure.

7.15 Fire Apparatus Performance.

7.15.1* The fire apparatus shall meet the requirements of this standard at elevations of 2000 ft (600 m) above sea level.

7.15.2* The fire apparatus shall meet all the requirements of this standard while stationary on a grade of 6 percent for structural fire apparatus, or 10 percent for wildland apparatus, in any direction.

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

7.16 Highway Performance.

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

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

7.16.2* The maximum top speed of any fire apparatus with a GVWR over 33,000 lb (15,000 kg) shall not exceed either 68 mph (109 km/hr) or the manufacturer's maximum fire service speed rating for the tires installed on the apparatus, whichever is lower.

7.16.3 If the combined water tank and foam agent tank capacities on the fire apparatus exceed 1250 gal (4732 L), or the GVWR of the vehicle is over 50,000 lb (22,680 kg), the maximum top speed of the apparatus shall not exceed either 60 mph (95 km/hr) or the manufacturer's maximum fire service speed rating for the tires installed on the apparatus, whichever is lower.

7.16.4* All wildland fire apparatus shall be capable of maneuvering across a 20 percent grade and up and down a 25 percent grade.

7.17 Serviceability.

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

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

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

7.18 General Pre-Delivery Tests.

7.18.1 Each apparatus shall be tested by the manufacturer before delivery to verify that it meets the criteria in this section.

7.18.1.1 Tests shall be conducted at a location and in a manner that does not violate local, state or provincial, or federal traffic laws.

7.18.1.2 Tests shall be conducted on a dry, level, paved surface that is free of loose material, oil, or grease.

7.18.1.3 Tests shall be conducted with the water and foam tanks full (water or product).

7.18.2 The apparatus shall accelerate from 0 to 35 mph (55 km/hr) within 25 seconds.

7.18.3 The apparatus shall attain a speed of 50 mph (80 km/hr).

7.18.4 The auxiliary braking system, if so equipped, shall function as intended by the auxiliary braking system manufacturer.

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

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

7.19 Tests on Delivery.

7.19.1* Wildland Fire Apparatus. If acceptance tests on wildland fire apparatus are to be performed at the point of delivery, they shall not be performed in a manner that requires the apparatus or a component to operate outside its designed operating range.

7.19.2 Structural Fire Apparatus. Sections 7.19.2.1 through 7.19.2.7.2.2 shall apply to structural fire apparatus only.

7.19.2.1* If acceptance tests are required at the point of delivery, the purchaser shall specify the details of the tests to be performed.

7.19.2.2 Acceptance tests shall not be performed in a manner that requires the apparatus or a component to operate outside its designed operating range.

7.19.2.3 Aerial device stability tests shall not be run other than at the manufacturer's facility.

7.19.2.4 An official of the company that manufactures the apparatus and, if applicable, the aerial device shall designate in writing who is qualified to provide operational instructions and apparatus familiarization to the final customer.

7.19.2.5 Programs shall be in place for training, proficiency testing, and performance verification of the qualified person in 7.19.2.4.

7.19.2.6 The authority having jurisdiction shall appoint a person(s) to receive operational instructions and apparatus familiarization.

7.19.2.7 Operational instructions shall be provided on new apparatus by the contractor in accordance with 7.19.2.7.1 through 7.19.2.7.2.2.

7.19.2.7.1 Review with the authorized person(s) as defined by the authority having jurisdiction all service, maintenance, operational, and instruction manuals, including the entire vehicle, chassis, major components, and auxiliary equipment provided.

7.19.2.7.2 Familiarization and demonstration of the vehicle shall be by a competent and qualified person as defined in 3.3.233 of this standard.

7.19.2.7.2.1 The familiarization and demonstration shall not include driving training or any firefighting training operations.

7.19.2.7.2.2 Familiarization of the vehicle shall include the following:

- (1) How to locate gauges or indicators and check all fluid levels and operational issues of the vehicle

- (2) How to tilt the chassis cab or hood assembly for access to the engine, fire pump, or aerial control, or any other device to allow access to fluids or for required maintenance
- (3) Interior cab controls, instruments, mirrors, safety devices or alarms, brake operations, transmission control, pump controls, exhaust regeneration (if provided), seat adjustments, warning light engagement, and other operational equipment
- (4) If the apparatus is provided with a fire pump system, the following minimum instructions:
 - (a) Setting of parking brake, proper transmission gear, and fire pump engagement operations
 - (b) Throttle control
 - (c) Primer and tank-to-pump operation
 - (d) Use of pressure control devices
 - (e) Tank refilling operations
 - (f) Proper operation of discharge controls
 - (g) Proper shutdown and draining of system
- (5) If the apparatus is provided with a generator, the following minimum instructions:
 - (a) Proper engagement if driven by the chassis
 - (b) Startup, operation, and shutdown of generator
 - (c) Monitoring of controls and instruments
- (6) If the apparatus is provided with a foam system, the following minimum instructions:
 - (a) Startup, operation, and shutdown of foam system
 - (b) Setting of foam percentages and other operational settings
 - (c) Proper flushing and draining of the system
- (7) If the apparatus is provided with a water tower or aerial device, the following minimum instructions:
 - (a) Positioning and locating the vehicle for safe operations
 - (b) Chassis parking brakes and engagement of hydraulic system
 - (c) Deployment of stabilization devices and use of ground pads
 - (d) Operation of elevation, extension, and rotation of the aerial device
 - (e) Operation of waterway, nozzle, and other firefighting devices of aerial device
 - (f) Operation and use of breathing air system
 - (g) Specific aerial device maintenance and service areas for operators
 - (h) Shutdown and return to service operations
 - (i) Operation of tip controls and platform controls
 - (j) General familiarization and demonstration of aerial device
 - (k) Review of all safety devices, interlocks, and operational hazards

7.20* Documentation. Any documentation delivered with the apparatus shall be permitted to be in printed format, electronic format, audiovisual format, or a combination thereof.

7.21 Data Required of the Contractor.

7.21.1 Fire Apparatus Documentation. The contractor shall supply, at the time of delivery, the following information:

- (1) The manufacturer's record of apparatus construction details, including the following information:
 - (a) Owner's name and address

- (b) Apparatus manufacturer, model, and serial number
 - (c) Chassis make, model, and serial number
 - (d) GAWR of front and rear axles and GVWR
 - (e) Front tire size and total rated capacity in pounds (kilograms)
 - (f) Rear tire size and total rated capacity in pounds (kilograms)
 - (g) Chassis weight distribution in pounds (kilograms) with water and manufacturer-mounted equipment (front and rear)
 - (h) For each engine, make, model, serial number, rated horsepower and related speed, and governed speed; and if so equipped, engine transmission PTO(s) make, model, and gear ratio
 - (i) Type of fuel and fuel tank capacity
 - (j) Electrical system voltage and alternator output in amps
 - (k) Battery make, model, and capacity in cold cranking amps (CCA)
 - (l) Chassis transmission make, model, and serial number; and if so equipped, chassis transmission PTO(s) make, model, and gear ratio
 - (m) Ratios of all driving axles
 - (n) Maximum governed road speed
 - (o) For each pump, make, model, rated capacity in gallons per minute (liters per minute where applicable), maximum discharge pressure capability rating, and serial number
 - (p) For each pump, transmission make, model, serial number, and gear ratio
 - (q) Auxiliary pump make, model, rated capacity in gallons per minute (liters per minute where applicable), and serial number
 - (r) Water tank certified capacity in gallons or liters
 - (s) Foam tank (if provided) certified capacity in gallons (liters)
 - (t) Aerial device (if provided) type, rated vertical height in feet (meters), rated horizontal reach in feet (meters), and rated capacity in pounds (kilograms)
 - (u) Paint manufacturer and paint number(s)
 - (v) Company name and signature of responsible company representative
 - (w) Weight documents from a certified scale showing actual loading on the front axle, rear axle(s), and overall fire apparatus (with the water tank full but without personnel, equipment, and hose)
- (2) Certification of compliance of the optical warning system (*see 10.7.17*)
 - (3) Siren manufacturer's certification of the siren (*see 10.8.1.1*)
 - (4) Written load analysis and results of the electrical system performance tests (*see 10.13.1 and Section 10.14*)
 - (5) Certification of slip resistance of all stepping, standing, and walking surfaces (*see 12.6.4.5*)
 - (6) If the apparatus has a fire pump or a wildland fire pump, the pump manufacturer's certification of suction capability (*see 13.2.4.1 or 15.2.4.1*)
 - (7) If the apparatus is equipped with a fire pump or a wildland fire pump and special conditions are specified by the purchaser, the pump manufacturer's certification of suction capacity under the special conditions (*see 13.2.4.2 or 15.2.4.2*)
 - (8) If the apparatus has a fire pump, or a wildland fire pump a copy of the apparatus manufacturer's approval for stationary pumping applications (*see 13.3.1 or 15.3.1*)
 - (9) If the apparatus has a fire pump, the engine manufacturer's certified brake horsepower curve for the engine furnished, showing the maximum governed speed (*see 13.3.2.2*)
 - (10) If the apparatus has a fire pump or a wildland fire pump, the pump manufacturer's certification of the hydrostatic test (*see 13.5.2.2 or 15.5.2.2*)
 - (11) If the apparatus has a fire pump with a maximum discharge pressure capability rating that exceeds the hydrostatic test pressure of 13.5.2.1, the pump manufacturer's certification of the hydrodynamic test
 - (12) If the apparatus has a fire pump or a wildland fire pump, the certification of inspection and test for the fire pump (*see 13.13.1.1.5 or 13.13.1.2.4 or 15.13.1.2.4, as applicable*)
 - (13) If the apparatus is equipped with an auxiliary pump, the apparatus manufacturer's certification of the hydrostatic test (*see Section 14.13*)
 - (14) When the apparatus is equipped with a water tank, the certification of water tank capacity (*see Section 17.6*)
 - (15) If the apparatus has an aerial device, the certification of inspection and test for the aerial device (*see Section 20.31*)
 - (16) If the apparatus has an aerial device, all the technical information required for inspections to comply with NFPA 1910
 - (17) If the apparatus has a foam proportioning system, the foam proportioning system manufacturer's certification of accuracy (*see 18.10.4.2*) and the final installer's certification the foam proportioning system meets this standard (*see 18.11.2*)
 - (18) If the system has a CAFS, the documentation of the manufacturer's predelivery tests (*see Section 19.9*)
 - (19) If the apparatus has a line voltage power source, the certification of the test for the power source (*see 21.15.7.2*)
 - (20) If the apparatus is equipped with an air system, air tank certificates (*see 23.5.1.2*), the SCBA fill station certification (*see 23.9.6*), and the results of the testing of the air system installation (*see 23.14.5 and 23.15.4*)
 - (21) For wildland fire apparatus, or structural apparatus without stability control, certification of vehicle side slope stability, including the weight distribution assumed for the calculations or as loaded on the vehicle for the tilt table test (*see 7.14.3*)
 - (22) Any other required manufacturer test data or reports
- 7.21.2 Operations and Service Documentation.**
- 7.21.2.1** The contractor shall deliver with the fire apparatus complete operation and service documentation covering the completed apparatus as delivered and accepted.
- 7.21.2.2** The documentation shall address at least the inspection, service, and operations of the fire apparatus and all major components thereof.
- 7.21.2.3** The contractor shall also provide the following documentation for the entire apparatus and each major operating system or major component of the apparatus:
- (1) Manufacturer's name and address
 - (2) Country of manufacture
 - (3) Source for service and technical information
 - (4) Parts replacement information

- (5) Descriptions, specifications, and ratings of the chassis, pump (if applicable), and aerial device (if applicable)
- (6) Wiring diagrams for low-voltage and line-voltage systems to include the following information:
 - (a) Pictorial representations of circuit logic for all electrical components and wiring
 - (b) Circuit identification
 - (c) Connector pin identification
 - (d) Zone location of electrical components
 - (e) Safety interlocks
 - (f) Alternator–battery power distribution circuits
 - (g)* Input/output assignment sheets or equivalent circuit logic implemented in multiplexing systems
- (7) Lubrication charts
- (8) Operating instructions for the chassis, any major components such as a pump or aerial device, and any auxiliary systems
- (9) Precautions related to multiple configurations of aerial devices, if applicable
- (10) Instructions regarding the frequency and procedure for recommended maintenance
- (11) Overall apparatus operating instructions
- (12) Safety considerations
- (13) Limitations of use
- (14) Inspection procedures
- (15) Recommended service procedures
- (16) Troubleshooting guide
- (17) Apparatus body, chassis, and other component manufacturer's warranties
- (18) Special data required by this standard
- (19) A safety data sheet (SDS) for any fluid that is specified for use on the apparatus
- (20) For structural fire apparatus, one copy of the latest edition of FAMA's *Fire Apparatus Safety Guide*

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

7.21.2.5 Apparatus operator manuals shall be publicly accessible on the manufacturer's website.

7.21.2.6 The apparatus shall include one or more of the following:

- (1) The applicable apparatus operator manual(s) stored on the apparatus and protected in a permanent, dedicated, accessible location
- (2) The applicable apparatus operator manual(s) available to be viewed on the apparatus on an accessible electronic display
- (3) A means of accessing an Internet link to the applicable operator manual(s) for viewing on a computer, tablet, or smart phone

7.21.2.7 The apparatus operator manual shall specify the quantity and type of the following fluids used in the vehicle:

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

- (9) Power steering fluid
- (10) Cab tilt mechanism fluid
- (11) Transfer case fluid
- (12) Equipment rack fluid
- (13) CAFS air compressor system lubricant
- (14) Generator system lubricant

7.21.2.8 The operator manual(s) shall specify all technical information needed to perform NFPA 1910 certification testing as described in 7.21.1 (16).

7.21.2.9* The operator manual shall address the water fording capabilities of the vehicle.

7.22* Statement of Exceptions. The final-stage manufacturer shall deliver with the fire apparatus either a certification that the apparatus fully complies with all requirements of chapters 7 through 16 or, alternatively, a Statement of Exceptions specifically describing each aspect of the completed apparatus that is not fully compliant with the requirements of chapters 7 through 16 at the time of delivery.

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

- (1) A separate specification of the section of the applicable standard for which compliance is lacking
- (2) A description of the particular aspect of the apparatus that is not in compliance therewith or required equipment that is missing
- (3) A description of the further changes or modifications to the delivered apparatus that must be completed to achieve full compliance
- (4) Identification of the entity that will be responsible for making the necessary postdelivery changes or modifications or for supplying and installing any missing required equipment to the apparatus to achieve full compliance with chapters 7 through 16

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

7.23 EV Engine Equipped Apparatus.

7.23.1 Crash Disconnect. If the high voltage EV batteries disconnect in the event of a crash, the crash detection shall not be required to function if the ignition is OFF.

7.23.2 High Voltage Battery First Responder Cut Loops.

7.23.2.1 There shall be a first responder cutloop in the battery management circuit that, when cut, will disconnect the charge from the high voltage battery cells.

7.23.2.2 Each first responder cut loop shall be protected behind an access door large enough to reach the loop with a standard pair of bolt cutters.

7.23.2.3 The access doors shall be located one on each side the apparatus on the pump panel or body as near to the back of the cab as practical.

7.23.2.4 The access doors shall be held closed without a latch to allow quick access to the first responder cut loop.

7.23.2.5 The first responder cut loop shall have a connector between it and the rest of the battery management circuit that allows the loop to be removed to temporarily disable the high voltage system.

7.23.2.6 Safety sign FAMA58, which identifies the location of the first responder cut loop, shall be located on each access door.

7.23.3 EV Identification Sign.

7.23.3.1 Identification signs shall be located on each side of the cab and at the rear of the apparatus.

7.23.3.2 Each sign shall be in accordance with ISO 17840-4, *Road vehicles — Information for first and second responders — Part 4: Propulsion energy identification*.

7.23.3.2.1 The size of the sign for a vehicle Class 5 and below shall be 4.72 in. (120 mm) wide and 3.27 in. (83 mm) high.

7.23.3.2.2 The size of the sign for a vehicle Class 6 and above shall be 5.7 in. (145 mm) wide and 4.2 in. (107 mm) high.

7.23.4 Safety sign FAMA57, which warns of electrocution hazards, shall be visible to an operator near the charge socket of any apparatus equipped with an EV engine.

Chapter 8 Fire Apparatus — Requirements by Type (NFPA 1901/1906)

8.1* General. Apparatus shall meet the minimum requirements in Table 8.1 based on the apparatus type.

8.2* Ground Ladders.

8.2.1 All fire department ground ladders carried on the apparatus shall meet the requirements of NFPA 1931 and be new or have successfully completed the annual service test per NFPA 1932 within the last year, except as permitted by 8.2.2.

8.2.2 If stepladders or other types of multipurpose ladders are provided they shall meet the requirements of ANSI A14.2, *Ladders — Portable Metal — Safety Requirements*, or ANSI A14.5, *Ladders — Portable Reinforced Plastic — Safety Requirements*, with duty ratings of Type 1A or 1AA.

8.3* Suction Hose or Supply Hose.

8.3.1 Where suction hose is provided, the friction and entrance loss of the combination suction hose and strainer shall not exceed the losses listed in Table 13.2.4.1(b) or Table 13.2.4.1(c).

8.3.2 Where supply hose is provided, it shall have couplings or provided adapters compatible with the local hydrant outlet connection on one end and the pump intake connection on the other end.

8.3.3 Suction hose and supply hose shall meet the requirements of NFPA 1961.

8.3.4 The purchaser shall specify whether suction hose or supply hose is to be provided, the length and size of the hose, the type and size of the couplings, the manner in which the hose is to be carried on the apparatus, and the style of brackets desired.

8.4* Equipment. A detailed list of who is to furnish the equipment to be carried on the apparatus and the method for organ-

izing and mounting these items shall be supplied by the purchasing authority.

8.5 Pumper Apparatus. (Reserved)

8.6 Initial Attack Apparatus. (Reserved)

8.7* Mobile Water Supply Apparatus. (Reserved)

8.8* Aerial Apparatus. The apparatus shall be equipped with an aerial ladder, elevating platform, or water tower that meets the requirements of this standard.

8.9 Aerial Quint Apparatus. The apparatus shall be equipped with an aerial ladder or elevating platform that meets the requirements of this standard.

8.10* Special Service Apparatus. (Reserved)

8.11 Mobile Foam Apparatus. (Reserved)

8.12 Wildland Apparatus. (Reserved)

8.13* Wildland Mobile Water Supply Apparatus. (Reserved)

8.14 Wildland Crew Carrier Apparatus. (Reserved)

8.15* Wheel Chocks.

8.15.1 Wheel chocks shall be mounted in a readily accessible location.

8.15.2 Wheel chocks for structural apparatus shall each hold the apparatus under the following conditions:

- (1) Apparatus loaded to its GVWR or GCWR
- (2) Road surface pitched to 10 percent for the length of the apparatus
- (3) Hard road surface such as asphalt or concrete
- (4) Transmission in neutral
- (5) Parking brake released

8.15.3 Wheel chocks for wildland apparatus shall each hold the apparatus under the following conditions:

- (1) Apparatus loaded to its GVWR
- (2) Road surface pitched to 15 percent for the length of the apparatus
- (3) Hard road surface such as asphalt or concrete
- (4) Transmission in neutral
- (5) Parking brake released

8.15.4 Wheel chocks for wildland apparatus shall have a solid bottom.

8.16 Traffic Vests.

8.16.1 Traffic vests shall comply with ANSI/ISEA 107, *American National Standard for High-Visibility Safety Apparel and Accessories*.

8.16.2 Traffic vest shall provide a five-point breakaway feature that includes two at the shoulders, two at the sides, and one at the front.

8.17 Traffic Cones.

8.17.1 Traffic cones shall be fluorescent orange in color.

8.17.2 Traffic cones shall be not less than 28 in. (711 mm) in height.

Table 8.1 Requirements by Apparatus Type

		Pumper	Initial Attack	Mobile Water Supply	Mobile Water Supply w/ pump	Aerial	Quint	Special Service	Mobile Foam	Wildland Fire Suppression			Wildland Mobile Water Supply	Wildland Crew Carrier
	GVWR lb (kg)	—	—	—	—	—	—	—	—	10,001–14,000 lb (4501–6350 kg)	14,001–26,000 lb (6351–11,793 kg)	Over 26,000 lb (Over 11,793 kg)	—	—
Pump	Fire pump capacity — GPM (LPM)	750 (3000)	250 (1000)	—	—	—	1000 (4000)	—	750 (3000)	—	—	—	—	—
	Pump specifications chapter	13	13	—	13	—	13	—	13	13 or 15	13 or 15	13 or 15	13 or 15	—
Tank	Fire suppression fluid tank capacity water and foam — gallons (liters)	300 (1100)	200 (750)	1000 (4000)	1000 (4000)	—	300 (1100)	—	—	150 (600)	150 (600)	150 (600)	1000 (4000)	—
	Foam tank capacity — gallons (liters)	—	—	—	—	—	—	—	500 (1900)	—	—	—	—	—
Equipment storage	Equipment storage compartment capacity — ft ³ (m ³)	40 (1.1)	22 (0.6)	10 (0.3)	10 (0.3)	40 (1.1)	40 (1.1)	120 (3.4)	40 (1.1)	20 (0.5)	50 (1.4)	75 (2.1)	20 (0.5)	—
Hose Storage	Fire hose storage volume — ft ³ (m ³)	37 (1.0)	17 (0.5)	6 (0.2)	6 (0.2)	—	37 (1.0)	—	37 (1.0)	—	—	—	—	—
	Fire hose for a protection line 1-½ in. (38 mm) or larger	—	—	—	100 (30)	—	—	—	—	—	—	—	—	—
	Supply hose storage — ft (m)	—	—	—	—	—	—	—	—	—	—	—	15 (4.5)	—
	Suction hose storage — ft (m)	—	—	—	—	—	—	—	—	—	—	—	20 (6.0)	—
Roadside Safety	Wheel chocks — structural	2	2	2	2	2	2	2	2	—	—	—	—	—
	Wheel chocks — wildland	—	—	—	—	—	—	—	—	2	2	2	2	2
	Traffic vests	1 per seating position												
	Traffic cones	5	5	5	5	5	5	5	5	—	—	—	—	—
	Illuminated traffic warning devices	5	5	5	5	5	5	5	5	5	5	5	5	5
	Traffic warning triangle kit	—	—	—	—	—	—	—	—	1	1	1	1	1
	Tire tools (if spare tire is provided)	—	—	—	—	—	—	—	—	1	1	1	1	1
Aerial Safety	Ladder belts meeting the requirements of NFPA 2500	—	—	—	—	4	4	—	—	—	—	—	—	—

8.17.3 Traffic cones shall be equipped with a 6 in. (152 mm) retroreflective white band no more than 4 in. (102 mm) from the top of the cone, and an additional 4 in. (102 mm) retroreflective white band 2 in. (51 mm) below the 6 in. (152 mm) band

8.18 Illuminated Traffic Warning Devices.

8.18.1 Illuminated traffic warning devices shall be self-illuminating such as fusee flares, liquid-burning flares, or battery powered warning lights.

8.18.2 Traffic cones shall be permitted to satisfy this requirement if they include a self-illuminating feature.

8.19 Traffic Warning Triangle Kit.

8.19.1 A traffic warning triangle kit shall include three reflective triangles.

8.19.2 Traffic warning triangles shall comply with the requirements of 49 CFR 571.125 Standard No. 125, Warning devices.

8.19.3 Three traffic cones shall be permitted to satisfy this requirement.

8.20 Tire Tools. If a tire tool kit is specified it shall include a jack and a lug wrench.

Chapter 9 Fire Apparatus — Chassis and Vehicle Components (NFPA 1901/1906)

9.1* Carrying Capacity. The GAWR and the GCWR or GVWR of the chassis shall be adequate to carry the weight of the fire apparatus when loaded to its estimated in-service weight as defined in 9.1.2.

9.1.1 The manufacturer shall establish the estimated in-service weight during the design of the fire apparatus.

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

- (1) The chassis, body, and tank(s)
- (2) Full fuel, lubricant, and other chassis or component fluid tanks or reservoirs
- (3) Full water and other agent tanks
- (4)* 250 lb (114 kg) in each seating position
- (5)* Fixed equipment such as pumps, aerial devices, generators, reels, and air systems as installed
- (6) Ground ladders, suction hose, designed hose load in their hose beds and on their reels
- (7)* An allowance for miscellaneous equipment that is the greatest of the following:
 - (a) The values shown in Table 9.1.2
 - (b) A purchaser-provided list of equipment to be carried with weights
 - (c) A purchaser-specified miscellaneous equipment allowance
- (8)* If a wildland fire apparatus is designed to accommodate SCBA, an additional 25 lb (11.4 kg) per seating position to the miscellaneous equipment allowance

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

Table 9.1.2 Miscellaneous Equipment Allowance

Apparatus Type	Apparatus Size	Equipment Allowance	
		lb	kg
Pumper fire apparatus	Less than 250 ft ³ (7 m ³) compartment space*	2,000	910
	250 ft ³ (7 m ³) or more of compartment space*	2,500	1,135
Initial attack fire apparatus	10,001 lb to 15,000 lb (4,501 kg to 7,000 kg) GVWR	900	410
	15,001 lb to 20,000 lb (7,001 kg to 9,000 kg) GVWR	1,500	680
	20,001 lb (9,000 kg) and up GVWR	2,000	910
Mobile water supply fire apparatus	All	1,000	455
Aerial fire apparatus	All	2,500	1,135
Quint fire apparatus	All	2,500	1,135
Special service fire apparatus	10,001 lb to 15,000 lb (4,501 kg to 7,000 kg) GVWR	2,000	910
	15,001 lb to 20,000 lb (7,001 kg to 9,000 kg) GVWR	2,500	1,135
	20,001 lb to 30,000 lb (9,001 kg to 14,000 kg) GVWR	3,000	1,350
	30,001 lb to 40,000 lb (14,001 kg to 18,000 kg) GVWR	4,000	1,800
	40,001 lb to 50,000 lb (18,001 kg to 23,000 kg) GVWR	6,000	2,700
	50,001 lb to 60,000 lb (23,001 kg to 27,000 kg) GVWR	8,000	3,600
Mobile foam fire apparatus	60,001 lb (27,001 kg) and up GVWR	10,000	4,500
	All	2,000	910
Wildland fire suppression apparatus	10,001 to 16,000 lb (4,501 to 7,260 kg) GVWR	200	90
	16,001 to 19,500 lb (7,261 to 8,845 kg) GVWR	500	225
	19,501 to 26,000 lb (8,846 to 12,000 kg) GVWR	500	225
	>26,000 lb (>12,000 kg) GVWR	750	340

(continues)

Table 9.1.2 *Continued*

Apparatus Type	Apparatus Size	Equipment Allowance	
		lb	kg
Wildland mobile water supply apparatus	All	200	90
Wildland fire crew carrier	≤19,500 lb (≤8,845 kg) GVWR	500	225
apparatus	>19,500 lb (>8,845 kg) GVWR	750	340

*Compartment space for pumpers is calculated based on the inside dimensions of the enclosed compartment.

9.1.4* A final manufacturer's certification of the GVWR or GCWR, along with a certification of each GAWR, shall be supplied on a label affixed to the vehicle.

9.1.5 The fire apparatus manufacturer shall permanently affix a high-visibility label in a location visible to the driver while seated.

9.1.5.1* The label shall show the height of the completed unequipped fire apparatus in feet and inches (meters), the length of the completed fire apparatus in feet and inches (meters), and the GVWR in tons (metric tons).

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

9.2 Engine and Engine System Design.

9.2.1 Chassis Engine.

9.2.1.1 Engine derate programming shall be permitted to be used to protect the engine.

9.2.1.2 IC Engine Speed Auxiliary Control Device.

9.2.1.2.1* If an IC engine speed auxiliary control device is provided, an interlock shall prevent the operation of the IC engine speed auxiliary control device unless the parking brake is engaged and the transmission is in neutral or park, or the parking brake is engaged and the IC engine is disengaged from the drive wheels.

9.2.1.2.2 The IC engine shall be prevented from regulating its own speed during times when speed control is critical for consistent apparatus functions such as generator, water pump, or aerial operation.

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

9.2.1.4 A means of displaying the total engine run time in hours shall be provided.

9.2.2 Cooling System. The engine's cooling system shall maintain a temperature in the engine at or below the engine manufacturer's maximum temperature rating under all conditions for which the apparatus is designed.

9.2.3 Lubrication System. A permanent label in the driving compartment shall specify the quantity and type of the following applicable fluids used in the vehicle and the following tire information:

- (1) Engine oil
- (2) Engine coolant
- (3) Chassis transmission fluid
- (4) Pump transmission lubrication fluid
- (5)* Front tire cold pressure
- (6)* Rear tire cold pressure
- (7) Maximum tire speed ratings

9.2.4* Air Intake System for IC Engines.

9.2.4.1* The air intake shall be equipped with a means of separating water and burning embers from the air intake system.

9.2.4.2 The requirement in 9.2.4.1 shall be permitted to be achieved by either of the following methods:

- (1) A device such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the air filter element
- (2) A device capable of meeting the test requirements of FAMA TC079, *Ember Separator Test*

9.2.5 Fuel System for IC Engines.

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

9.2.5.2 The filters or strainers shall be of a serviceable type and mounted in an accessible location.

9.2.6 Exhaust System for IC Engines.

9.2.6.1 The exhaust piping and discharge outlet shall be located or shielded so as not to expose any portion of the apparatus or equipment to excessive heating.

9.2.6.2 Exhaust pipe discharge shall be directed away from any operator's position.

9.2.6.3 If the apparatus is equipped with stabilizers, the exhaust piping discharge shall be directed away from the contact area between the stabilizer and the ground when the stabilizer is deployed.

9.2.6.4 Where parts of the exhaust system are exposed so that they are likely to cause injury to operating personnel, protective guards shall be provided.

9.2.6.5 Exhaust System for Diesel Engines.

9.2.6.5.1 Diesel engine equipped apparatus having GVWR of 19,501 lb (8,846 kg) or greater shall be equipped with a switch located in the driver's area of the driving compartment to initiate the regeneration process manually.

9.2.6.5.2 Instructions for initiating the manual regeneration process shall be explained in the apparatus operator's manual.

9.2.6.5.3* For apparatus over 19,501 lb (8,846 kg), a switch shall be provided at the driver's area that will inhibit inhibit

diesel particulate filter (DPF) regeneration until the switch is reset or the engine is shut down and restarted.

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

9.3 Vehicle Components.

9.3.1 Braking System.

9.3.1.1 All brakes shall be accessible for adjustment.

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

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

9.3.1.3 Quick Buildup System.

9.3.1.3.1 Structural fire apparatus braking systems shall include a quick buildup section in the air reservoir system arranged so that if the apparatus has a completely discharged air system it is able to move within 60 seconds of startup.

9.3.1.3.2 The quick buildup system shall provide sufficient air pressure so that the apparatus has no brake drag and is able to stop under the intended operating conditions following the 60-second buildup time.

9.3.1.3.3* On a chassis that cannot be equipped with a quick buildup air brake system, an onboard automatic electric compressor or a fire station compressed air shoreline hookup shall be permitted to maintain full operating air pressure while the vehicle is not running.

9.3.1.4* Auxiliary Brake.

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

9.3.1.4.2 Auxiliary brakes shall have a switch to turn them off during adverse road conditions.

9.3.1.4.3 The DOT brake lights shall illuminate when the auxiliary brake is applied.

9.3.1.5 All fire apparatus, including those with an axle rated greater than 29,000 lb, (13,154 kg) shall comply with 49 CFR 571.121.

9.3.2 Suspension and Wheels.

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

9.3.2.2* Safety sign FAMA12, which warns of the special requirements for fire-service-rated tires, shall be visible to the driver entering the cab of any apparatus so equipped.

9.3.2.3 Ground Clearance.

9.3.2.3.1 For structural fire apparatus axle housings and any components other than wheels, tires, automatic tire chains, and

items designed to swing clear shall clear the road surface by at least 8 in. (203 mm).

9.3.2.3.2 For wildland fire apparatus any components other than axle housings, wheels, tires, automatic tire chains, and items designed to swing clear shall clear the road surface by at least the ground clearance specified in Table 9.3.2.3.2.

9.3.2.4* Approach and Departure Angles.

9.3.2.4.1 For structural fire apparatus, an angle of approach and an angle of departure of at least 8 degrees shall be maintained at the front and the rear of the vehicle when it is loaded to the estimated in-service weight.

9.3.2.4.2 For wildland fire apparatus, an angle of approach and an angle of departure of at least 20 degrees shall be maintained at the front and the rear of the vehicle when it is loaded to the estimated in-service weight.

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

9.3.2.6 The power train of a wildland fire apparatus shall allow the vehicle to function and operate smoothly at 2 mph (3.2 km/hr).

9.3.3 Steering.

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

9.3.3.2 Power steering or power-assisted steering shall be provided.

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

9.3.4 IC Engine Fuel Tank.

9.3.4.1* For structure fire apparatus, the fuel capacity shall allow the engine to drive the pump for 2½ hours at rated pump capacity at 150 psi (1000 kPa) net pump pressure and at the suction conditions specified in this standard.

9.3.4.2 The tank fill opening shall be marked with a label indicating the type of fuel to be used.

9.3.4.3 The tank fill piping shall be placed so it is protected from mechanical damage during the normal use of the fire apparatus.

9.3.4.4 The tank and the fill piping shall be located or shielded so that they are not exposed to heat from an exhaust system or other source of ignition on the apparatus.

Table 9.3.2.3.2 Under-Vehicle Clearance

Chassis GVWR		Ground Clearance	
lb	kg	in.	mm
10,001–16,000	4536–7257	12	300
16,001–19,500	7258–8845	13	330
19,501 and above	8846 and above	15	380

9.3.4.5 The tank shall be placed so it is removable for repairs.

9.3.4.6 On structural fire apparatus a means for draining the tank without removing the tank shall be supplied.

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

9.3.6 Towing Capability. If the apparatus is equipped for towing a trailer, the provisions of 9.3.6.1 through 9.3.6.5 shall apply.

9.3.6.1 For hydraulic-brake-equipped, electric-brake-equipped, or non-brake-equipped trailer towing capability, a primary electrical receptacle shall comply with both of the following:

- (1) Be provided near the hitch point
- (2) Match the umbilical cable specified in 25.10.4.5

9.3.6.2 For air-brake-equipped trailer towing capability, the following shall apply:

- (1) A primary electrical receptacle shall be provided near the hitch point.
- (2) The primary electrical receptacle shall match the umbilical cable specified in 25.10.4.4.
- (3) Gladhands shall be provided for air brake connections.

9.3.6.3 Auxiliary Receptacle.

9.3.6.3.1 An auxiliary electrical receptacle shall be provided near the hitch point.

9.3.6.3.2 The auxiliary receptacle shall match the umbilical cable specified in 25.10.4.6.

9.3.6.4 A label that states the maximum GVWR and tongue weight of the trailer that can be towed with the hitch system shall be provided in a location in which it is visible to an operator making trailer connections.

9.3.6.5 Two safety chain attachment points shall be provided near the hitch point for hitches designed to use safety chains, each designed with an ultimate strength of not less than the maximum GVWR specified on the label required in 9.3.6.4.

9.4 Tractor-Drawn Aerial Fire Apparatus.

9.4.1 If a tractor-drawn vehicle is provided for an aerial fire apparatus, it shall consist of a tractor with a permanent, nonking-pinned "fifth wheel" mounted on the rear of the chassis to carry the forward end of the aerial ladder trailer unit.

9.4.2 The fifth wheel and body design shall be of a type that allows full 90-degree jackknifing of the tractor trailer combination with the stabilizers in the stored position.

9.4.3 A steering wheel shall be provided to steer the rear wheels of the trailer unit.

9.4.4 The steering shall be of the power or power-assisted type.

9.4.5 A minimum wheel cramp angle of 20 degrees right and left shall be provided.

9.4.6 An audible and visual warning system shall be provided to warn both drivers when the jackknife position approaches the manufacturer's maximum allowable position.

9.4.7 If the manufacturer's design does not permit the load from the aerial device to be transferred to the rear springs of the tractor, a device shall be installed that will prevent such a weight transfer.

Chapter 10 Fire Apparatus — Low Voltage Electrical Systems and Warning Devices (NFPA 1901/1906)

10.1* General. Any low voltage electrical systems or warning devices installed on the fire apparatus shall be appropriate for the mounting location and intended electrical load and shall meet the specific requirements of Chapter 10.

10.2 Wiring. All electrical circuit feeder wiring supplied and installed by the fire apparatus manufacturer shall meet the requirements of 10.2.1 through 10.2.8.

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

10.2.1.1 Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent.

10.2.1.2 The use of star washers for circuit ground connections shall not be permitted.

10.2.1.3 All circuits shall otherwise be wired in conformance with SAE J2202, *Heavy-Duty Wiring Systems for On-Highway Trucks*, or for trailer wiring, SAE J2174, *Heavy-Duty Wiring Systems for Trailers 2032 mm or More in Width*.

10.2.2 Wiring and Wire Harness Construction.

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

10.2.2.1.1 All conductors shall be constructed in accordance with SAE J1127 or SAE J1128, except where good engineering practice dictates special strand construction.

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

10.2.2.1.3 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127 or SAE J1128, except where good engineering practice dictates special conductor insulation.

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

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

10.2.4 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection.

10.2.4.1 The wiring connections and terminations shall be installed in accordance with the device manufacturer's instructions.

10.2.4.2* All ungrounded electrical terminals shall have protective covers, enclosures, or a means to protect from accidental shorting.

10.2.4.3 Wire nut, insulation displacement, and insulation piercing connections shall not be used.

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

10.2.6* Wiring shall be uniquely identified at least every 2 ft (0.6 m) by color coding or permanent marking with a circuit function code. The identification shall reference a wiring diagram. [See 7.21.2.3(6).]

10.2.7 Circuits shall be provided with properly rated low voltage overcurrent protective devices.

10.2.7.1 Such devices shall be readily accessible and protected against heat in excess of the overcurrent device's design range, mechanical damage, and water spray.

10.2.7.2 Circuit protection shall be accomplished by utilizing fuses, circuit breakers, fusible links, or solid state equivalent devices.

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

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

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

10.3 Power Supply.

10.3.1* An alternator or other means of charging the apparatus's low voltage electrical system while operating shall be provided.

10.3.2* The charging system shall comply with both of the following:

- (1) Have a minimum output at idle to meet the minimum continuous electrical load of the fire apparatus as defined in 10.3.3, at 200°F (93°C) ambient temperature within the engine compartment
- (2) Be provided with full automatic regulation

10.3.3 Minimum Continuous Electrical Load.

10.3.3.1 The minimum continuous electrical load shall consist of the total amperage required to simultaneously operate the following in a stationary mode during emergency operations:

- (1) The propulsion engine and transmission
- (2) All legally required clearance and marker lights, headlights, and other electrical devices except windshield wipers and four-way hazard flashers
- (3) The radio(s) at a duty cycle of 10 percent transmit and 90 percent receive (for calculation and testing purposes, a default value of 5 A continuous)

- (4) The lighting necessary to produce 5 fc (50 lx) of illumination on all control and instrument panels
- (5) On structural fire apparatus, the lighting necessary to produce 2 fc (20 lx) of illumination on all walking surfaces on the apparatus and on the ground at all egress points onto and off the apparatus, and 50 percent of the total compartment lighting loads
- (6) The minimum optical warning system required in Section 10.7, where the apparatus is blocking the right-of-way
- (7) The continuous electrical current required to simultaneously operate any water pumps, aerial devices, and hydraulic pumps
- (8)* Other warning devices and electrical loads that are designated as critical to the mission of the apparatus

10.3.3.2 If the apparatus is equipped to tow a trailer, an additional 45 A shall be added to the minimum continuous electrical load to provide electrical power for the federally required clearance and marker lighting and the optical warning devices mounted on the trailer.

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

10.3.4.1 The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the electrical system voltage.

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

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

10.3.6 Load Management.

10.3.6.1* If the total continuous electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 10.3.2, an automatic electrical load management system shall be required.

10.3.6.2 The minimum continuous electrical loads defined in 10.3.3 shall not be subject to automatic load management.

10.4* Low Voltage Batteries.

10.4.1 Low voltage batteries shall be of the high-cycle type.

10.4.2 With the engine off, the low voltage battery system shall be able to provide the minimum continuous electrical load for 10 minutes without discharging more than 50 percent of the reserve capacity and then to restart the engine.

10.4.3 The low voltage battery system cold cranking amps (CCA) rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer.

10.4.4 The low voltage batteries shall be mounted to prevent movement during fire apparatus operation and be protected against accumulations of road spray, snow, and road debris.

10.4.4.1 The low voltage batteries shall be readily accessible for examination, testing, and maintenance.

10.4.4.2 A means shall be provided for jump-starting the engine if the low voltage batteries are not accessible without lifting the cab of a tilt-cab apparatus.

10.4.4.3 Where an enclosed low voltage battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes.

10.4.4.4* The low voltage batteries shall be protected against vibration and temperatures that exceed the battery manufacturer's recommendation.

10.4.4.5 Safety sign FAMA01, which warns of battery chemical and explosion hazard, shall be visible to personnel near batteries.

10.4.5* Low Voltage Battery Charger.

10.4.5.1 An onboard low voltage battery conditioner or charger or a polarized inlet shall be provided for charging all batteries.

10.4.5.2 Where an onboard conditioner or charger is supplied, the associated line-voltage electrical power system shall be installed in accordance with Chapter 21.

10.4.5.3 The rated output of the low voltage battery charger shall exceed the draw of any loads that draw power when the major load disconnect switch is turned off.

10.4.6 A major load disconnect switch shall be provided to minimize the electrical drain on the low voltage batteries when the switch is in the OFF position.

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

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

10.7 Optical Warning Systems. Each structural apparatus shall have an optical warning system that meets or exceeds the requirements of this section.

10.7.1 Wildland apparatus shall meet one of the following criteria:

- (1) Have an optical warning system that meets or exceeds the requirements of this section
- (2) For wildland fire apparatus that is not equipped to call for or block right-of-way on public roads, have a sign affixed on the dashboard that reads as follows: "This apparatus is not equipped to call for or block right-of-way on public highways."

10.7.2* The optical warning system shall include an upper and a lower level of optical warning devices.

10.7.3 The requirements for each level shall be met by the warning devices in that particular level without consideration of the warning devices in the other level.

10.7.4 For defining and measuring the required optical performance (not the physical device mounting locations), the upper and lower warning levels shall be divided into four warning zones.

10.7.4.1 The four warning zones shall be determined by lines drawn from the vehicle centerline out through the corners of the apparatus at 45 degrees to a line drawn lengthwise through the geometric center of the apparatus.

10.7.4.2* The four warning zones shall be designated A, B, C, and D in a clockwise direction, with zone A to the front of the apparatus. (See Figure 10.7.4.2.)

10.7.4.3 Optical system compliance by zone shall be provided.

10.7.4.4* An optical warning system shall consist of eight individual zones — four zones on the upper level and four zones on the lower level.

10.7.5 Each optical warning device shall be installed on the apparatus and connected to the apparatus's electrical system in accordance with the applicable requirements of this standard and the requirements of the manufacturer of the device.

10.7.6* A master optical warning system switch that energizes all the optical warning devices shall be provided.

10.7.7* The optical warning system on the fire apparatus shall be capable of at least two separate signaling modes during emergency operations.

10.7.7.1 One mode shall signal to drivers and pedestrians that the apparatus is responding to an emergency and is calling for the right-of-way.

10.7.7.2 One mode shall signal that the apparatus is stopped and is blocking the right-of-way.

10.7.7.3 Any optical characteristic changes made within any mode shall meet the minimum requirements of this chapter.

10.7.8 Mode Selection.

10.7.8.1 A switching system shall be provided that senses the position of the parking brake or the park position of an automatic transmission.

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

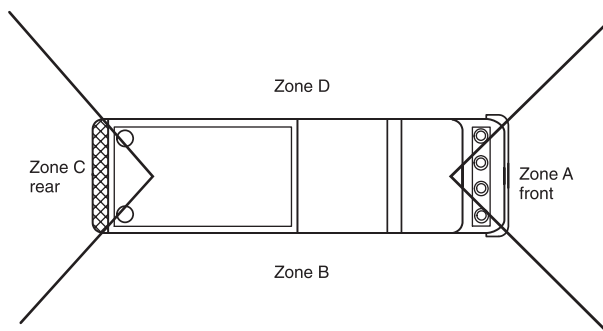


FIGURE 10.7.4.2 Warning Zones for Optical Warning Devices.

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

10.7.8.4 Any method used in changing a signaling mode shall comply with the requirements of this chapter.

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

10.7.10* The optical warning devices shall not impair the effectiveness of lighting devices required under 49 CFR 571, FMVSS 108 including headlights, turn signals, clearance lights, and brake lights.

10.7.11* The optical warning light systems shall have optical sources on each level and in each zone so that failure of a single optical source does not create a zone without a visible warning signal at a distance of 100 ft (30 m) from the geometric center of the apparatus.

10.7.12 Flashing.

10.7.12.1 Flash Rate. The flash rate of any optical source shall be between 60 and 240 flashes per minute.

10.7.12.2 Steady Lights. The optical energy provided by nonflashing optical sources, or the steady burning part of an optical flash characteristic, shall not be included in the calculations of the zone's total optical power.

10.7.13 Color of Warning Lights.

10.7.13.1 Permissible optical colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table 10.7.13.1.

10.7.13.1.1 The optical energy provided by green optical sources shall not be included in the calculations of the zone's total optical power or meeting the requirements for any required lights.

10.7.13.2 All colors shall be as specified in SAE J578, *Chromaticity Requirements of Ground Vehicle Lamps and Lighting Equipment*, for red, blue, yellow, green, or white.

10.7.14* Requirements for Large Apparatus.

10.7.14.1 If the apparatus has a bumper-to-bumper length of 25 ft (7.6 m) or more or has an optical center on any optical warning device greater than 8 ft 6 in. (2.6 m) above level ground, the requirements of 10.7.14.2 through 10.7.14.6 shall apply.

Table 10.7.13.1 Zone Colors

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

10.7.14.2 Upper-Level Optical Warning Devices.

10.7.14.2.1 To define the clearance lines of the vehicle, the optical center of the upper-level optical warning devices shall be mounted as high and as close to the corner points of the apparatus as is practicable.

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

10.7.14.3 Lower-Level Optical Warning Devices.

10.7.14.3.1 To define the clearance lines of the apparatus, the optical center of the lower-level optical warning devices in the front of the vehicle shall be mounted on or forward of the front axle centerline and as close to the front corner points of the apparatus as is practicable.

10.7.14.3.2 The optical center of the lower-level optical warning devices at the rear of the vehicle shall be mounted on or behind the rear axle centerline and as close to the rear corners of the apparatus as is practicable.

10.7.14.3.3 The optical center of any lower-level device shall be between 18 in. and 62 in. (460 mm and 1600 mm) above level ground.

10.7.14.4 Midship Optical Warning Devices.

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

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

10.7.14.4.3 The optical center of any midship-mounted optical warning device shall be between 18 in. and 62 in. (460 mm and 1600 mm) above level ground.

10.7.14.5* For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone total optical power requirements shown in Table 10.7.14.5.

10.7.14.6 No individual photometric measurement point shall be less than that shown in Table 10.7.14.5.

10.7.15* Requirements for Small Apparatus.

10.7.15.1 If the apparatus has a bumper-to-bumper length of less than 25 ft (7.6 m) and has the optical center of all optical warning devices at 8 ft 6 in. (2.6 m) or less above level ground, the requirements of 10.7.15.2 through 10.7.15.5 shall apply.

10.7.15.2 Upper-Level Optical Warning Devices.

10.7.15.2.1 The upper-level optical warning devices shall be mounted as high as practicable, but not over 8 ft 6 in. (2.6 m), at the optical center.

10.7.15.2.2* The upper-level optical warning devices shall consist of a single optical warning device providing 360 degrees of conspicuity or a combination of optical devices creating 360 degrees of conspicuity.

Table 10.7.14.5 Minimum Optical Power Requirements for Large Apparatus

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

Notes:

(1) All values are in candela-seconds/minute.

(2) *H* = Horizontal plane passing through the optical center.(3) The values in the *H* Total columns are the total of 19 data point values for each light, with data points on the boundary between zones counted in both zones.**10.7.15.3 Lower-Level Optical Warning Devices.****10.7.15.3.1** One or more lower-level optical warning devices shall be visible from the front and the side of the apparatus.**10.7.15.3.2** To define the front clearance lines of the vehicle, the optical center of the lower-level optical warning devices in the front of the vehicle shall be mounted on or forward of the front wheel centerline and as close to the front corner points of the apparatus as is practicable.**10.7.15.3.3** The optical center of the device(s) shall be between 18 in. and 48 in. (460 mm and 1220 mm) above level ground.**10.7.15.4** For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone's total optical power requirements shown in Table 10.7.15.4.**10.7.15.5** No individual photometric measurement point shall be less than that shown in Table 10.7.15.4.**Table 10.7.15.4 Minimum Optical Power Requirements for Small Apparatus**

		Mode of Operation					
		Calling for Right-of-Way			Blocking Right-of-Way		
		At Any Point 5 Degrees Up or 5 Degrees Down from <i>H</i>			At Any Point 5 Degrees Up or 5 Degrees Down from <i>H</i>		
Zone	Level	<i>H</i> Total	At Any <i>H</i> Point	<i>H</i>	<i>H</i> Total	At Any <i>H</i> Point	<i>H</i>
A	Upper	1,000,000	10,000	3,500	400,000	10,000	3,500
B	Upper	200,000	8,000	3,500	200,000	8,000	3,500
C	Upper	400,000	10,000	3,500	800,000	10,000	3,500
D	Upper	200,000	8,000	3,500	200,000	8,000	3,500
A	Lower	150,000	3,750	1,300	150,000	3,750	1,300
B	Lower	75,000	1,875	650	75,000	1,875	650
C	Lower	0	0	0	0	0	0
D	Lower	75,000	1,875	650	75,000	1,875	650

Notes:

(1) All values are in candela-seconds/minute.

(2) *H* = Horizontal plane passing through the optical center.(3) The values in the *H* Total columns are the total of 19 data point values for each light, with data points on the boundary between zones counted in both zones.

10.7.16 Tests of Optical Warning Devices.

10.7.16.1 Mechanical and Environmental Test.

10.7.16.1.1 All optical warning devices and components shall be tested in accordance with SAE J845, *Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, and comply with the following performance requirements of that standard:

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

10.7.16.2 Photometric Test Procedures for Optical Devices.

10.7.16.2.1 Testing shall be performed by, or on behalf of, the device manufacturer to ensure compliance with the requirements of 10.7.16.2.1.1 through 10.7.16.2.2.2.

10.7.16.2.1.1 Testing Results.

(A) The results of the testing shall be used to determine compliance.

(B) All required photometric data shall be available, upon request, from the optical warning device manufacturer.

10.7.16.2.1.2 All optical warning devices shall be tested with the test procedures of SAE J845, *Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, under the following conditions:

- (1) Optical measurements shall be made in candela-seconds per minute
- (2) Optical measurements shall be made for the photometric measurement points defined in 10.7.16.2.2.
- (3) Optical power shall be measured at photometric stability, not adjusted back to 1-minute photometric performance.

10.7.16.2.2 Photometric Measurement Points.

10.7.16.2.2.1 Measurements shall be made along the horizontal plane that passes through the optical center, beginning at the optical center and repeated at 5-degree intervals to the left and to the right of the optical center throughout the active horizontal angle of light emission of the optical source.

10.7.16.2.2.2 Measurements shall be repeated at 5 degrees up and 5 degrees down from the horizontal plane that passes through the optical center, beginning at a point on the vertical plane passing through the optical center and repeated at 5 degree intervals to the left and to the right of this vertical plane throughout the active horizontal angle of light emission of the optical source.

10.7.17* Compliance Documentation. The apparatus manufacturer shall demonstrate compliance of the optical warning system optical power requirements by one of the following methods:

- (1) Certification that the optical warning devices were installed within the geometric parameters specified by the manufacturer of the devices and referencing certification by the optical warning device manufacturer that the

system meets or exceeds the minimum optical power requirements for the specified zone and level

- (2) Certification that a mathematical calculation based on photometric test reports for individual optical sources provided by the manufacturer of the devices and performed by a qualified person demonstrates that the combination of individual devices as installed meets the requirements for the specified zone and level

10.8 Audible Warning Devices.

10.8.1 Audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren shall be provided.

10.8.1.1 The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens*.

10.8.1.2* A means shall be provided to allow the activation of the siren within convenient reach of the driver.

10.8.2 Where furnished, air horns, electric siren(s), and electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as is practicable.

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

10.8.4 Safety sign FAMA42, which warns of the dangers of siren noise, shall be located on the inside of the driver cab door.

10.9* Work Lighting. All light level measurements shall be made with a light meter with a hemispherical light sensor held against the surface, facing perpendicular to the surface, and not deliberately pointed toward the light source.

10.9.1 Ground Lighting. Ground lighting requirements shall apply to structural fire apparatus only.

10.9.1.1* Rear Work Area.

10.9.1.1.1 The work area immediately behind the vehicle shall be illuminated to an average level of at least 3 fc (30 lx), measured at the center of 25 equally spaced 2 ft² divisions within a 10 ft × 10 ft (3 m × 3 m) grid that is square to the rear of the vehicle, as shown in Figure 10.9.1.1.1.

10.9.1.1.2 At least 80 percent of the 25 measurements shall meet or exceed 3 fc (30 lx).

10.9.1.1.3 If the apparatus includes an aerial platform stowed over the rear work area, the measurements shall be made with the aerial raised.

10.9.1.2 The fire apparatus shall be equipped with lighting that is capable of providing illumination at a minimum level of 2 fc (20 lx) on ground areas within 30 in. (800 mm) of the edge of the apparatus in areas designed for personnel to climb onto the apparatus or descend from the apparatus to the ground level.

10.9.1.3 Lighting designed to provide illumination on areas under the driver and crew riding area exits shall be switchable but activated automatically when the exit doors are opened.

10.9.1.4 All other ground area lighting shall be switchable.

10.9.2* Hose Bed Lighting. Hose bed lighting requirements shall apply to structural fire apparatus only.

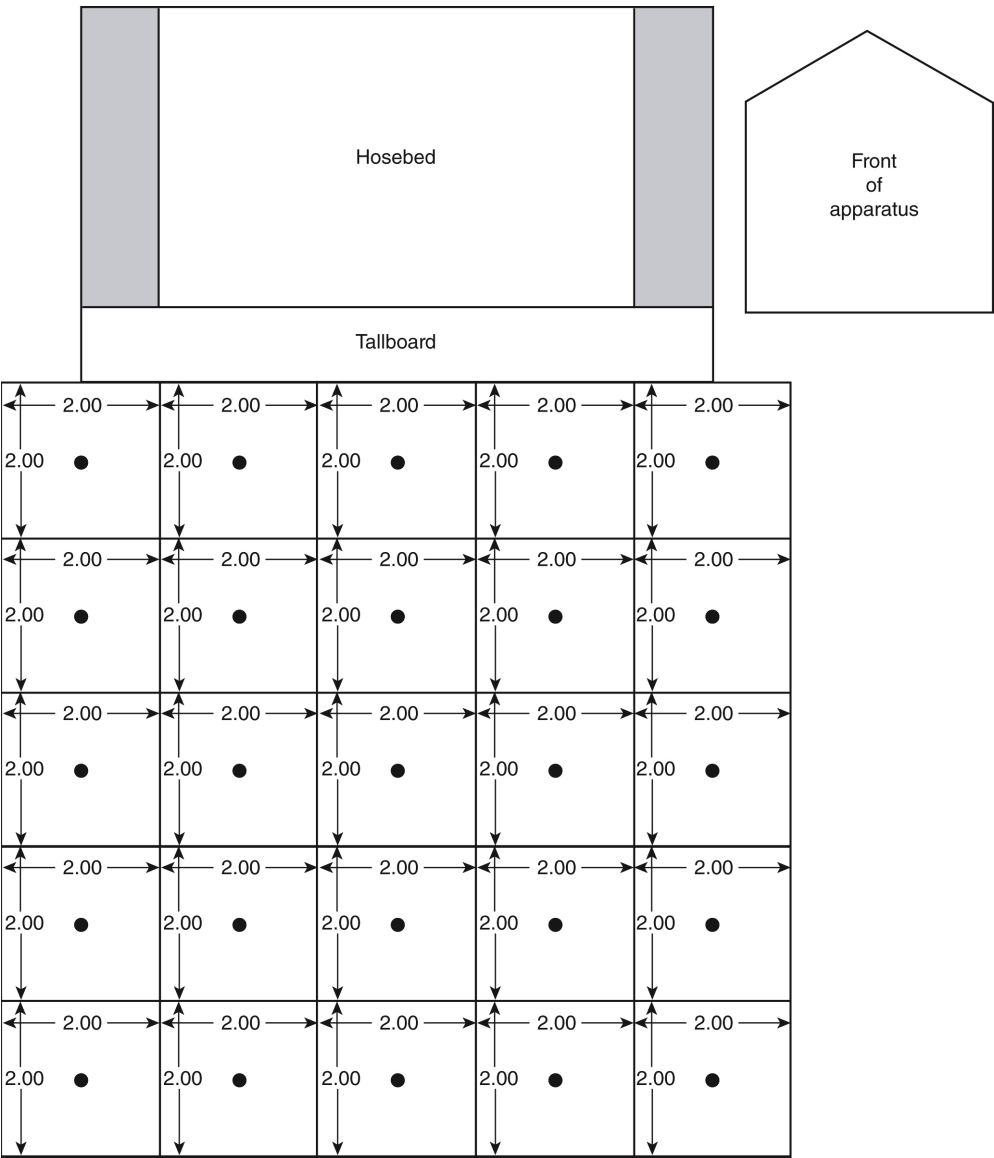


FIGURE 10.9.1.1.1 Measurement Grid for Lighting.

10.9.2.1 If a hose bed is provided, lighting on the hose bed floor shall be at an average level of 3 fc (30 lx) or higher measured at 30 in. equally spaced intervals along the center of the hose bed floor with all dividers and covers removed.

10.9.2.2 Lateral hose beds (i.e., crosslays) shall not be required to be illuminated.

10.9.3* Surface Lighting. Structural fire apparatus shall have sufficient lighting to provide a minimum level of 2 fc (20 lx) on all work surfaces, steps, and walkways.

10.9.4* Interior Lighting. Structural fire apparatus shall have sufficient lighting to provide an average level of 2 fc (20 lx) at each seating surface when measured at the center and at each corner of the seat cushion in the driving and crew compartments.

10.9.5 Compartment Lighting. Compartment lighting requirements shall apply to structural fire apparatus only.

10.9.5.1 Each engine compartment and pump compartment shall have a light of at least 20 candlepower (250 lumens).

10.9.5.2 The priming lubricant reservoir, if applicable, shall be illuminated.

10.9.5.3 Each enclosed tool and equipment compartment greater than 4 ft³ (0.1 m³) in volume and having an opening greater than 144 in.² (92,900 mm²) shall have sufficient compartment lighting to provide a minimum of 2 fc (20 lx) at any location on the floor of the compartment without any shelves, dividers, or equipment in the compartment.

10.9.5.4 Compartments such as ladder tunnels, pike pole storage tubes, or underbody compartments designed around the volumetric requirements of specific equipment that can be removed without the use of article illumination shall not be required to have compartment lighting.

10.9.6 Switching. Switches for all work lighting on structural fire apparatus shall be readily accessible.

10.9.7 Protection. The work lights on structural fire apparatus shall be arranged or protected to minimize accidental breakage.

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

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

10.9.9* Thermal Degradation. All devices used for work or scene lighting shall show no more than 25 percent drop in light output from initial turn-on with the light at room temperature to photometric stability per SAE J1889, *L.E.D. Signal and Marking Lighting Devices*.

10.9.10* Scene Lighting Systems. Where fixed low-voltage scene lights are supplied, the requirements in 10.9.10.1 through 10.9.10.2.4 shall apply.

10.9.10.1 All scene lights shall be as follows:

- (1) Provided with a lens or a means for preventing damage from water spray
- (2) Designed for wet locations

10.9.10.2* Handle on Lights.

10.9.10.2.1* If the light is directly adjustable and the housing temperature can exceed 131°F (55°C) at 110°F (43°C) ambient temperature, a handle shall be provided.

10.9.10.2.2 The design of the light shall not allow the temperature of the handle to exceed 131°F (55°C) at 110°F (43°C) ambient temperature.

10.9.10.2.3 If manually operated floodlights are not operable from the ground, access steps that meet the requirements of Section 12.6 and handrails that meet the requirements of Section 12.7 shall be provided to allow the user to reach the floodlights.

10.9.10.2.4 Any scene lights shall be mounted in a way that they do not block the DOT clearance or identification lights on the cab or the body.

10.10 Hazard Light. Hazard light requirements shall apply to structural fire apparatus only.

10.10.1 A red flashing or rotating light, located in the driving compartment, shall be illuminated automatically whenever the apparatus's parking brake is not fully engaged and any of the following conditions exist:

- (1) Any driver, passenger, or equipment compartment door is not closed.
- (2) Any ladder or equipment rack is not in the stowed position.
- (3) The stabilizer system is not in its stowed position.

- (4) The powered light tower is not stowed.
- (5) Any other device permanently attached to the apparatus is open, extended, or deployed in a manner that is likely to cause damage to the apparatus if the apparatus is moved.

10.10.2 Compartments meeting all of the following conditions shall be permitted to be exempt from the requirements of 10.10.1:

- (1) The volume is less than or equal to 4 ft³ (0.1 m³).
- (2) The compartment has an opening less than or equal to 144 in.² (92,900 mm²).
- (3) The open door does not extend sideways beyond the mirrors or up above the top of the fire apparatus.
- (4) All equipment in the compartment is restrained so that nothing can fall out if the door is open while the apparatus is moving.

10.10.3* Subsection 10.10.1 shall not apply to the following:

- (1) Manually raised pole lights with an extension of less than 5 ft (1.5 m)
- (2) Compartments located in the front bumper
- (3) Compartments mounted on an aerial device or turntable that would not affect the structure or operation of the aerial device if the compartment door was left open while the apparatus was moved

10.10.4 The hazard light shall be marked with a sign that reads "Do Not Move Apparatus When Light Is On."

10.11* Backup Devices.

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

10.11.2 A rear-view visibility system shall be provided that, upon placing the vehicle transmission into reverse, allows the vehicle operator to visibly see an area no less than 10 ft × 20 ft (3 m × 6 m) directly behind the vehicle.

10.12 Stop, Tail, and Directional Lights.

10.12.1 The apparatus shall be equipped with all legally required stop, tail, and directional lights.

10.12.2 Directional lights shall be visible from the front, sides, and rear of the apparatus.

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

10.12.4 Equipment shall not be mounted in a manner that obscures the stop, tail, or directional lights.

10.13 Low Voltage Electrical System Performance Tests.

10.13.1* The fire apparatus low voltage electrical system shall be tested as required by Section 10.13 and its subsections as applicable.

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

10.13.1.2 The certification shall be delivered with the apparatus.

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

10.13.3 Test Sequence.

10.13.3.1 The three tests defined in 10.13.3.2 through 10.13.3.4.4 shall be performed in the order in which they appear.

10.13.3.1.1 Before each test, the batteries shall be fully charged until the voltage stabilizes at the voltage regulator set point and the lowest charge current is maintained for 10 minutes.

10.13.3.1.2 Failure of any of these tests shall require a repeat of the sequence.

10.13.3.2 IC Engine Starting Reserve Capacity Test.

10.13.3.2.1 The engine shall be started and kept running until the engine and engine compartment temperatures are stabilized at normal operating temperatures and the battery system is fully charged.

10.13.3.2.2 The engine shall be shut off, and the minimum continuous electrical load shall be activated for 10 minutes.

10.13.3.2.3 All electrical loads shall be turned off prior to attempting to restart the engine.

10.13.3.2.4 The battery system shall then be capable of restarting the engine.

10.13.3.2.5 Failure to restart the engine shall be considered a test failure of the battery system.

10.13.3.3 IC Engine Alternator Performance Test at Idle.

10.13.3.3.1 The minimum continuous electrical load shall be activated with the engine running at idle speed.

10.13.3.3.2 The engine temperature shall be stabilized at normal operating temperature.

10.13.3.3.3 The battery system shall be tested to detect the presence of battery discharge current.

10.13.3.3.4 The detection of battery discharge current shall be considered a test failure.

10.13.3.4* Alternator Performance Test at Full Load.

10.13.3.4.1 The total continuous electrical load shall be activated with the engine running up to the engine manufacturer's governed speed.

10.13.3.4.2 The test duration shall be a minimum of 2 hours.

10.13.3.4.3 Activation of the load management system shall be permitted during this test.

10.13.3.4.4 An alarm sounded by excessive battery discharge, as detected by the warning system required in 10.3.4, or a system voltage of less than 11.8 V dc for a 12 V nominal system, 23.6 V dc for a 24 V nominal system, or 35.4 V dc for a 42 V nominal system for more than 120 seconds shall be considered a test failure.

10.13.4 IC Engine Low Voltage Alarm Test.

10.13.4.1 The following test shall be started with the engine off and the battery voltage at or above 12 V for a 12 V nominal system, 24 V for a 24 V nominal system, or 36 V for a 42 V nominal system.

10.13.4.2 With the engine shut off, the total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates.

10.13.4.3 The battery voltage shall be measured at the battery terminals.

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

10.13.4.5 The battery system shall then be able to restart the engine.

10.13.4.6 Failure to restart the engine shall be considered a test failure.

10.13.5 Low Voltage Battery Charger/Conditioner Test.

10.13.5.1 If the apparatus is equipped with a low voltage battery charger/conditioner, it shall be tested as follows:

- (1) Low voltage batteries are fully charged to at least 12.66 V for a 12 V nominal system, 25.32 V for a 24 V nominal system, and 37.98 V for a 42 V nominal system with the engine off and the shoreline disconnected.
- (2)* Connect a dc ammeter to each output of the low voltage battery charger/conditioner.
- (3) Connect the shoreline to power the low voltage battery charger/conditioner.
- (4) Perform the test with the engine off and the shoreline power cord connected.
- (5)* Add or apply loads to each charger output so that the output current is between 80 percent and 100 percent of the rated output current for that output.
- (6) Record the low voltage battery voltage and output current for each charger output at the beginning of the test and every 20 minutes.
- (7) Maintain the load for 60 minutes.
- (8) Record the low voltage battery voltage and output current for each charger output at the end of the test with the load still applied and the charger/conditioner powered.
- (9) Remove any added load.

10.13.5.2 The test shall be considered a failure if the charger/conditioner does not maintain an output voltage of at least 12.54 V for a 12 V nominal system, 25.08 V for a 24 V nominal system, and 37.62 V for a 42 V nominal system, or if it cannot maintain at least 80 percent of the rated output current for the duration of the test.

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

- (1) Documentation of the electrical system performance tests
- (2) A written electrical load analysis, including the following:
 - (a) The nameplate rating of the alternator
 - (b) The alternator rating under the conditions specified in 10.3.2
 - (c) Each of the component loads specified in 10.3.3 that make up the minimum continuous electrical load
 - (d) Additional electrical loads that, when added to the minimum continuous electrical load, determine the total continuous electrical load
 - (e) Each individual intermittent electrical load

Chapter 11 Fire Apparatus — Driving and Crew Areas (NFPA 1901/1906)

11.1* General.

11.1.1* Each crew riding position shall be within a fully enclosed personnel area.

11.1.2 Safety sign FAMA14, which states the number of personnel the vehicle is designed to carry, shall be located in an area visible to the driver.

11.1.3 Each crew riding position shall be provided with a seat and an approved seat belt designed to accommodate a person with and without heavy clothing.

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

- (1) Locate an imaginary line where the plane of the center of the seat back surface intersects the plane of the center of the seat cushion surface (line 1 in Figure 11.1.3.1). For seats with an SCBA seat back, use a plane that simulates the position of an SCBA back pad installed in the SCBA holder.
- (2) Locate point A on line 1 at the outside of the seat on the retractor side of the seat.
- (3) Locate point C on line 1 at the outside of the seat on the buckle side of the seat.
- (4) Locate point D at the tip of the buckle.
- (5) Pull the seat belt webbing entirely out of the retractor and measure along the webbing between point A and the seat belt latch plate (tongue). Record this length as AD.
- (6) Measure from point C to point D and record this length as CD.
- (7) The effective seat belt web length equals $AD + CD$.

11.1.3.2* A Type 2 seat belt shall have either a single retractor or dual retractors. A single retractor, Type 2 pelvic and upper torso restraint-style seat belt assembly shall have a minimum effective seat belt web length of 110 in. (2800 mm) with the seat adjusted all the way back and down and when measured in

accordance with 11.1.3.2.1. A dual retractor Type 2 pelvic and upper torso restraint-style seat belt assembly shall have a minimum effective shoulder belt web length of 50 in. (1270 mm) and a minimum effective lap belt web length of 60 in. (1530 mm) with the seat all the way back and down and as measured in 11.1.3.2.2.

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

- (1) Locate an imaginary line where the plane of the center of the seat back surface intersects the plane of the center of the seat cushion surface (line 1 in Figure 11.1.3.1). For seats with an SCBA seat back, use a plane that simulates the position of an SCBA back pad installed in the SCBA holder.
- (2) Locate an imaginary line parallel with line 1 and lying on the center of the seat back surface 29 in. (740 mm) from line 1 (line 2 in Figure 11.1.3.1).
- (3) Locate point A on line 1 at the outside of the seat on the retractor side of the seat.
- (4) Locate point B on line 2 at the shoulder strap edge of the seat back.
- (5) Locate point C on line 1 at the outside of the seat on the buckle side of the seat.
- (6) Locate point D at the tip of the buckle.
- (7) Pull the seat belt webbing entirely out of the retractor and measure along the webbing between points A and B. Record this length as AB.
- (8) Measure from point C to Point D and record this length as CD.
- (9) The effective seat belt web length equals $AB + 2CD$.

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

- (1) Locate an imaginary line where the plane of the center of the seat back surface intersects the plane of the center of the seat cushion surface (line 1 in Figure 11.1.3.1). For seats with an SCBA seat back, use a plane that simulates the position of an SCBA back pad installed in the SCBA holder.
- (2) Locate point A on line 1 at the outside of the seat on the retractor side of the seat.
- (3) Locate point C on line 1 at the outside of the seat on the buckle side of the seat.
- (4) Locate point D at the tip of the buckle.
- (5) Pull the lap belt webbing entirely out of the lap belt retractor and measure along the webbing between point A and the seat belt latch plate (tongue). Record this length as AD.
- (6) Locate an imaginary line parallel with line 1 and lying on the center of the seat back surface 29 in. (740 mm) from line 1 (line 2 in Figure 11.1.3.1).
- (7) Locate point B on line 2 at the shoulder strap edge of the seat back.
- (8) Pull the shoulder belt webbing entirely out of the shoulder belt retractor and measure along the webbing between point B and the seat belt latch plate (tongue). Record this length as BD.
- (9) Measure from point C to Point D and record this length as CD.
- (10) The effective lap belt web length equals $AD + CD$.
- (11) The effective shoulder belt web length equals $BD + CD$.

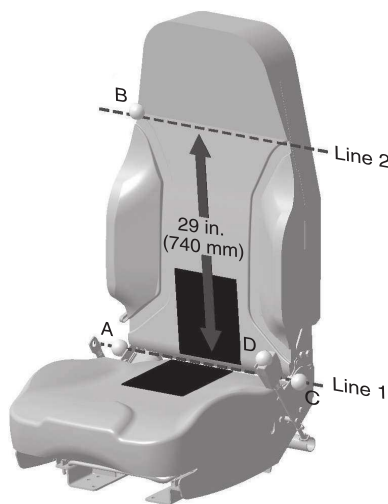


FIGURE 11.1.3.1 Dimension Lines for Measuring Seat Belt Effective Length.

11.1.3.2.3* In the case of a Type 2 seat belt, the distance from the buckle anchorage (point E in Figure 11.1.3.2.3) to the buckle tip (point D in Figure 11.1.3.2.3) shall be no more than 4 in. (102 mm) longer than the perpendicular distance from the buckle anchorage to a lateral axis through the H point of the seat (line 3 in Figure 11.1.3.2.3) when the seat is adjusted to its lowest and most rearward position.

11.1.3.3* The seat belt webbing shall be red or orange in color on the following:

- (1) SAE Class 4, Class 5, or Class 6 apparatus with seating for more than five occupants.
- (2) SAE Class 7 or Class 8 apparatus with seating for more than three occupants.

11.1.3.4 The seat belt buckle receiver shall be mounted on a rigid or semirigid stalk such that the buckle remains positioned in an accessible location.

11.1.3.5 All forward-facing seats adjacent to a side wall shall be provided with a Type 2 pelvic and upper torso restraint-style seat belt assembly.

11.1.3.6 Safety sign FAMA07, which warns of the importance of seat belt use, shall be visible from each seat that is intended to be occupied while the vehicle is in motion.

11.1.3.7 Safety sign FAMA06 shall be visible from each seat that is not equipped with occupant restraint and therefore not intended to be occupied while the vehicle is in motion.

11.1.3.8* A seat belt warning system shall be provided on the following structural fire apparatus:

- (1) SAE Class 4, Class 5, or Class 6 apparatus with seating for more than five occupants.
- (2) SAE Class 7 or Class 8 apparatus with seating for more than three occupants.

11.1.3.8.1 The warning system shall consist of an audible warning device that can be heard at all seating positions designed to be occupied while the vehicle is in motion and a visual display visible to the driver or the officer showing the condition of each seating position.

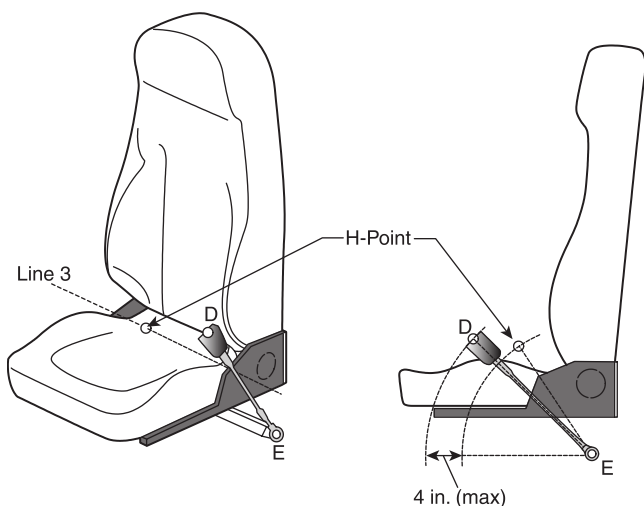


FIGURE 11.1.3.2.3 Dimension Lines for Measuring Buckle Length.

11.1.3.8.2 The warning shall be activated anytime the parking brake is released or the automatic transmission is not in park.

11.1.3.8.3 The seat position display shall indicate conditions in accordance with Table 11.1.3.8.3.

11.1.3.8.4 The display indication shall be permitted to consist of lights, text, graphical indicators, digital displays, or other methods.

11.1.3.8.5 The warning system shall not show an affirmative indication unless it has determined that the seat was occupied before the seat belt was buckled.

11.1.3.8.6 Once an affirmative indication has been established for a seating position, it shall remain an affirmative indication until the next time the seat belt buckle is released or the system power is cycled.

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

11.1.5 Any door of the apparatus designed to allow persons to enter or exit the apparatus shall have at least 96 in.² (62,000 mm²) of retroreflective material affixed to the inside of the door.

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

11.1.7 Safety sign FAMA42, which warns of loud sounds, shall be visible from each seat that is intended to be occupied while the vehicle is in motion.

11.1.8 Seat Head Height.

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

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

Table 11.1.3.8.3 Display for Seating System

Display Indication	Seat Belt	Seat Sensor
Affirmative indication	Buckled	Senses occupant
Negative indication	Buckled	No occupant
Negative indication	Unbuckled	Senses occupant
Dark	Unbuckled	No occupant

11.1.8.2 When independent vertical and/or horizontal seat adjustment is provided, it shall be fully adjustable within 10 seconds.

11.1.8.3 The seat-to-ceiling height shall be measured at the lowest surface in the area immediately above the projected area of the seat as it moves through its horizontal travel with any soft headliner material depressed by hand.

11.1.8.4* One of the following statements shall be included in the operator's manual:

- (1) For structural fire apparatus: "Fire helmets shall not be worn by persons riding in enclosed driving and crew areas. "Fire helmets are not designed for crash protection and they will interfere with the protection provided by head rests. The use of seat belts is essential to protecting firefighters during driving."
- (2) For wildland fire apparatus: "Warning: Serious head/neck injury can result from helmet use in cab. Do not wear helmet while seated unless necessary during suppression operations. Fire helmets are not designed for crash protection and they will interfere with the protection provided by head rests. Reduction of head clearance can increase the risk of spinal compression injury from roof contact. The use of seat belts is essential to protecting firefighters during driving."

11.1.8.4.1 In structural fire apparatus, a location for helmet storage shall be provided.

11.1.8.4.2 If helmets are to be stored in the driving or crew compartment, the helmets shall be secured in compliance with 11.1.11.2.

11.1.8.4.3 Safety sign FAMA15 (structural fire apparatus) or FAMA 43 (wildland fire apparatus), which warn not to wear helmets while the vehicle is in motion, shall be visible from each seat that is intended to be occupied while the vehicle is in motion.

11.1.9* Seat Arrangement.

11.1.9.1 Seating Position Width.

11.1.9.1.1 Each designated primary seating position shall have a minimum clear width of 20.8 in. (529 mm) at the hip level and 27.6 in. (701 mm) at the shoulder level.

11.1.9.1.2 Each designated secondary seating position shall have a minimum clear width of 20 in. (508 mm) at the hip level and 22 in. (559 mm) at the shoulder level.

11.1.9.1.3 Width at hip level shall be measured at the seating H-point.

11.1.9.1.4 Width at shoulder level shall be measured at the height of line 2 as defined in the seat belt length determination procedure in 11.1.3.2.

11.1.9.1.5 Width shall be measured with the seat adjusted to the center of its horizontal and vertical travel adjustment.

11.1.9.1.6 The center of any clear width shall not be offset from the center of the seat cushion by more than 3.0 in. (76 mm).

11.1.9.1.7 Overlap.

11.1.9.1.7.1 The clear width of any primary seating position shall not overlap the clear width of any other primary seating position.

11.1.9.1.7.2 The clear width of any primary seating position shall be permitted to overlap the clear width of a secondary seating position.

11.1.9.1.8 Every seating position shall provide a minimum clear width of 22 in. (560 mm) at the shoulder level without overlap.

11.1.9.2 Seat Cushion. Seat cushions shall be a minimum of 18 in. (460 mm) in width and 15 in. (380 mm) from the front of the cushion to the face of the seat back.

11.1.9.3 Back Cushion. A back cushion that extends from the face of the seat vertically at least 18 in. (460 mm) and that is a minimum of 18 in. (460 mm) wide at the base shall be provided.

11.1.9.3.1 The back cushion shall be permitted to be split to accommodate a fully recessed SCBA and bracket.

11.1.9.3.2 Where the back cushion is split to accommodate a SCBA, a headrest shall be supplied.

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

- (1) The SCBA holder shall retain a backpack and harness assembly and cylinder combination for the published weight rating of the holder when subjected to the dynamic force pulse per SAE J2418, *Occupant Restraint System Evaluation — Frontal Impact Component-Level Heavy Trucks*.
- (2) If the SCBA unit is mounted in a seatback, the release mechanism shall be accessible to the user while seated.
- (3) Brackets that lock automatically either in the event of impact or when the parking brake is released, but are not locked at other times, shall be permitted.
- (4)* The SCBA holder shall retain the cylinder when subjected to the deceleration pulse at 0, 30, 90, and 180 degrees with respect to the direction of bottle extraction and in the horizontal plane.
- (5) The SCBA holder shall retain the cylinder when subjected to a deceleration pulse that exceeds 2 g for at least 60 ms in the vertical direction.
- (6) The deceleration pulse shall meet the SAE J2418, *Occupant Restraint System Evaluation — Frontal Impact Component-Level Heavy Trucks*, deceleration profile with an accuracy of ± 10 percent within the 35 to 95 ms range.
- (7) The deceleration pulse shall be measured on a rigid portion of the base of the test fixture.
- (8) The test component shall be retained in the holder during and after the dynamic test.
- (9) The force required to extract the cylinder after each test shall be no more than 125 percent of the initial extraction force.
- (10) The SCBA holder shall be attached to the fixture in the same manner that it will be fastened to the seat or vehicle.
- (11) The test cylinder shall not move more than 3 in. (76 mm) relative to the frame of the holder during each test.

- (12) The test fixture shall not allow the holder frame to move more than 3 in. (76 mm) relative to the base of the test sled.
- (13) Each holder shall bear a label affixed by the holder manufacturer certifying compliance to these specifications.

11.1.11 Equipment Mounting.

11.1.11.1 All equipment required to be used during an emergency response shall be securely fastened.

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

11.1.11.3 Cab Equipment Mounting. Safety sign FAMA10, which warns of the need to secure items in the cab, shall be visible inside the cab.

11.1.12 Steps and access handrails that comply with 12.6.1 through 12.6.4.6 and Section 12.7 shall be provided as necessary for access to all driving and crew compartments.

11.1.13 Where the crew compartment and the driving compartment are separated, prohibiting direct voice communication, a two-way buzzer or two-way voice intercom system shall be provided.

11.1.14 Means of Escape.

11.1.14.1 Any interior area to be occupied by personnel shall have a minimum of two means of escape.

11.1.14.2 Each opening shall be a minimum of 24 in. × 24 in. (610 mm × 610 mm).

11.1.15 Fresh Air Intake.

11.1.15.1 A climate control or fresh air system of an enclosed occupant compartment on wildland fire apparatus that draws air from the exterior of the apparatus shall be equipped with a means of separating burning embers from the air intake system.

11.1.15.2 The requirement in 11.1.15.1 shall be permitted to be achieved by either of the following methods:

- (1) A device such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot pass into the occupant area
- (2) A device capable of meeting the test requirements of FAMA TC079, *Ember Separator Test*

11.2 Cab Tilt Systems. If the fire apparatus has a cab tilt system, the system shall meet the requirements of 11.2.1 through 11.2.4.

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

11.2.2 If the cab has a powered tilting system, the system shall be both of the following:

- (1) Interlocked to operate only when the parking brake is engaged
- (2) Configured so that the failure of a single component will not result in unintentional tilting of the cab

11.2.3 The control of the cab tilt mechanism shall be accomplished clear of the cab travel area while still having the travel area in clear view.

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

11.2.3.2 If the cab is able to be raised to a defined intermediate position, a mechanical means shall also be provided to hold the cab in that intermediate position.

11.2.4 Safety sign FAMA41, which warns of the dangers of cab tilt systems, shall be located on the inside panel of the driver cab door.

11.3 Driving Compartment.

11.3.1* A fully enclosed driving compartment with seating capacity for not fewer than two persons shall be provided except at a tiller operator's driving position. (*See 11.4.1.*)

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

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

11.3.3 Driver's Seat. The driver's seat shall be adjustable by the driver.

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

11.3.5 All primary rear view mirrors used by the driver shall be adjustable from the driver's position.

11.3.6 Instrumentation and Controls.

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

- (1) Speedometer
- (2) Tachometer
- (3) Odometer
- (4) Oil-pressure indicator or gauge
- (5) Coolant temperature indicator or gauge
- (6) Automatic transmission temperature indicator or gauge, if applicable
- (7) Voltmeter
- (8) Hazard indicator light (*see Section 10.10*)
- (9) Air-pressure gauge(s), if applicable
- (10) Turn signal control and indicator lights
- (11) Headlight/DOT light switch
- (12) High-beam headlight switch and indicator
- (13) Fuel level gauge(s)
- (14) Master ignition switch (if a key is provided, it shall be unable to be removed from the driving compartment interior)
- (15) Heater/defroster controls

- (16) Warning lights and siren switches
- (17) Major load disconnect switch
- (18) Windshield wipers and windshield washer control
- (19) PTO-engaged indicator, if applicable
- (20) Pump engagement controls, if applicable

11.3.6.2 Controls and switches that are expected to be operated by the driver while the apparatus is in motion shall be within convenient reach for the driver.

11.3.7 Safety sign FAMA17, which warns of vehicle backing hazards, shall be visible to the driver while sitting in the driver seat.

11.4 Tractor-Drawn Vehicles. Where a tractor-drawn vehicle with tillered steering is provided, the requirements of this section shall apply.

11.4.1 Tiller Cab.

11.4.1.1 A fully enclosed tiller operator's cab with seating for one person shall be provided at the tiller trailer steering position.

11.4.1.2 The tiller cab shall meet the requirements of SAE J2422, *Cab Roof Strength Evaluation — Quasi-Static Loading Heavy Trucks*.

11.4.1.3 A cab heater shall be provided.

11.4.1.4 A windshield defrosting system shall be provided.

11.4.1.5 Ventilation or opening side windows shall be provided.

11.4.1.6 A windshield wiper and washer fluid system shall be provided.

11.4.1.7 Exterior rearview mirrors shall be provided.

11.4.2* Tiller Cab Seating.

11.4.2.1 The seating position shall have a minimum clear width of 20.8 in. (529 mm) at the hip level and 27.6 in. (701 mm) at the shoulder level.

11.4.2.2 The seat cushion shall be a minimum of 18 in. (460 mm) in width and 15 in. (380 mm) from the front of the cushion to the face of the seat back.

11.4.2.3 A back cushion that extends from the face of the seat vertically at least 18 in. (460 mm) and that is a minimum of 18 in. (460 mm) wide at the base shall be provided.

11.4.2.4 The seat shall have an adjustment range of at least 3 in. (76 mm) from front to rear.

11.4.3* Tiller Training Seat.

11.4.3.1 If a second seat is provided for training purposes, it shall be located within the enclosed portion of the tiller cab.

11.4.3.2 The training seat shall be equipped with a seat belt.

11.4.3.3 The tiller operator and training seating positions shall together have a minimum clear width of 40 in. (1016 mm) at the hip level and 44 in. (1118 mm) at the shoulder level.

11.4.4 Tiller Operator Presence.

11.4.4.1 One of the following means shall be provided to indicate that the tiller operator is present:

- (1) Tiller seat cushion occupant sensor
- (2) Seat-belt-engaged indicator
- (3) Manual operator presence switch
- (4) Other means to sense that an operator is seated at the tiller operator position

11.4.4.2 An audible warning alarm shall sound in the tractor cab if the parking brake is released and tiller operator presence is not indicated.

11.4.4.3 If a means of locking the tiller steering is provided, a means of suppressing the audible warning alarm shall also be provided.

11.4.4.4 The audible alarm suppression shall reset each time the tractor engine ignition switch is cycled.

11.4.5 Tractor to Trailer Communications.

11.4.5.1 One of the following means shall be provided for communication between the driver and the tiller operator:

- (1) Two-way audible signal with a tone that is unique from other in-cab audible alert signals
- (2) Two-way push-to-talk intercom
- (3) Two-way hands-free intercom
- (4) Other two-way means to allow the driver and the tiller operator to communicate basic driving intentions

11.4.5.2 The communication system shall be operable without the tiller operator having to take his/her hands off the steering wheel.

11.4.6 Instruments and Controls.

11.4.6.1 The following instrumentation and controls shall be mounted in the tiller operator's compartment:

- (1) Heater controls
- (2) Defroster controls
- (3) Turn signal indicator lights
- (4) Two-way buzzer signal switch
- (5) Windshield wiper and washer fluid control

11.4.6.2 The instrumentation and control listed in 11.4.6.1 shall be identified and visible to the tiller operator while seated.

11.4.6.3 Controls and switches that are expected to be operated by the tiller operator while the apparatus is in motion shall be within reach of that operator.

Chapter 12 Fire Apparatus — Body, Compartments, and Equipment Mounting (NFPA 1901/1906)

12.1* Compartmentation.

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

12.1.2 All electrical junctions or wiring within compartments shall be protected from mechanical damage resulting from equipment stored in the compartment.

12.2 Equipment Containment.

12.2.1* Equipment holders or compartments shall be provided for all tools, equipment, and other items that are on the fire apparatus.

12.2.2* Equipment holders shall be attached and shall be designed so that equipment remains in place under all vehicle operating conditions.

12.3 Equipment Racks. When an equipment rack is provided, it shall meet the requirements of this section.

12.3.1 A means shall be provided that will retain the device in the stowed position during travel.

12.3.2 Retroreflective material marking the extremity of the deployed equipment rack shall be visible when approaching the rack from any direction.

12.3.3 A visual signal shall be provided at the driver's position to indicate that the equipment rack is not stowed and the parking brake is not engaged.

12.3.4 Power-operated equipment racks shall meet the requirements of this section.

12.3.4.1 An interlock shall be provided to prevent operation of the equipment rack unless the apparatus parking brake has been activated.

12.3.4.2 Controls shall be provided in a position where the operator can visually follow the travel of the equipment rack.

12.3.4.3 Controls shall be provided in a position where the operator will be clear of a falling load.

12.3.5 Manually operated equipment racks shall meet the requirements of this section.

12.3.5.1 A means shall be provided that prevents the rapid deployment of the load.

12.3.5.2 Instructions on how to safely stow and deploy the rack and how many personnel are required shall be visible to the operator(s).

12.3.5.3 Stowing and deploying of a loaded rack shall require no more than 70 lbf. (310 N) of human force per required personnel.

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

12.4.1 If an SCBA unit or cylinder is stored within a driving or crew compartment, the mounting shall comply with the requirements of Section 12.4 and 11.1.10.

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

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

12.4.4 The SCBA storage area shall be a ventilated, dry area away from all heat sources that could damage the SCBA (e.g., mufflers, engines).

12.4.5* Vertical Storage of SCBA Cylinders in Tubes.

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

12.4.5.2 Each storage tube shall have a drain to prevent accumulation of moisture.

12.4.6* Horizontal Storage of SCBA Cylinders.

12.4.6.1 The storage rack or tube assembly shall be designed to prevent the cylinder from accidentally sliding out from the storage rack or tube and shall be installed so as to keep the cylinder from hitting or rubbing on compartment doors by preventing movement or shifting when in transit.

12.4.6.2 The rear wall of each SCBA storage area or tube shall be covered with a rubber, plastic, or similar material to prevent wear on cylinders.

12.5 Pump and Plumbing Access.

12.5.1 On structural fire apparatus, 12.5.1.1 through 12.5.1.5 shall apply.

12.5.1.1 One or more doors or panels that open or are removable without the use of tools shall be provided to allow visual inspection or access for checking the fire pump and plumbing area.

12.5.1.2 The clear opening shall have no one dimension measure less than 18 in. (460 mm).

12.5.1.3 Additional door(s) or panel(s) that require no more than standard tools to be opened or removed shall be provided for access to the pump and plumbing area.

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

12.5.1.5* The clear space required by the pump manufacturer to perform in-truck overhaul and maintenance shall be provided.

12.5.2 On wildland fire apparatus, all valves, gauges, controls, pump, and other plumbing equipment shall be accessible for service and replacement.

12.6 Stepping, Standing, and Walking Surfaces.

12.6.1* Steps, platforms, or permanently attached access ladders shall be provided so that firefighters have access to all working and storage areas of the fire apparatus.

12.6.1.1 The maximum vertical stepping height shall not exceed either of the following:

- (1) 18 in. (460 mm)
- (2) 24 in. (610 mm) for the ground to first step when the vehicle is loaded to its estimated in-service weight

12.6.1.1.1 The maximum horizontal offset between steps shall not exceed 18 in. (460 mm).

12.6.1.1.2 A permanently attached supplemental access/egress means from the ground to these steps, platforms, or permanently attached access ladders shall be provided where the ground to the first step, platform, or ladder exceeds 24 in. (610 mm).

12.6.1.1.3 The supplemental access means shall consist of a step(s), platform(s), or access ladder(s).

12.6.1.1.4 The ground-to-first-step height shall be determined with the apparatus on level ground.

12.6.1.1.5 Any step that decreases the approach or departure angle specified in this standard shall be designed to be movable so as not to be damaged when the vehicle travels over terrain that requires the full angle of approach or departure.

12.6.1.1.6 Where the apparatus is supplied with stabilizers, the ground-to-first-step height shall be determined with the apparatus on level ground and the stabilizers deployed in accordance with the manufacturer's instructions so that the aerial device meets the stability requirements of Section 20.28.

12.6.1.2* All steps shall comply with the following:

- (1) Have a minimum area of 35 in.² (22,580 mm²)
- (2) Be of such a shape that a 5 in. (125 mm) diameter disk does not overlap any side when placed on the step
- (3) Be arranged to provide at least 6 in. (150 mm) of clearance between the leading edge of the step and any obstruction

12.6.1.3 All platforms shall have a minimum depth of 8 in. (200 mm) from the leading edge of the platform to any obstruction.

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

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

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

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

12.6.3 Ladder rungs on access ladders shall have a skid resistant surface or covering, but that surface or covering shall not

be required to meet the slip resistance performance requirements of 12.6.4.

12.6.4* Slip Resistance.

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

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

12.6.4.3 A standard Neolite® test sensor shall be used with both the English XL tester and the Brungraber Mark II tester.

12.6.4.4 Sampling Strategy.

12.6.4.4.1 For uniformly patterned materials, at least 16 readings shall be taken on each sample.

12.6.4.4.1.1 Each reading shall be taken 90 degrees clockwise from the previous orientation, resulting in at least four readings in each orientation.

12.6.4.4.1.2 The readings shall be averaged and reported as the slip resistance for the material.

12.6.4.4.2 For directionally patterned materials, at least 32 readings shall be taken on each sample.

12.6.4.4.2.1 Each reading shall be taken 45 degrees clockwise from the previous orientation, resulting in at least four readings in each orientation.

12.6.4.4.2.2 The four readings in each direction shall be averaged and reported as the slip resistance for the material in that orientation.

12.6.4.5 The contractor shall deliver with the fire apparatus a certification that all materials used for exterior surfaces designated as stepping, standing, and walking areas, all interior steps, and all interior floors meet the requirements of 12.6.4.

12.6.4.6 Where the fuel fill is located at or near a stepping surface, the surface shall be constructed of an open grate-type material to facilitate draining of accidentally spilled fuel to lessen any slipping hazard.

12.6.5 Safety sign FAMA24, which warns personnel not to ride on the vehicle, shall be located at the rear step areas and at any cross walkways.

12.7 Access Handrails or Handholds.

12.7.1 Access handrails or handholds shall be provided at each entrance to a driving or crew compartment and at each position where steps or ladders for climbing are located.

12.7.2 Exterior access handrails shall be constructed of or covered with a slip-resistant, noncorrosive material.

12.7.3 Exterior access handrails shall be between 1 in. and 1½ in. (25 mm and 42 mm) in diameter and have a minimum

clearance between the handrails and any surface of at least 2 in. (50 mm).

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

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

12.7.6* Access handrails supplied by the chassis manufacturer on a commercial chassis shall be permitted to be used to meet the requirements of this section.

12.8 Metal Finish.

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

12.8.2* Painting.

12.8.2.1* All exposed ferrous metal surfaces that are neither plated nor stainless steel shall be both of the following:

- (1) Cleaned and prepared
- (2) Painted or coated

12.8.2.2 The paint or coating, including any primer, shall be applied in accordance with the paint or coating manufacturer's recommendation.

12.8.3* Reflective Striping.

12.8.3.1* A retroreflective stripe(s) shall be affixed to the apparatus as follows:

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

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

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

12.8.3.1.3 A graphic design shall be permitted to replace all or part of the required striping material if the design or combination thereof covers at least the same perimeter length(s) required by 12.8.3.1.

12.8.3.2* On structural fire apparatus at least 50 percent of the rear-facing vertical surfaces, visible from the rear of the apparatus, excluding any pump panel areas not covered by a

door, shall be equipped with retroreflective striping in a chevron pattern sloping downward and away from the centerline of the vehicle at an angle of 45 degrees.

12.8.3.2.1 Each stripe in the chevron shall conform to one of the following:

- (1) A single color alternating between red and either yellow, fluorescent yellow, or fluorescent yellow-green
- (2) A single color alternating between different and high-contrasting colors

12.8.3.2.2 Each stripe shall be 6 in. (150 mm) in width.

12.8.3.3 All retroreflective materials required by 12.8.3.1 and 12.8.3.2 shall conform to the requirements of ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1 for Type I Sheeting.

12.8.3.3.1 All retroreflective materials used to satisfy the requirements of 12.8.3.1 that are colors not listed in ASTM D4956, Section 6.1.1, shall have a minimum coefficient of retroreflection of 10 with observation angle of 0.2 degrees and entrance angle of -4 degrees.

12.8.3.3.2 Fluorescent yellow and fluorescent yellow-green retroreflective materials used to meet the requirements of 12.8.3.2 shall conform to the minimum requirements specified for yellow Type I Sheeting in ASTM D4956, Section 6.1.1.

12.8.3.3.3 Any printed or processed retroreflective film construction used to meet the requirements of 12.8.3.1 and 12.8.3.2 shall conform to the standards required of an integral colored film as specified in ASTM D4956, Section 6.1.1.

12.9* Hose Storage. If a hose storage area(s) is provided, it shall comply with this section.

12.9.1 The hose storage area shall be designed to minimize the effects of corrosion.

12.9.2 The bottom shall be constructed to prevent the accumulation of water and allow ventilation to aid in drying hose.

12.9.3 The interior shall be smooth and free from all projections, such as nuts, sharp angles, or brackets, that might cause damage to the hose.

12.9.4 The interior of a hose storage area shall not be required to meet the slip resistance requirements given in 12.6.4.

12.9.5 Reels, handrails, ladders, and equipment holders shall be placed so as not to obstruct the laying or removal of hose from the storage area.

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

12.9.7 Safety sign FAMA22, which warns of the need to secure hose, shall be visible to personnel at each hose storage area.

12.9.8* If a fire suppression hose reel is provided, it shall meet the requirements of 12.9.8.1 through 12.9.8.3.

12.9.8.1 The hose reel shall be equipped with a brake.

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

12.9.8.3 Where the reel has a capacity of over 100 ft (30 m) of hose, the reel shall have power rewind capability.

12.10 Requirements for Mounting of Ground Ladders.

12.10.1 Ground ladders shall be mounted and protected to prevent movement, abrasion, or other damage to the ground ladder while they are on the fire apparatus. [1932:4.1.2]

12.10.2 When mounted on the apparatus, ground ladders shall not be subject to exposure to heat sources (such as engine heat) of 212°F (100°C) or greater. [1932:4.1.3]

12.10.3 Ground ladders shall be supported to prevent any sagging or distortion while they are mounted on the fire apparatus. [1932:4.1.4]

12.10.4 The rollers and other moving parts of the frame holding the ground ladders on the apparatus shall be readily accessible to permit lubrication.

12.11* Receivers and Anchors for Rope and Removable Winches.

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

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

12.11.3 Safety sign FAMA28 shall be located on or near each receiver or anchor stating the maximum straight line pull rating.

12.12 Slip-On Firefighting Module. If the pump, piping, and tank are built as a slip-on, self-contained unit, it shall meet the requirements of 12.12.1 through 12.12.3 and shall be mounted on the fire apparatus in accordance with 12.12.4.

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

12.12.2 Intake and discharge piping shall not interfere with the routine maintenance of the pump, engine, or auxiliary systems and shall not unduly restrict the servicing of these components.

12.12.3 The manufacturer of a slip-on firefighting module shall provide the following data with the module:

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

12.12.4 Mounting.

12.12.4.1 The slip-on module shall be mounted in a manner that allows access to the engine, pump, and auxiliary systems for routine maintenance.

12.12.4.2 The slip-on module shall be removable using common hand tools.

12.12.4.3 The slip-on module shall be mounted in a manner that prevents damage by vibration.

12.12.4.4* Special anchorage shall be provided on the vehicle chassis and on the slip-on firefighting module to secure the firefighting module to the vehicle chassis.

12.12.4.5 The anchorage described in 12.12.4.4 shall be designed to prevent movement of the slip-on module during rapid acceleration, deceleration, or side-hill operations.

12.12.4.6 For apparatus manufactured in two or more stages, drilling on chassis frame flanges or welding to the chassis frame shall not be permitted unless allowed by the incomplete vehicle manufacturer.

Chapter 13 Fire Apparatus — Fire Pumps and Associated Equipment (NFPA 1901)

13.1 Application. If the apparatus is equipped with a fire pump, the provisions of this chapter shall apply.

13.2 Design and Performance Requirements.

13.2.1 Fire Pump Rated Capacity.

13.2.1.1 The fire pump shall be mounted on the apparatus and shall have a minimum rated capacity of 250 gpm (1000 L/min) at 150 psi (1000 kPa) net pump pressure.

13.2.1.2 Pumps of higher capacity shall be rated at one of the capacities specified in Table 13.2.4.1(a).

13.2.2* Where the apparatus is designed for "pump-and-roll" operations, the vehicle drive engine and drive train shall be arranged so that the pump can deliver at least 20 gpm (76 L/min) at a gauge pressure of 80 psi (550 kPa) while the fire apparatus is moving at 2 mph (3.2 kmph) or less.

13.2.3 Pumping System Capability.

13.2.3.1 If the pumping system is rated at less than 3000 gpm (12,000 L/min), it shall be capable of delivering the following:

- (1) One hundred percent of rated capacity at 150 psi (1000 kPa) net pump pressure
- (2) Seventy percent of rated capacity at 200 psi (1400 kPa) net pump pressure
- (3) Fifty percent of rated capacity at 250 psi (1700 kPa) net pump pressure

13.2.3.2* If the pumping system is rated at 3000 gpm (12,000 L/min) or greater, it shall be capable of delivering the following:

- (1) One hundred percent of rated capacity at 100 psi (700 kPa) net pump pressure
- (2) Seventy percent of rated capacity at 150 psi (1000 kPa) net pump pressure
- (3) Fifty percent of rated capacity at 200 psi (1400 kPa) net pump pressure

13.2.3.3* When dry, the pump system shall be capable of meeting the requirements of 13.2.3.3.1 through 13.2.3.3.5.

13.2.3.3.1 Where pumps are rated at less than 1500 gpm (6000 L/min), they shall be capable of taking suction through 20 ft (6 m) of suction hose under the conditions specified in

13.2.4.1 for the rated capacity of the pump and shall begin discharging water in not more than 30 seconds.

13.2.3.3.2 Where pumps are of 1500 gpm (6000 L/min) or larger but less than 3000 gpm (12,000 L/min), they shall be capable of taking suction through 20 ft (6 m) of suction hose under the conditions specified in 13.2.4.1 for the rated capacity of the pump and begin discharging water in not more than 45 seconds.

13.2.3.3.3 Where pumps are of 3000 gpm (12,000 L/min) or larger capacity, they shall be capable of taking suction through 20 ft (6 m) of suction hose under the conditions specified in 13.2.4.1 for the rated capacity of the pump and begin discharging water in not more than 90 seconds.

13.2.3.3.4 Where the pump system includes an auxiliary 4 in. (100 mm) or larger intake pipe having a volume of 1 ft³ (0.03 m³) or more, an additional 15 seconds beyond that allowed in 13.2.3.3.1, 13.2.3.3.2, and 13.2.3.3.3 shall be permitted.

13.2.3.3.5* Where pumps are of the parallel/series type, they shall complete the requirements of 13.2.3.3.1 through 13.2.3.3.4 in both parallel and series operation.

13.2.3.4 Vacuum.

13.2.3.4.1 The completed pumping system shall be capable of developing a vacuum of 22 in. Hg (75 kPa) at altitudes up to 2000 ft (600 m) by means of the pump priming system and sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (34 kPa).

13.2.3.4.2 The requirement in 13.2.3.4.1 shall be met with all intake valves open, with all intakes capped or plugged, with all discharge caps removed and valves closed, and without the use of the pump primer during the 5-minute period.

13.2.4 Pump Suction Capability.

13.2.4.1* The pump manufacturer shall certify that the fire pump is capable of pumping 100 percent of rated capacity at 150 psi (1000 kPa) net pump pressure for pumps rated at less than 3000 gpm (12,000 L/min) or at 100 psi (700 kPa) for pumps rated at 3000 gpm (12,000 L/min) or greater from draft through 20 ft (6 m) of suction hose with a strainer attached under the following conditions:

- (1) An altitude of 2000 ft (600 m) above sea level
- (2) Atmospheric pressure of 29.9 in. Hg (101 kPa) (corrected to sea level)
- (3) Water temperature of 60°F (15.6°C)
- (4) Suction hose size and number of hose not to exceed those indicated in Table 13.2.4.1(a)
- (5) Lift as indicated in Table 13.2.4.1(a)
- (6) Friction and entrance loss in suction hose, including strainer, as given in Table 13.2.4.1(b) or Table 13.2.4.1(c)

13.2.4.2* The pump manufacturer shall certify that the pump is capable of pumping rated capacity at 150 psi (1000 kPa) net pump pressure for pumps rated at less than 3000 gpm (12,000 L/min) or at 100 psi (700 kPa) for pumps rated at 3000 gpm (12,000 L/min) or greater at any of the following special conditions when these conditions are specified by the purchaser:

- (1) At an elevation above 2000 ft (600 m)
- (2) At lifts higher than those listed in Table 13.2.4.1(a), through more than 20 ft (6 m) of suction hose, or both

Table 13.2.4.1(a) Suction Hose Size, Number of Suction Lines, and Lift for Pump Manufacturer's Suction Capability Certification

Rated Capacity		Suction Hose Size		Number of Suction Lines	Lift	
gpm	L/min	in.	mm		ft	m
250	1,000	3	75	1	10	3
300	1,100	3	75	1	10	3
350	1,300	4	100	1	10	3
500	2,000	4½	110	1	10	3
750	3,000	4½	110	1	10	3
1,000	4,000	6	150	1	10	3
1,250	5,000	6	150	1	10	3
1,500	6,000	6	150	2	10	3
1,750	7,000	6	150	2	8	2.4
2,000	8,000	6	150	2	6	1.8
2,000	8,000	8	200	1	6	1.8
2,250	9,000	6	150	3	6	1.8
2,250	9,000	8	200	1	6	1.8
2,500	10,000	6	150	3	6	1.8
2,500	10,000	8	200	1	6	1.8
3,000	12,000	6	150	3	6	1.8
3,000	12,000	8	200	2	6	1.8
3,500	14,000	6	150	4	6	1.8
3,500	14,000	8	200	2	6	1.8
4,000	16,000	6	150	4	6	1.8
4,000	16,000	8	200	2	6	1.8
4,500	18,000	6	150	6	6	1.8
4,500	18,000	8	200	3	6	1.8
5,000	20,000	6	150	6	6	1.8
5,000	20,000	8	200	3	6	1.8
5,500	22,000	6	150	6	6	1.8
5,500	22,000	8	200	4	6	1.8
5,500	22,000	12	300	2	6	1.8
6,000	24,000	6	150	6	6	1.8
6,000	24,000	8	200	4	6	1.8
6,000	24,000	12	300	2	6	1.8
6,500	26,000	8	200	4	6	1.8
6,500	26,000	12	300	2	6	1.8
7,000	28,000	8	200	4	6	1.8
7,000	28,000	12	300	2	6	1.8
7,500	30,000	8	200	4	6	1.8
7,500	30,000	12	300	2	6	1.8

- (3) For pumps having a rated capacity of 1500 gpm (6000 L/min) or larger, through a single suction hose only, or through the number of hose listed in Table 13.2.4.1(a) attached to one side of the apparatus only

13.2.5 Fire Pump Maximum Discharge Pressure Capability Rating.

13.2.5.1 The fire pump manufacturer shall establish the maximum discharge pressure capability rating of the pump.

13.2.5.2 The fire pump manufacturer shall certify the maximum discharge pressure capability rating of the pump if it exceeds the hydrostatic test gauge pressure in 13.5.2.1.

Table 13.2.4.1(b) Friction and Entrance Loss in 20 ft of Suction Hose, Including Strainer (United States customary system [USCS] units)

Flow Rate (gpm)	Number of Suction Hose and Size (inside diameter)									
	One 3 in.		One 4 in.		One 4½ in.		One 5 in.		One 6 in.	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
250	5.2	4.6								
175	2.6	2.3								
125	1.4	1.2								
300	7.5	6.6								
210	3.8	3.4								
150	1.9	1.7								
350			2.5	2.1						
245			1.2	1.1						
175			0.7	0.6						
500			5.0	4.4	3.6	3.2				
350			2.5	2.1	1.8	1.6				
250			1.3	1.1	0.9	0.8				
750			11.4	9.8	8.0	7.1	4.7	4.2	1.9	1.7
525			5.5	4.9	3.9	3.4	2.3	2.0	0.9	0.8
375			2.8	2.5	2.0	1.8	1.2	1.1	0.5	0.5
1000					14.5	12.5	8.4	7.4	3.4	3.0
700					7.0	6.2	4.1	3.7	1.7	1.5
500					3.6	3.2	2.1	1.9	0.9	0.8
Flow Rate (gpm)	One 5 in.		One 6 in.		Two 4½ in.		Two 5 in.		Two 6 in.	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
1250	13.0	11.5	5.2	4.7	5.5	4.9				
875	6.5	5.7	2.6	2.3	2.8	2.5				
625	3.3	2.9	1.3	1.1	1.4	1.2				
1500			7.6	6.7	8.0	7.1	4.7	4.2	1.9	1.7
1050			3.7	3.3	3.9	3.4	2.3	2.0	0.9	0.8
750			1.9	1.7	2.0	1.8	1.2	1.1	0.5	0.5
1750			10.4	9.3	11.0	9.7	6.5	5.7	2.6	2.3
1225			5.0	4.6	5.3	4.7	3.1	2.7	1.2	1.1
875			2.6	2.3	2.8	2.5	1.6	1.4	0.7	0.6
2000					14.5	12.5	8.4	7.4	3.4	3.0
1400					7.0	6.2	4.1	3.7	1.7	1.5
1000					3.6	3.2	2.1	1.9	0.9	0.8
2250							10.8	9.5	4.3	3.8
1575							5.3	4.7	2.2	1.9
1125							2.8	2.5	1.1	1.0
2500							13.0	11.5	5.2	4.7
1750							6.5	5.7	2.6	2.3
1250							3.3	2.9	1.3	1.1
Flow Rate (gpm)	Two 6 in.		Three 6 in.		Four 6 in.		One 8 in.		Two 8 in.	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
2000	3.4	3.0					4.3	3.8		
1400	1.7	1.5					2.0	1.8		
1000	0.9	0.8					1.0	0.9		
2250	4.3	3.8	2.0	1.8			5.6	5.0	1.2	1.1
1575	2.2	1.9	1.0	0.9			2.5	2.2	0.6	0.5
1125	1.1	1.0	0.5	0.5			1.2	1.1	0.3	0.3
2500	5.2	4.7	2.3	2.0			7.0	6.2	1.5	1.3
1750	2.6	2.3	1.2	1.1			3.2	2.8	0.8	0.7
1250	1.3	1.1	0.6	0.5			1.5	1.3	0.4	0.4
3000	7.6	6.9	3.4	3.0					2.3	2.1
2100	3.7	3.4	1.7	1.5					1.0	0.9
1500	1.9	1.7	0.9	0.8					0.6	0.5

(continues)

Table 13.2.4.1(b) *Continued*

Flow Rate (gpm)	Number of Suction Hose and Size (inside diameter)									
	One 3 in.		One 4 in.		One 4½ in.		One 5 in.		One 6 in.	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
3500	4.7	4.3	2.6	2.3			3.2	2.8		
2450	2.9	2.6	1.2	1.1			1.5	1.3		
1750	1.2	1.1	0.7	0.6			0.7	0.6		
4000			3.4	3.0			4.3	3.8		
2800			1.7	1.5			2.0	1.8		
2000			0.9	0.8			1.0	0.9		
4500					2.1	1.9			2.3	2.0
3150					1.1	1.0			1.2	1.0
2250					0.55	0.45			0.6	0.5
5000					2.3	2.0			2.5	2.2
3500					1.2	1.1			1.5	1.3
2500					0.6	0.5			0.7	0.6

Flow Rate (gpm)	Six 6 in.		Four 8 in.		Two 12 in.	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
5500	2.5	2.2	2.1	1.9	1.9	1.7
3850	1.4	1.2	0.9	0.8	0.8	0.7
2750	0.7	0.6	0.5	0.4	0.46	0.36
6000	3.4	3.0	2.3	2.1	2.1	1.9
4200	2.0	1.7	1.0	0.9	0.9	0.8
3000	1.7	1.5	0.6	0.5	0.5	0.4
6500			2.5	2.2	2.3	2.1
4550			1.1	1.0	1.0	0.9
3250			0.7	0.6	0.6	0.5
7000			3.3	2.9	2.5	2.2
4900			1.5	1.3	1.1	1.0
3500			0.7	0.6	0.7	0.6
7500			3.7	3.3	2.7	2.5
5250			1.9	1.7	1.3	1.1
3750			1.1	1	0.9	0.8

13.3 Pumping Engine Requirements.

13.3.1* The apparatus manufacturer shall approve the use of the pumping engine for stationary pumping applications based on the size of the fire apparatus and the rating of the pump being furnished.

13.3.2 Engine Speed.

13.3.2.1 The engine shall be capable of performing the pumping tests herein specified without exceeding the maximum governed speed of the engine as shown on a certified brake horsepower curve of the type of engine used without accessories.

13.3.2.2 The brake horsepower curve certification shall be signed by a responsible official of the engine manufacturer.

13.3.3 If the fire pump is rated at 750 gpm (3000 L/min) or greater but less than 3000 gpm (12,000 L/min), the engine/pump combination shall be capable of delivering the rated pump capacity at 165 psi (1100 kPa) net pump pressure.

13.3.4* If a separate pumping engine is provided, it shall meet the requirements of 9.2.1.1, 9.2.1.3, 9.2.1.4, 9.2.2, 9.2.4, 9.2.5 through 9.2.6, Section 10.2, 10.4.3, 10.4.4, 10.4.4.1, 10.4.4.3, 10.4.4.4, 10.4.5, Section 10.5, and Section 10.6.

13.3.5 Indicator or Light.

13.3.5.1 Where a separate engine is used to drive the pump, an indicator or light that is energized when the pump engine is running shall be provided in the driving compartment.

13.3.5.2 The indicator or light shall be marked with a label that reads "Pump Engine Running."

13.4 Power Train Capability.

13.4.1 All components in the power train from the engine to the fire pump shall be capable of transmitting the torque necessary to power the pump, as installed in the apparatus, for the pump performance points specified in 13.2.3.1 or 13.2.3.2, as applicable, without exceeding the component manufacturer's continuous duty torque rating.

13.4.2 When pumping continuously at each of the pump performance points specified in 13.2.3.1 or 13.2.3.2, as applicable, lubricant temperatures in any power train component installed in the apparatus from the engine to the pump shall not exceed the component manufacturer's recommendation for maximum temperature.

Table 13.2.4.1(c) Friction and Entrance Loss in 6 m of Suction Hose, Including Strainer (SI units)

Flow Rate (L/min)	Number of Suction Hose and Size (inside diameter)									
	One 75 mm		One 100 mm		One 110 mm		One 125 mm		One 150 mm	
	m water	kPa	m water	kPa	m water	kPa	m water	kPa	m water	kPa
1,000	1.6	16								
700	0.8	8								
500	0.4	4								
1,100	2.2	22								
770	1.1	12								
550	0.6	6								
1,300			0.7	7						
910			0.4	4						
650			0.2	2						
2,000			1.5	15	1.1	11				
1,400			0.7	7	0.5	5				
1,000			0.4	4	0.3	3				
3,000			3.5	33	2.4	24	1.4	14	0.6	6
2,100			1.7	17	1.2	11	0.7	7	0.3	3
1,500			0.9	8	0.6	6	0.4	4	0.2	2
4,000					4.4	42	2.6	25	1.0	10
2,800					2.1	21	1.2	13	0.5	5
2,000					1.1	11	0.6	6	0.3	3
Flow Rate (L/min)	One 125 mm		One 150 mm		Two 110 mm		Two 125 mm		Two 150 mm	
	m water	kPa	m water	kPa	m water	kPa	m water	kPa	m water	kPa
5,000	4.0	39	1.6	16	1.7	17				
3,500	2.0	19	0.8	8	0.9	8				
2,500	1.0	10	0.4	4	0.4	4				
6,000			2.3	23	2.4	24	1.4	14	0.6	6
4,200			1.1	11	1.2	12	0.7	7	0.3	3
3,000			0.6	6	0.6	6	0.4	4	0.2	2
7,000			3.2	31	3.6	33	2.0	19	0.8	8
4,900			1.5	16	1.6	16	0.9	9	0.4	4
3,500			0.8	8	0.9	8	0.5	5	0.2	2
8,000					4.4	42	2.6	25	1.0	10
5,600					2.1	21	1.2	13	0.5	5
4,000					1.1	11	0.6	6	0.3	3
9,000							3.3	32	1.3	13
6,300							1.6	16	0.7	6
4,500							0.9	8	0.3	3
10,000							4.0	39	1.6	16
7,000							2.0	19	0.8	8
5,000							1.0	10	0.4	4
Flow Rate (L/min)	Two 150 mm		Three 150 mm		Four 150 mm		One 200 mm		Two 200 mm	
	m water	kPa	m water	kPa	m water	kPa	m water	kPa	m water	kPa
8,000	1.0	10					1.3	13		
5,600	0.5	5					0.6	6		
4,000	0.3	3					0.3	3		
9,000	1.3	13	0.6	6			1.7	17	0.4	4
6,300	0.7	6	0.3	3			0.7	7	0.2	2
4,500	0.3	3	0.2	2			0.4	4	0.1	1
10,000	1.6	16	0.7	7			2.1	21	0.5	4
7,000	0.8	8	0.4	4			1.0	9	0.2	2
5,000	0.4	4	0.2	2			0.5	4	0.1	1
12,000	2.3	23	1.09	10.1					0.7	7
8,400	1.1	12	0.52	5.1					0.3	3
6,000	0.58	5.7	0.27	2.71					0.18	1.69
14,000			1.42	13.9	0.8	8			1.0	9

(continues)

Table 13.2.4.1(c) *Continued*

Flow Rate (L/min)	Number of Suction Hose and Size (inside diameter)									
	One 75 mm		One 100 mm		One 110 mm		One 125 mm		One 150 m	
	m water	kPa	m water	kPa	m water	kPa	m water	kPa	m water	kPa
9,800			0.88	8.6	0.4	4			0.5	4
7,000			0.36	3.56			0.21	2.03	.021	2.03
16,000			1.5	15	1.0	10			1.3	13
11,200			0.9	8	0.5	5			0.6	6
8,000					0.27	2.71			0.31	3.05
Flow Rate (L/min)	Six 150 mm		Three 200 mm		Four 200 mm		Two 300 mm			
	m water	kPa	m water	kPa	m water	kPa	m water	kPa		
18,000	0.64	6.43	0.7	6.77						
12,600	0.33	3.38	0.37	3.38						
9,000	0.17	1.52	0.18	1.69						
20,000	0.7	6.77	0.76	7.45						
14,000	0.37	3.72	0.46	4.4						
10,000	0.18	1.69	0.21	2.03						
22,000	0.76	7.45			0.64	6.43	0.58	5.76		
15,400	0.43	4.06			0.27	2.71	0.24	2.37		
11,000	0.21	2.03			0.15	1.35	0.15	1.22		
24,000	1.04	10.16			0.7	7.11	0.64	6.43		
16,800	0.61	5.76			0.31	3.05	0.27	2.71		
12,000	0.51	5.08			0.18	1.69	0.15	1.35		
Flow Rate (L/min)	Six 150 mm		Three 200 mm		Four 200 mm		Two 300 mm			
	m water	kPa	m water	kPa	m water	kPa	m water	kPa		
26,000			0.76		7.45		0.7	7.11		
18,200			0.33		3.38		0.33	3.05		
13,000			0.21		2.03		0.18	1.69		
28,000			1.0		9.82		0.76	7.45		
19,600			0.46		4.4		0.33	3.38		
14,000			0.21		2.03		0.21	2.03		
30,000			1.13		11.17		0.82	8.47		
21,000			0.58		5.76		0.4	3.72		
15,000			0.33		3.38		0.27	2.71		

13.4.3* A means shall be provided to limit the nominal net engine output during pumping operation to a torque level equal to the nominal continuous duty torque rating of the weakest component or, if there are multiple devices to be driven simultaneously, to a level equal to the sum of the nominal continuous duty torque ratings of multiple components.

13.5 Construction Requirements.

13.5.1* Wetted moving parts shall be constructed of a corrosion-resistant material.

13.5.2 Hydrostatic Test.

13.5.2.1 The pump body shall be subjected to a hydrostatic test to a minimum gauge pressure of 500 psi (3400 kPa) for a minimum of 10 minutes.

13.5.2.2 The pump manufacturer shall provide a certificate of completion for the hydrostatic test.

13.5.3 Plumbing Pressure Capability.

13.5.3.1 The entire discharge piping system; valves; drain cocks; and outlet closures, excluding the tank fill line on the tank side of the valve and CAF system piping and components

that include valves that permit isolation from discharge pressure, shall be capable of withstanding a hydrodynamic discharge pressure of 500 psi (3400 kPa) or 100 psi (700 kPa) over the maximum discharge pressure capability rating of the pump, whichever is greater.

13.5.3.2 The aerial waterway and master stream waterway on the discharge side of the valves in those lines and CAF system piping and components shall be capable of withstanding a hydrostatic pressure of 250 psi (1700 kPa).

13.5.3.3 The entire intake piping system, valves, bleeder valves, and intake closures, excluding the tank-to-pump line on the tank side of the valve, shall be capable of withstanding a hydrostatic pressure of 250 psi (1700 kPa).

13.5.4 Hydrodynamic Test.

13.5.4.1 If the maximum discharge pressure capability rating of the pump identified in 13.2.5.1 exceeds the hydrostatic test pressure performed in 13.5.2.1, the pump shall be subjected to a hydrodynamic test during which the discharge pressure equals or exceeds the maximum discharge pressure capability rating for a minimum of 5 minutes.

13.5.4.2 When the hydrodynamic test is required to be performed, the pump manufacturer shall provide a certificate of completion for the hydrodynamic test.

13.5.5 The pump shall allow a positive-pressure water source to directly add to the pump's discharge pressure.

13.6 Pump Intake Connections.

13.6.1* The pump shall have a sufficient number and size of intakes to perform the apparatus pump system certification test.

13.6.1.1* The intakes specified in 13.6.1 shall have male National Hose (NH) threads if the apparatus is to be used in the United States.

13.6.1.2 If the couplings on the suction hose carried on the apparatus are of a different size from that of the pump intake(s) or have means of hose attachment other than that provided on the intake(s), an adapter(s) shall be provided to allow connection of the suction hose to the pump intake(s).

13.6.1.3* Safety sign FAMA25, which warns of the need for training prior to operating the apparatus, shall be located on the pump operator's panel.

13.6.2 Intake Strainer.

13.6.2.1 Each intake shall have a removable or accessible strainer inside the connection.

13.6.2.2* The strainer(s) shall restrict spherical debris that is too large to pass through the pump.

13.6.3 At least one valved intake shall be provided.

13.6.3.1* The valve shall be controlled from the pump operator's position.

13.6.3.2 The valve and piping shall be a minimum 2½ in. (65 mm) nominal size.

13.6.3.3 If the intake is 2½ in. (65 mm) nominal size, the intake shall be equipped with a female swivel coupling with NH threads.

13.6.4 Any 3 in. (75 mm) or larger intake valve except the tank-to-pump intake valve shall be a slow-operating valve.

13.6.5* Each valved intake shall be equipped with a bleeder valve.

13.6.5.1 The bleeder valve shall be operational without the operator having to get under the apparatus.

13.6.5.2 If a valved appliance is attached to an intake, it shall be equipped with a bleeder valve on each intake.

13.6.5.3 Bleeder valves for valved intakes 4 in. (100 mm) and larger not located at the pump operator's panel shall be located where the bleeder valve controls are visible and operationally functional while the operator remains stationary at the valved intake position.

13.6.6 Each valved intake having a connection size larger than 3 in. (75 mm) shall be equipped with an adjustable automatic pressure relief device installed on the supply side of the valve to bleed off pressure from a hose connected to the valved intake.

13.6.6.1 The pressure relief device shall discharge to atmosphere, and the discharge shall be piped or directed away from the pump operator's position.

13.6.6.2 The automatic pressure relief device shall be adjustable from a minimum of 90 psi (620 kPa) to at least 185 psi (1275 kPa).

13.6.6.3 The pressure relief device, when preset at 125 psi (860 kPa), shall not allow a pressure rise greater than 60 psi (400 kPa) at the device inlet while flowing a minimum of 150 gpm (570 L/min).

13.6.7 If the pump is equipped with one or more intakes larger than 3 in. (75 mm) that are not valved, an adjustable automatic pressure relief device shall be installed on the pump system to bleed off excess pressure from a hose connected to the pump intake.

13.6.7.1 The automatic pressure relief device shall be adjustable from a minimum of 90 psi (620 kPa) to at least 185 psi (1275 kPa).

13.6.7.2 The pressure relief device, when preset at 125 psi (860 kPa), shall not allow a pressure rise greater than 60 psi (400 kPa) at the device inlet while flowing a minimum of 150 gpm (570 L/min).

13.6.7.3 The pressure relief device shall discharge to atmosphere.

13.6.8 Intake Covers. All intakes shall be provided with caps, plugs, or closures capable of withstanding a hydrostatic gauge pressure of 500 psi (3400 kPa).

13.6.8.1 Intakes having male threads shall be equipped with caps.

13.6.8.2 Intakes having female threads shall be equipped with plugs.

13.6.8.3 Where adapters for special threads or other means for hose attachment are provided on the intakes, closures shall be provided for the adapters in lieu of caps or plugs.

13.6.8.4 Caps, plugs, or closures for 3½ in. (90 mm) and smaller intakes shall remain secured to the apparatus when removed from the intakes.

13.6.9 If the suction inlets are to be equipped with a valve, siamese, or adapter that will remain in place while the apparatus is in motion, that valve, siamese, or adapter shall not project beyond the apparatus running board.

13.6.10 The purchaser shall specify if any valve, siamese, or adapter is to be permanently installed on an intake and identify the brand and model of such item.

13.7* Pump Discharge Outlets.

13.7.1* Discharge outlet connections of 2½ in. (65 mm) or larger shall be provided to discharge the rated capacity of the pump at the flow rates shown in Table 13.7.1.

13.7.1.1 If the apparatus is equipped with an aerial device with a waterway that is permanently connected to the pump, the discharge from that waterway shall be permitted to be credited as a 1000 gpm (4000 L/min) outlet.

13.7.1.2 A minimum of two 2½ in. (65 mm) outlets shall be provided on any pump rated at 750 gpm (3000 L/min) or greater, and a minimum of one 2½ in. (65 mm) outlet shall be provided on any pump rated at less than 750 gpm (3000 L/min).

Table 13.7.1 Discharge Rates by Outlet Size

Outlet Size		Flow Rates	
in.	mm	gpm	L/min
2½	65	250	1000
3	75	375	1400
4	100	625	2400
5	125	1000	4000
6	150	1500	6000

13.7.2 Discharge Outlet Connections.

13.7.2.1* All 2½ in. (65 mm) or larger discharge outlet connections shall be equipped with male National Hose (NH) threads if the apparatus is to be used in the United States.

13.7.2.2* Adapters with special threads or other means for hose attachment shall be permitted to be attached to any outlets.

13.7.3* The piping and valves supplying any preconnected 1½ in. (38 mm), 1¾ in. (45 mm), or 2 in. (52 mm) hose line, including piping to the preconnected hose storage areas specified in Table 8.1, as applicable, shall be at least 2 in. (52 mm) in size.

13.7.4 All discharge outlet connections, except connections to which a hose will be preconnected, shall be equipped with caps or closures capable of withstanding a hydrostatic gauge pressure of 100 psi (700 kPa) over the maximum pump close-off pressure or 500 psi (3400 kPa), whichever is greater.

13.7.4.1 Where adapters are provided on the discharge outlet connections, the closures shall fit on the adapters.

13.7.4.2 Caps or closures for outlet connections smaller than 4 in. (100 mm) shall remain secured to the apparatus when removed from the connection.

13.7.4.3 Threaded caps shall automatically release pressure in the discharge outlet before the threads are completely disengaged unless the outlet and the cap are equipped with drains or bleeder valves.

13.7.4.4 The pressure relief shall discharge to atmosphere, and the discharge shall direct away from the operator's position.

13.7.4.5 Safety sign FAMA18, which warns of cap pressure dangers, shall be placed on each side and back of the vehicle where caps are present.

13.7.5 Each discharge outlet shall be equipped with a valve that can be opened and closed smoothly at the discharge rates shown in Table 13.7.1 at a pump discharge gauge pressure of 250 psi (1700 kPa).

13.7.5.1 The flow-regulating element of each valve shall not change its position under any condition of operation that involves discharge pressures to the maximum pressure of the pump.

13.7.5.2 The means to prevent a change in position shall be incorporated in the operating mechanism and shall be permitted to be manually or automatically controlled.

13.7.5.3* Any 3 in. (75 mm) or larger discharge valve shall be a slow-operating valve.

13.7.6 All 1½ in. (38 mm) or larger discharge outlets shall be equipped with a drain or bleeder valve having a minimum ¼ in. (19 mm) pipe thread connection for draining or bleeding off pressure from a hose connected to the outlet.

13.7.7 Any 2 in. (52 mm) or larger discharge outlet that is located more than 42 in. (1070 mm) off the ground to which hose is to be connected and that is not in a hose storage area shall be supplied with a sweep elbow of at least 30 degrees downward.

13.7.8 Valves.

13.7.8.1 Each pump discharge shall have a valve that can be controlled from the pump operator's position.

13.7.8.2 A secondary valve shall be permitted to be provided at a discharge outlet if required for special applications.

13.7.9* Location of Discharge Outlets.

13.7.9.1 No discharge outlet larger than 2½ in. (65 mm) shall be located at the pump operator's panel.

13.7.9.2 If the apparatus has a top console-type pump operator's panel, vertical discharge outlets larger than 2½ in. (65 mm) shall be permitted at the top midship position of apparatus where the outlets are used for directly connected deck guns or monitors and no fire hose is used for coupling the components.

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

13.8 Pump Drains.

13.8.1 A readily accessible drain valve(s) that is marked with a label as to its function shall be provided to allow for draining of the pump and all water-carrying lines and accessories.

13.8.2 The drain valve(s) shall be operational without the operator having to get under the apparatus.

13.9 Pump Operator's Panel.

13.9.1* Each pump control, gauge, and other instrument necessary to operate the pump shall be located on a panel known as the pump operator's panel and shall be marked with a label as to its function.

13.9.2 All gauges, discharge outlets, pump intakes, and controls shall be illuminated in compliance with 7.11.1.

13.10* Pump Controls.

13.10.1 General Provisions. Provisions shall be made for placing the pump drive system in operation using controls and switches that are identified and within convenient reach of the operator.

13.10.1.1 Where the pump is driven by the chassis engine and engine compression brakes or engine exhaust brakes are furnished, these engine brakes shall be automatically disengaged for pumping operations.

13.10.1.2* Any control device used in the pumping system power train between the engine and the pump, except a manual pump shift override device if provided, shall be equip-

ped with a means to prevent unintentional movement of the control device from its set position in the pumping mode.

13.10.1.3 Where the pump is driven by the chassis engine, a label indicating the chassis transmission shift selector position to be used for pumping shall be provided in the driving compartment and located so that it can be read from the driver's position.

13.10.1.4 Where the pump is driven by the chassis engine and automatic transmission through a split shaft PTO, an interlock system shall be provided to prevent the pump drive system from being shifted out of the "pump engaged" pumping mode of operation when the chassis transmission is in pump gear.

13.10.1.5 Where the power train from engine to pump includes auxiliary braking devices, they shall be automatically disengaged for pumping operations.

13.10.1.6 Where the pump is driven by the chassis engine and an automatic chassis transmission through a split-shaft PTO, the chassis transmission shall shift to neutral upon engagement of the parking brake.

13.10.2* Interlocks and Indicators. Where the water pump is driven by the chassis engine, an interlock system shall be provided to ensure that the pump drive system components are engaged in the pumping mode of operation so that the pumping system can be operated from the pump operator's position, with indicators to inform the operators of the status of the controls.

13.10.2.1 Required Indicators.

13.10.2.1.1 All apparatus shall have both a "Pump Engaged" indicator and an "OK to Pump" indicator in the driver compartment.

13.10.2.1.2* All apparatus shall have both a "Throttle Ready" indicator and an "OK to Pump" indicator on the pump operator's panel.

13.10.2.1.3 If the apparatus is designed to do pump-and-roll, an "OK to Pump-and-Roll" indicator shall also be in the driver compartment.

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

13.10.2.3 OK to Pump. An "OK to Pump" indicator shall be provided in the driving compartment and on the pump operator's panel to indicate that all of the following conditions have been met to safely operate the pump in stationary mode:

- (1) The pump shift is engaged.
- (2) The parking brake is engaged.
- (3) If the pump is driven from a transfer case PTO or auxiliary transmission PTO, the drive to the wheels is in neutral.
- (4) If the apparatus is equipped with an automatic transmission, the chassis transmission is in the correct pump gear as identified in 13.10.1.3 as follows:
 - (a) If the pump is driven by a PTO after the chassis transmission gearing (e.g., split shaft PTO, transfer case PTO, etc.) the transmission is in the correct forward drive gear.

- (b) If the pump is driven by a PTO ahead of the chassis transmission gearing (e.g., flywheel PTO, crankshaft PTO, etc.) the transmission is in neutral.

- (5) If the apparatus is equipped with a manual transmission, any gear, including neutral, will allow an "OK to Pump" indicator to come on provided all other conditions are met.

13.10.2.4* OK to Pump-and-Roll. If the apparatus is designed to be used in both stationary pumping mode and "pump-and-roll" pumping mode, an "OK to Pump-and-Roll" indicator shall be provided in the driving compartment to indicate that all of the following conditions have been met to safely operate the pump in pump-and-roll mode:

- (1) The pump shift is engaged.
- (2) The parking brake is released.

13.10.2.5 Throttle Ready.

13.10.2.5.1 A "Throttle Ready" indicator shall be provided on the pump operator's panel.

13.10.2.5.2 The "Throttle Ready" indicator shall indicate when the pump is in "OK to Pump" mode.

13.10.2.5.3* The "Throttle Ready" indicator at the pump operator's panel shall be permitted to indicate when the parking brake is engaged and, if the apparatus is equipped with an automatic transmission, when the chassis transmission is in neutral.

13.10.2.5.4 If there are multiple pumps, generators, aerial devices, hydraulic pumps, or other devices powered off of the chassis engine, the "Throttle Ready" indicator shall only indicate when all such devices are in a mode where the advancement of the engine throttle is safe.

13.10.2.6 Engine Speed Control.

13.10.2.6.1 An engine speed control shall be provided at the pump operator's panel.

13.10.2.6.2 An interlock system shall be provided to prevent advancement of the engine speed at the pump operator's panel unless the apparatus has a "Throttle Ready" indication.

13.10.2.6.3 Loss of power to the interlock system shall return the engine speed to idle and prevent advancement from the pump operator's panel.

13.10.2.7 Manual Override. If a pump shift manual override device is provided, the "Pump Engaged," "OK to Pump," "OK to Pump-and-Roll," and "Throttle Ready" indicators and the pump operator's panel engine speed advancement interlock system shall be operationally functional when the manual override device is used to shift the pump.

13.10.3 Parallel/Series Control.

13.10.3.1 With parallel/series centrifugal pumps, the control positions for parallel operation (volume) and series operation (pressure) shall be indicated.

13.10.3.2 The control for changing the pump from series to parallel, and vice versa, shall be operable at the pump operator's position.

13.10.4* Pressure Control System.

13.10.4.1* A system shall be provided that, when set in accordance with the manufacturer's instructions, will automatically

control the increase in net pump pressure to a maximum of 30 psi (200 kPa) pressure rise when all discharge valves are closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds during the following conditions:

- (1) Over a range of pressures from 70 psi to 300 psi (500 kPa to 2000 kPa) net pump pressure with intake gauge pressure between -10 psi and 185 psi (-70 kPa and 1300 kPa) and discharge gauge pressure between 90 psi and 300 psi (620 kPa and 2000 kPa)
- (2) With initial engine and pump controls set to produce a range of flows from 150 gpm (550 L/min) to the rated capacity of the pump

13.10.4.2 If the pump is equipped with a relief valve system where the system does not control engine speed, the system shall be equipped with a means to indicate when the system is in control of the pressure.

13.10.4.2.1 If the pump is equipped with a governor system that controls engine speed, an indicator shall show when the system is turned on and whether it is controlling the engine speed or pump pressure.

13.10.4.2.2 Either system shall be controllable by one person at the pump operator position.

13.10.4.3 If the system discharges water to the atmosphere, the discharge shall be in a manner that will not expose personnel to high-pressure water streams.

13.10.5* Priming System. A priming system shall be provided and controlled from the pump operator's position.

13.10.5.1 The priming system shall be capable of meeting the requirements of 13.2.3.3 and 13.2.4.

13.10.5.2 The priming system shall be capable of operating with no lubricant or with a biodegradable nontoxic lubricant.

13.10.6 Protection of Pump Controls. All pump controls and devices shall be installed so as to be protected against mechanical damage and the effects of adverse weather conditions on their operation.

13.11 Pump Engine Controls.

13.11.1* A throttle control that holds its set position shall be provided to control the pump engine speed.

13.11.2 The throttle control on vertically (greater than 45 degrees) arranged pump panels shall be located not higher than 72 in. (1830 mm) nor lower than 42 in. (1070 mm) from the operator's standing position with all instruments in full view.

13.11.3 The throttle control on horizontally (less than 45 degrees) arranged pump panels shall be located not higher than 50 in. (1270 mm) nor lower than 32 in. (810 mm) from the operator's standing position with all instruments in full view.

13.12 Instrumentation.

13.12.1 Pump Operator's Panel.

13.12.1.1* The following controls and instruments shall be provided and installed as a group on the pump operator's panel:

- (1) Master pump intake pressure gauge
- (2) Master pump discharge pressure gauge

- (3) Pumping engine tachometer
- (4) Pumping engine coolant temperature gauge—unless pumping engine is air cooled or electric
- (5) Pumping engine oil pressure gauge—unless pumping engine is electric
- (6) Voltmeter
- (7) Pump pressure control(s)
- (8) Pumping engine throttle
- (9) Primer control
- (10) Water-tank-to-pump valve control
- (11) Water tank fill valve control
- (12) Water tank level gauge
- (13) CAF system isolation valve control (if so equipped)

13.12.1.2 The instruments and controls required by 13.12.1.1 shall be placed so as to keep the pump operator as far as practicable from all discharge and intake connections and in a location where the instruments and controls are visible and operationally functional while the operator remains stationary.

13.12.1.3 Any instrumentation exposed to the elements shall be weatherproof.

13.12.1.4 The pumping engine oil pressure and engine coolant temperature gauges shall be equipped with audible and visual warnings.

13.12.1.5 All engine operation gauges on the pump operator's panel shall be in addition to those on the vehicle's instrument panel.

13.12.2 Master Pump Intake and Discharge Pressure Gauges.

13.12.2.1 Master pump intake and pump discharge pressure gauges shall be located within 8 in. (200 mm) of each other, edge to edge, with the intake pressure gauge to the left of or below the pump discharge pressure gauge.

13.12.2.1.1 The intake pressure gauge shall read from 30 in. Hg (100 kPa) vacuum to at least a gauge pressure of 300 psi (2000 kPa).

13.12.2.1.2 The discharge pressure gauge shall read from a gauge pressure of 0 psi or lower to a gauge pressure of at least 300 psi (2000 kPa).

13.12.2.1.3 Pressure gauges shall not be damaged by a 30 in. Hg (100 kPa) vacuum.

13.12.2.1.4 Pressure gauges shall be marked with labels that read "Pump Intake" for the intake pressure gauge and "Pump Discharge" for the discharge pressure gauge.

13.12.2.2 If analog gauges are used, they shall meet the requirements of 13.12.2.2.1 through 13.12.2.2.7.

13.12.2.2.1 There shall be at least a 1 in. (25 mm) diameter differential in viewing area between the master gauges and the individual discharge gauges, with the master gauges being the larger.

13.12.2.2.2 Analog gauges displaying the vacuum portion in 120 degrees of arc or less shall have an accuracy complying with Grade 1A as defined by ASME B40.100, *Pressure Gauges and Gauge Attachments*.

13.12.2.2.3 Analog gauges displaying the vacuum portion in greater than 120 degrees of arc shall have an accuracy of 3½ percent or better on vacuum and 3½ percent or better on pressure over their entire respective scale.

13.12.2.2.4 Analog gauges displaying the vacuum portion in greater than 120 degrees of arc shall have graduation lines on the vacuum side every 1 in. Hg (5 kPa) with major and immediate graduation lines emphasized and figures at least every 10 in. Hg (50 kPa).

13.12.2.2.5 Numerals for master gauges shall be a minimum of 0.25 in. (6.4 mm) high.

13.12.2.2.6 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa).

13.12.2.2.7 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

13.12.2.3 If digital master pressure gauges are used, they shall meet the requirements of 13.12.2.3.1 through 13.12.2.3.3.

13.12.2.3.1 The digits shall be at least 0.5 in. (12.7 mm) high.

13.12.2.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

13.12.2.3.3 Digital master pressure gauges shall have an accuracy of ± 3 percent over the full scale.

13.12.2.4 If the apparatus is designed for pump-and-roll operations using the chassis engine-driven pump, a second discharge pressure gauge of the type required by 13.12.2.1.2 shall be mounted in the driving compartment in view of the driver.

13.12.3 Discharge Outlet Instrumentation.

13.12.3.1 A pressure gauge shall be provided for each discharge outlet 1½ in. (38 mm) or larger in size and shall be marked with a label to indicate the outlet to which it is connected.

13.12.3.2* Any discharge outlet that is equipped with a flowmeter shall also be provided with a pressure gauge.

13.12.3.3 The pressure gauge or flowmeter display shall be located adjacent to the corresponding valve control with no more than 6 in. (150 mm) separating the pressure gauge or flowmeter bezel and the valve control midpoint or centerline.

13.12.3.4 If both a flowmeter and a pressure gauge are provided for an individual discharge outlet, the pressure gauges shall be located within 6 in. (150 mm) of the valve control midpoint or centerline, and the flowmeter display shall be adjacent to and within 2 in. (51 mm) of the pressure gauge bezel.

13.12.3.5 Pressure gauges shall be connected to the outlet side of the valve.

13.12.3.6 Flowmeters shall display flow in increments no greater than 10 gpm (50 L/min).

13.12.3.7 Where analog pressure gauges are used, they shall have a minimum accuracy of Grade B as defined in ASME B40.100.

13.12.3.7.1 Numerals for gauges shall be a minimum ⅝ in. (4 mm) high.

13.12.3.7.2 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized, and figures at least every 100 psi (500 kPa).

13.12.3.7.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

13.12.3.8 If digital pressure gauges are used, they shall meet the requirements of 13.12.3.8.1 through 13.12.3.8.3.

13.12.3.8.1 The digits shall be at least ¼ in. (6.4 mm) high.

13.12.3.8.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

13.12.3.8.3 Digital pressure gauges shall have an accuracy of ± 3 percent over the full scale.

13.12.3.9 Each flowmeter shall be calibrated to an accuracy of ± 5 percent when flowing the amount of water shown in Table 13.12.3.9 for the pipe size in which it is mounted.

13.12.4 Each pressure gauge or flowmeter and its display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

13.12.5 Connections for test gauges shall be provided at the pump operator's panel.

13.12.5.1 One test gauge connection shall be connected to the intake side of the pump, and the other shall be connected to the discharge manifold of the pump.

13.12.5.2 The test gauge connections shall have a 0.25 in. (6.4 mm) standard pipe thread, shall be plugged, and shall be marked with a label.

13.13 Required Testing.

13.13.1 Apparatus Pump System Certification.

13.13.1.1 If the fire pump has a rated capacity of 750 gpm (3000 L/min) or greater, the pump shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus.

13.13.1.1.1 The tests shall include at least the pumping test (*see 13.13.2*), the pressure control system test (*see 13.13.4*), the priming system tests (*see 13.13.5*), the vacuum test (*see 13.13.6*), and the gauge and flowmeter test (*see 13.13.9*).

13.13.1.1.2 If the fire pump is rated at 750 gpm (3000 L/min) or greater but less than 3000 gpm (12,000 L/min), the pump-engine overload test (*see 13.13.3*) shall be included.

13.13.1.1.3 If the fire pump is driven by the chassis engine, the engine speed advancement interlock test (*see 13.13.8*) shall be included.

Table 13.12.3.9 Flowmeter Calibration Flow for Each Pipe Size

Pipe Size		Flow	
in.	mm	gpm	L/min
1	25	40	150
1½	40	90	340
2	50	160	600
2½	65	250	950
3	80	375	1400
4	100	625	2400
5	125	1000	4000
6	150	1440	5500

13.13.1.1.4 If the apparatus is equipped with a water tank, the water tank-to-pump flow test (*see 13.13.7*) shall be included.

13.13.1.1.5 The independent third-party organization shall witness all required tests by an in-person representative(s) at the test site or by use of verifiable automated data collection and image recording equipment.

13.13.1.1.6 The independent third-party organization shall witness all required tests and certify the test results.

13.13.1.2 If the fire pump has a rated capacity of less than 750 gpm (3000 L/min), the pump shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus.

13.13.1.2.1 The tests shall include at least the pumping test (*see 13.13.2*), the pressure control system test (*see 13.13.4*), the priming system tests (*see 13.13.5*), the vacuum test (*see 13.13.6*), and the gauge and flowmeter test (*see 13.13.9*).

13.13.1.2.2 If the apparatus is equipped with a water tank, the water tank-to-pump flow test (*see 13.13.7*) shall be included.

13.13.1.2.3 If the fire pump is driven by the chassis engine, the engine speed advancement interlock test (*see 13.13.8*) shall be included.

13.13.1.2.4* The test results shall be certified by the apparatus manufacturer.

13.13.1.3 Test Label.

13.13.1.3.1 A test label shall be provided at the pump operator's panel that gives the rated discharges and pressures together with the speed of the engine as determined by the certification test for each unit, the position of the parallel/series pump as used, and the governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve.

13.13.1.3.2 The label shall be completely stamped with all information at the factory and attached to the vehicle prior to shipping.

13.13.2 Pumping Test.

13.13.2.1 Conditions for Test.

13.13.2.1.1 The test site shall be adjacent to a supply of clear water at least 4 ft (1.2 m) deep 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.

13.13.2.1.2* Tests shall be performed when conditions are as follows:

- (1) Air temperature: 0°F to 110°F (-18°C to 43°C)
- (2) Water temperature: 35°F to 90°F (2°C to 32°C)
- (3) Barometric pressure: 29 in. Hg (98.2 kPa), minimum (corrected to sea level)
- (4)* Minimum lift: 3 ft (1 m) from center of pump intake to the surface of the water

13.13.2.1.3 If it is necessary to perform the test outside the air or water temperature ranges stated in 13.13.2.1.2 and the pump passes the certification test, the test results shall be acceptable.

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

13.13.2.1.4.1 If the chassis engine drives the pump, the total continuous electrical loads, excluding those loads associated with the equipment defined in 13.13.2.1.4.3, shall be applied for the entire pumping portion of this test.

13.13.2.1.4.2 If the vehicle is equipped with a fixed power source driven by the same engine that drives the fire pump, the fixed power source shall be running at a minimum of 50 percent of its rated capacity throughout the pumping portion of the pump test.

13.13.2.1.4.3 The following devices shall be permitted to be turned off or not operating during the pump test:

- (1) Aerial hydraulic pump
- (2) Foam pump
- (3) Hydraulically driven equipment (other than hydraulically driven line voltage generator)
- (4) Winch
- (5) Windshield wipers
- (6) Four-way hazard flashers
- (7) Compressed air foam system (CAFS) compressor

13.13.2.1.5 All structural enclosures, such as floorboards, gratings, grilles, and heat shields, not furnished with a means for opening them in service shall be kept in place during the tests.

13.13.2.2 Equipment.

13.13.2.2.1 Suction Hose.

13.13.2.2.1.1 The suction hose size and maximum number of lines during the apparatus pump system certification testing shall be as defined in Table 13.13.2.2.1.1.

13.13.2.2.1.2 A suction strainer and hose that will allow flow with total friction and entrance loss not greater than that specified in Table 13.2.4.1(b) or Table 13.2.4.1(c) shall be used.

13.13.2.2.2 Sufficient fire hose shall be provided to discharge the rated capacity of the pump to the nozzles or other flow measuring equipment without exceeding a flow velocity of 35 ft/sec (10 m/sec) [approximately 500 gpm (2000 L/min) for 2½ in. (65 mm) hose].

13.13.2.2.3 Where nozzles are used, they shall be smoothbore, and the inside diameters shall be from ¾ in. to 2½ in. (19 mm to 63.5 mm).

13.13.2.2.4 Test Gauges.

13.13.2.2.4.1 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*, and shall be at least size 3½ per ASME B40.100.

13.13.2.2.4.2 The pump intake gauge shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge or 30 in. Hg (100 kPa) vacuum to a gauge pressure of 150 psi (1000 kPa) for a compound gauge.

13.13.2.2.4.3 The discharge pressure gauge shall have a gauge pressure range of 0 psi to 400 psi (0 kPa to 2800 kPa).

13.13.2.2.4.4 Pitot gauges shall have a gauge pressure range of at least 0 psi to 160 psi (0 kPa to 1100 kPa).

Table 13.13.2.2.1.1 Suction Hose Size and Number of Suction Lines for Fire Pumps

Rated Capacity		Maximum Suction Hose Size		Maximum Number of Suction Lines*
gpm	L/min	in.	mm	
250	1,000	3	75	1
300	1,100	3	75	1
350	1,300	4	100	1
500	2,000	4	100	1
750	3,000	4½	110	1
1,000	4,000	6	150	1
1,250	5,000	6	150	1
1,500	6,000	6	150	2
1,750	7,000	6	150	2
2,000	8,000	6	150	2
2,000	8,000	8	200	1
2,250	9,000	6	150	3
2,250	9,000	8	200	1
2,500	10,000	6	150	3
2,500	10,000	8	200	1
3,000	12,000	6	150	3
3,000	12,000	8	200	2
3,500	14,000	6	150	4
3,500	14,000	8	200	2
4,000	16,000	6	150	4
4,000	16,000	8	200	2
4,500	18,000	6	150	6
4,500	18,000	8	200	3
5,000	20,000	6	150	6
5,000	20,000	8	200	3
5,500	22,000	6	150	6
5,500	22,000	8	200	4
5,500	22,000	12	300	2
6,000	24,000	6	150	6
6,000	24,000	8	200	4
6,000	24,000	12	300	2
6,500	26,000	8	200	4
6,500	26,000	12	300	2
7,000	28,000	8	200	4
7,000	28,000	12	300	2
7,500	30,000	8	200	4
7,500	30,000	12	300	2

*Where more than one suction line is used, all suction lines do not have to be the same hose size.

13.13.2.2.4.5 All gauges shall be calibrated in the month preceding the tests using a dead-weight gauge tester or a master gauge meeting the requirements for Grade 3A or 4A gauges, as defined in ASME B40.100, that has been calibrated within the preceding year.

13.13.2.2.5 Each test gauge shall include a means for “snubbing,” such as a needle valve, to damp out rapid needle movements.

13.13.2.2.6* The engine speed-measuring equipment shall consist of a nonadjustable tachometer supplied from the engine or transmission electronics, a revolution counter on a checking shaft outlet and a stopwatch, or other engine speed-

measuring means that is accurate to within ± 50 rpm of actual speed.

13.13.2.3 Procedure.

13.13.2.3.1* The ambient air temperature, water temperature, vertical lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to and after each pump test.

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

13.13.2.3.3* If the fire pump is a multistage pump and has provisions for controlling the flow between stages or for controlling the flow discharged from specific stages of the pump, the pump shall be tested with the controls set in accordance with the pump manufacturer's instructions.

13.13.2.3.4 Engine Speed Check. A check of the no-load governed speed of the engine shall be made and recorded.

13.13.2.3.5 If the apparatus is equipped with a fire pump rated at 750 gpm (3000 L/min) or greater but less than 3000 gpm (12,000 L/min), the pump shall be subjected to a 3-hour pumping test from draft consisting of 2 hours of continuous pumping at rated capacity at a minimum of 150 psi (1000 kPa) net pump pressure, followed by ½ hour of continuous pumping at 70 percent of rated capacity at a minimum of 200 psi (1400 kPa) net pump pressure and ½ hour of continuous pumping at 50 percent of rated capacity at a minimum of 250 psi (1700 kPa) net pump pressure.

13.13.2.3.5.1 The pump shall not be stopped until after the 2-hour test at rated capacity, unless it becomes necessary to clean the suction strainer.

13.13.2.3.5.2 The pump shall be permitted to be stopped between tests in order to change the hose or nozzles, clean the strainer, add fuel for the pump drive IC engine, add fuel for the fuel cell, or recharge the EV motor batteries.

13.13.2.3.5.3 The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence.

13.13.2.3.5.4 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

13.13.2.3.6 If the apparatus is equipped with a fire pump rated at 3000 gpm (12,000 L/min) or greater, the pump shall be subjected to a 3-hour pumping test from draft consisting of 2 hours of continuous pumping at rated capacity at a minimum of 100 psi (700 kPa) net pump pressure, followed by ½ hour of continuous pumping at 70 percent of rated capacity at a minimum of 150 psi (1000 kPa) net pump pressure and ½ hour of continuous pumping at 50 percent of rated capacity at a minimum of 200 psi (1400 kPa) net pump pressure.

13.13.2.3.6.1 The pump shall not be stopped until after the 2-hour test at rated capacity, unless it becomes necessary to clean the suction strainer.

13.13.2.3.6.2 The pump shall be permitted to be stopped between tests in order to change the hose or nozzles, clean the strainer, add fuel for the pump drive IC engine, add fuel for the fuel cell, or recharge the EV motor batteries.

13.13.2.3.6.3 The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence.

13.13.2.3.6.4 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

13.13.2.3.7 If the fire pump or industrial supply pump is a two-stage, parallel/series-type pump, the following criteria shall apply:

- (1) The test at 100 percent of rated capacity shall be run with the pump in parallel mode.
- (2) The test at 70 percent of rated capacity shall be permitted to be run with the pump in either series or parallel mode.
- (3) The test at 50 percent of rated capacity shall be run with the pump in series mode.

13.13.2.3.8 If the apparatus is equipped with a fire pump rated at less than 750 gpm (3000 L/min), the pump shall be subjected to a 50-minute pumping test from draft consisting of 30 minutes of continuous pumping at rated capacity at a minimum of 150 psi (1000 kPa) net pump pressure, followed by 10 minutes of continuous pumping at 70 percent of rated capacity at a minimum of 200 psi (1400 kPa) net pump pressure, and 10 minutes of continuous pumping at 50 percent of rated capacity at a minimum of 250 psi (1700 kPa) net pump pressure.

13.13.2.3.8.1 The pump shall not be stopped until after the 30-minute test at rated capacity, unless it becomes necessary to clean the suction strainer.

13.13.2.3.8.2 The pump shall be permitted to be stopped between tests in order to change the hose or nozzles or clean the strainer.

13.13.2.3.8.3 The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least every 10 minutes but not fewer than three times for each test sequence.

13.13.2.3.8.4 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

13.13.3 Pumping Engine Overload Test. If the pump has a rated capacity of 750 gpm (3000 L/min) or greater but less than 3000 gpm (12,000 L/min), the apparatus shall be subjected to an overload test consisting of pumping rated capacity at 165 psi (1100 kPa) net pump pressure for at least 10 minutes.

13.13.3.1 This test shall be performed immediately following the pumping test of rated capacity at 150 psi (1000 kPa).

13.13.3.2 The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least three times during the overload test.

13.13.4 Pressure Control System Test.

13.13.4.1 If the pump is rated at less than 3000 gpm (12,000 L/min), the pressure control system on the pump shall be tested as follows:

- (1) The pump shall be operated at draft, delivering rated capacity at a discharge gauge pressure of 150 psi (1000 kPa).
- (2) The pressure control system shall be set in accordance with the manufacturer's instructions to maintain the

discharge gauge pressure at 150 psi (1000 kPa) ± 5 percent.

- (3) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
- (4) The rise in discharge pressure shall not exceed 30 psi (200 kPa) and shall be recorded.
- (5) The original conditions of pumping rated capacity at a discharge gauge pressure of 150 psi (1000 kPa) shall be re-established.
- (6) The discharge pressure gauge shall be reduced to 90 psi (620 kPa) by reducing the engine speed, with no change to the discharge valve settings, hose, or nozzles.
- (7) The pressure control system shall be set according to the manufacturer's instructions to maintain the discharge gauge pressure at 90 psi (620 kPa) ± 5 percent.
- (8) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
- (9) The rise in discharge pressure shall not exceed 30 psi (200 kPa) and shall be recorded.
- (10) The pump shall be operated at draft, pumping 50 percent of rated capacity at a discharge gauge pressure of 250 psi (1700 kPa).
- (11) The pressure control system shall be set in accordance with the manufacturer's instructions to maintain the discharge gauge pressure at 250 psi (1700 kPa) ± 5 percent.
- (12) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
- (13) The rise in discharge pressure shall not exceed 30 psi (200 kPa) and shall be recorded.

13.13.4.2 If the pumping system is rated at 3000 gpm (12,000 L/min) or greater, the pressure control system on the pump shall be tested as follows:

- (1) The pump shall be operated at draft, delivering rated capacity at a discharge gauge pressure of 100 psi (700 kPa).
- (2) The pressure control system shall be set in accordance with the manufacturer's instructions to maintain the discharge gauge pressure at 100 psi (700 kPa) ± 5 percent.
- (3) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
- (4) The rise in discharge pressure shall not exceed 30 psi (200 kPa) and shall be recorded.
- (5) The pump shall be operated at draft, pumping 50 percent of rated capacity at a discharge gauge pressure of 200 psi (1400 kPa).
- (6) The pressure control system shall be set in accordance with the manufacturer's instructions to maintain the discharge gauge pressure at 200 psi (1400 kPa) ± 5 percent.
- (7) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
- (8) The rise in discharge pressure shall not exceed 30 psi (200 kPa) and shall be recorded.

13.13.5 Priming System Tests. With the apparatus set up for the pumping test, the primer shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water.

13.13.5.1 This test shall be permitted to be performed in connection with priming the pump for the pumping test.

13.13.5.2 The interval from the time the primer is started until the time the pump is discharging water shall be noted.

13.13.5.3 The time required to prime the pump shall not exceed 30 seconds if the rated capacity is 1250 gpm (5000 L/min) or less.

13.13.5.4 The time required to prime the pump shall not exceed 45 seconds if the rated capacity is 1500 gpm (6000 L/min) or more but less than 3000 gpm (12,000 L/min).

13.13.5.5 The time required to prime the pump shall not exceed 90 seconds if the rated capacity is 3000 gpm (12,000 L/min) or more.

13.13.5.6 An additional 15 seconds shall be permitted to meet the requirements of 13.13.5.3, 13.13.5.4, and 13.13.5.5 where the pump system includes an auxiliary 4 in. (100 mm) or larger intake pipe having a volume of 1 ft³ (0.03 m³) or more.

13.13.5.6.1 The additional 15 seconds shall not apply to valved intake pipes such that when the valve is closed, the pipe volume between the fire pump and the valve is reduced to less than 1 ft³ (0.03 m³).

13.13.6 Vacuum Test. The vacuum test shall consist of subjecting the interior of the pump, with all intake valves open, all intakes capped or plugged, and all discharge caps removed and valves closed, to a vacuum of 22 in. Hg (75 kPa) by means of the pump priming system.

13.13.6.1 At altitudes above 2000 ft (600 m), the vacuum attained shall be permitted to be less than 22 in. Hg (75 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (300 m) of altitude above 2000 ft (600 m).

13.13.6.2 The primer shall not be used after the 5-minute test period has begun.

13.13.6.3 The engine shall not be operated at any speed greater than the governed speed during this test.

13.13.6.4 The vacuum shall not drop more than 10 in. Hg (34 kPa) in 5 minutes.

13.13.6.5* The vacuum test shall then be repeated with all intake valves closed and the caps or plugs on all gated intakes removed.

13.13.7 Water Tank-to-Pump Flow Test.

13.13.7.1 A water tank-to-pump flow test shall be conducted as follows:

- (1) The water tank shall be filled until it overflows.
- (2) All intakes to the pump shall be closed.
- (3) The tank fill line and bypass cooling line shall be closed.
- (4) A hose line(s) and nozzle(s) for discharging water at the rated tank-to-pump flow rate shall be connected to one or more discharge outlets.
- (5) The tank-to-pump valve(s) and the discharge valve(s) leading to the hose line(s) and nozzle(s) shall be fully opened.
- (6) The engine speed shall be adjusted until the required flow rate -0/+5 percent is established (*see 17.3.2*).
- (7) The discharge pressure shall be recorded.
- (8) The discharge valves shall be closed and the water tank refilled.
- (9) The bypass cooling line shall be permitted to be opened temporarily, if needed, to keep the water temperature in the pump within acceptable limits.
- (10) The discharge valves shall be fully reopened and the time noted.
- (11) If necessary, the engine speed shall be adjusted to maintain the discharge pressure recorded as noted in 13.13.7.1(7).
- (12) When the discharge pressure drops by 10 psi (70 kPa) or more, the time shall be noted and the elapsed time from the opening of the discharge valves shall be calculated and recorded.

13.13.7.2 Volume Discharge Calculation.

13.13.7.2.1 The volume discharged shall be calculated by multiplying the rate of discharge in gallons per minute (liters per minute) by the time in minutes elapsed from the opening of the discharge valves until the discharge pressure drops by at least 10 psi (70 kPa).

13.13.7.2.2 Other means shall be permitted to be used to determine the volume of water pumped from the tank, such as a totalizing flowmeter, weighing the fire apparatus before and after, or refilling the tank using a totalizing flowmeter.

13.13.7.3 The rated tank-to-pump flow rate as defined in 17.3.2 shall be maintained until 80 percent of the rated capacity of the tank has been discharged.

13.13.8* Engine Speed Advancement Interlock Test. The engine speed advancement interlock system shall be tested to verify that engine speed cannot be increased at the pump operator's panel unless the proper conditions are met.

13.13.8.1 If the apparatus is equipped with a pump driven through a split shaft PTO, the test shall verify that for each of the conditions specified in the first four columns of Table 13.13.8.1, the indicators and engine speed controls operate as specified in the last four columns.

13.13.8.2 If the apparatus is equipped with a pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO that is designed for stationary pumping only, the test shall verify that for each of the conditions specified in the first four columns of Table 13.13.8.2, the indicators and engine speed controls operate as specified in the last four columns.

13.13.8.3 If the apparatus is equipped with a pump driven by the chassis engine designed for both stationary pumping and pump-and-roll, the test shall verify that for each of the conditions specified in the first four columns of Table 13.13.8.3, the indicators and engine speed controls operate as specified in the last four columns.

13.13.8.4 If the apparatus is equipped with a pump driven through a transfer case PTO or auxiliary transmission PTO designed for stationary pumping only, the test shall verify that for each of the conditions specified in the first five columns of Table 13.13.8.4, the indicators and engine speed controls operate as specified in the last four columns.

Table 13.13.8.1 Pump Driven Through Split Shaft PTO

Test Conditions				Verifications			
Transmission Type	Chassis Transmission Gear Selected	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Pump Indicator Status (Driving Compartment)	Pump Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^b	On	Road	None	None ^c	Yes	No ^c
Either	Neutral ^b	On	Road	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Off	Road	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" ^e	None ^c	Yes	No ^c
Automatic	Neutral	On	Engaged	"Pump Engaged" ^e	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Automatic	Neutral	Off	Engaged	"Pump Engaged" ^e	None	Yes	No
Automatic	Pump gear ^f	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Automatic	Pump gear ^f	Off	Engaged	"Pump Engaged" ^e	None	Yes	No
Automatic	Pump gear ^f	On	Road	None	None	Yes	No
Automatic	Pump gear ^f	Off	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	On	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Off	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	On	Engaged	"Pump Engaged" ^e	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Off	Engaged	"Pump Engaged" ^e	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" ^e	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bA manual transmission can be in any gear or neutral.

^cEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^dSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^eSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

^fThe chassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.

^gThe chassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.

Table 13.13.8.2 Pump Driven Through Transmission-Mounted PTO, Front-of-Engine Crankshaft PTO, or Engine Flywheel PTO Designed for Stationary Pumping Only

Test Conditions				Verifications			
Transmission Type	Chassis Transmission Gear Selected	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^b	On	Disengaged	None	None ^c	Yes	No ^c
Either	Neutral ^b	On	Disengaged	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Automatic	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral	Off	Disengaged	None	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bA manual transmission can be in any gear or neutral.

^cEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^dSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^eSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

13.13.9 Gauge and Flowmeter Test.

13.13.9.1 Pump intake and discharge pressure gauges shall be checked for accuracy while pumping at rated capacity of the pump at 150 psi (1000 kPa) or 100 psi (700 kPa) for pumps rated 3000 gpm (12,000 L/min) or greater.

13.13.9.2 Any gauge that is off by more than 10 psi (70 kPa) from the calibrated test gauge shall be recalibrated, repaired, or replaced.

13.13.9.3 Each flowmeter shall be checked for accuracy while pumping water at the flow listed in Table 13.12.3.9 at 100 psi (700 kPa).

13.13.9.4 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced.

13.13.10* Manufacturer's Predelivery Test.

13.13.10.1 The manufacturer shall conduct a piping hydrostatic in accordance with 13.13.10.2 and a piping hydrodynamic test in accordance with 13.13.10.3 prior to delivery of the apparatus.

13.13.10.2 The hydrostatic test shall be conducted as follows:

- (1) The pump and its connected piping system are hydrostatically tested to a gauge pressure of 250 psi (1700 kPa).
- (2) The hydrostatic test is conducted with the tank fill line valve, the bypass line valve if so equipped, and the tank-to-pump valve closed.
- (3) All discharge valves are open and the outlets capped.
- (4) All intake valves are closed with intakes uncapped, and nonvalved intakes are capped.
- (5) This hydrostatic test pressure is maintained for 3 minutes.

Table 13.13.8.3 Stationary Pumping and Pump-and-Roll

Test Conditions				Verifications			
Transmission Type	Chassis Transmission Gear Selected	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment) ^b	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^c	On	Disengaged	None	None ^d	Yes	No ^d
Either	Neutral ^c	On	Disengaged	None	"Throttle Ready" ^d	Yes or No ^e	Yes ^d
Either	Neutral ^c	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^e	Yes
Automatic	Neutral	Off	Engaged	"Pump Engaged" and "OK to Pump-and-Roll" ^f	None	Yes	No
Automatic	Any gear other than neutral	On	Engaged	"Pump Engaged" ^b	None	Yes	No
Automatic	Any gear other than neutral	Off	Engaged	"Pump Engaged" and "OK to Pump-and-Roll"	None	Yes	No
Automatic	Any gear other than neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral	Off	Disengaged	None	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^e	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" and "OK to Pump-and-Roll"	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

^cA manual transmission can be in any gear or neutral.

^dEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^eSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^f"OK to Pump-and-Roll" stays on in neutral to allow shifting to neutral when temporarily stopped with the foot brake applied. This allows additional throttle to be applied for greater pump speed. Do not shift to neutral while the vehicle is moving; this is a prohibited operation in at least 17 states.

13.13.10.3 The hydrodynamic test shall be conducted as follows:

- (1) The pump and its connected piping system are hydrodynamically tested at the prescribed maximum discharge pressure capability rating pressure of the pump or the maximum pump close-off pressure, whichever is less.
- (2) Water is permitted to be supplied to the pump from either a pump intake connection or from the apparatus water tank if so equipped.
- (3) The hydrodynamic test is conducted with the following valves closed: tank fill line valve, the aerial waterway valve if so equipped, CAFS component supply line valve if so equipped, and the master stream valve if so equipped.

- (4) The hydrodynamic test is permitted to be conducted with a bypass valve or discharge valve opened as necessary to maintain pump temperature during the test.
- (5) All other discharge valves are open and the outlets capped.
- (6) The hydrodynamic test pressure is maintained for 3 minutes.

13.13.10.4 The hydrodynamic test in 13.13.10.3 shall be permitted to be performed in conjunction with the pumping test performed in 13.13.2.

Table 13.13.8.4 Pump Driven Through Transfer Case PTO or Auxiliary Transmission PTO Designed for Stationary Pumping Only

Test Conditions					Verifications			
Transmission Type	Chassis Transmission Gear Selected	Transfer Case	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^b	Neutral	On	Disengaged	None	None ^c	Yes	No ^c
Either	Neutral ^b	Engaged	On	Disengaged	None	None ^c	Yes	No ^c
Either	Neutral ^b	Neutral	On	Disengaged	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Engaged	On	Disengaged	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Neutral	Off	Disengaged	None	None	Yes	No
Either	Neutral ^b	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	Neutral	On	Engaged	"Pump Engaged" ^c	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Automatic	Neutral	Engaged	On	Engaged	"Pump Engaged" ^c	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Automatic	Neutral	Neutral	Off	Engaged	"Pump Engaged" ^c	None ^c	Yes	No ^c
Automatic	Neutral	Engaged	Off	Engaged	"Pump Engaged" ^c	None ^c	Yes	No ^c
Automatic	Pump gear ^f	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Automatic	Pump gear ^f	Engaged	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Pump gear ^f	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Pump gear ^f	Engaged	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Pump gear ^f	Neutral	On	Disengaged	None	None	Yes	No
Automatic	Pump gear ^f	Engaged	On	Disengaged	None	None	Yes	No
Automatic	Pump gear ^f	Neutral	Off	Disengaged	None	None	Yes	No
Automatic	Pump gear ^f	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Engaged	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No

(continues)

Table 13.13.8.4 *Continued*

Test Conditions					Verifications			
Transmission Type	Chassis Transmission Gear Selected	Transfer Case	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Automatic	Any gear other than neutral and pump gear ^g	Engaged	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Engaged	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Manual	Any gear or neutral	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Manual	Any gear or neutral	Engaged	On	Engaged	"Pump Engaged" ^c	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Manual	Any gear or neutral	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Manual	Any gear or neutral	Engaged	Off	Engaged	"Pump Engaged" ^c	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bA manual transmission can be in any gear or neutral.

^cEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^dSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^eSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

^fChassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.

^gChassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.

Chapter 14 Fire Apparatus — Auxiliary Pumps and Associated Equipment (NFPA 1901)

14.1* Application. If the apparatus is equipped with an auxiliary pump, the provisions of this chapter shall apply.

14.2 Pump Performance.

14.2.1 Auxiliary pumps shall be rated as either high pressure or normal pressure.

14.2.2 High-Pressure Pumps.

14.2.2.1 The performance of a high-pressure auxiliary pump shall be a minimum of 66 gpm (250 L/min) at 600 psi (4000 kPa) discharge pressure for each high-pressure hose reel connected to it that can be operated simultaneously with other high-pressure hose reels.

14.2.2.2 The fire apparatus manufacturer shall establish the maximum discharge pressure capability rating.

14.2.3 Normal-Pressure Auxiliary Pumps.

14.2.3.1 The pump shall have one of the following rated capacities: 30 gpm (115 L/min), 60 gpm (230 L/min), 90 gpm

(345 L/min), 120 gpm (460 L/min), 250 gpm (1000 L/min), or 350 gpm (1300 L/min).

14.2.3.2 The pump shall be capable of pumping 100 percent of its rated capacity at 150 psi (1000 kPa) discharge pressure, 70 percent of its rated capacity at 200 psi (1400 kPa) discharge pressure, and 50 percent of its rated capacity at 250 psi (1700 kPa) discharge pressure.

14.2.4 The rating for auxiliary pumps shall be based on the pump taking water from the apparatus water tank.

14.2.5 Where an auxiliary pump is provided in combination with a fire pump and the pumps are interconnected so that pressure from one pump can be transmitted to the other pump, check valves, intake or discharge relief valves, pump drive gear ratios, or other automatic means shall be provided to avoid pressurizing either pump beyond its maximum hydrostatic test pressure.

14.3 Pump Rating Label. A rating label showing the rated flow and pressure capacities of the auxiliary pump system shall be supplied at the pump operator's location.

14.4* Power Train Capability.

14.4.1* All components in the power train from the engine to the pump shall be capable of transmitting the continuous duty power required by the pump for at least 50 minutes at the pump's rated capacity and pressure.

14.4.2* When pumping rated capacity and pressure, lubricant temperatures in any power train component shall not exceed the component manufacturer's recommendation for maximum temperature.

14.5 Construction Requirements. The pump, piping, and valves shall be capable of withstanding a minimum hydrostatic pressure of 100 psi (700 kPa) above the maximum pump close off pressure.

14.6 Pump Intakes.

14.6.1* Each pump intake shall be sized to permit the full rated performance of the pump and shall be equipped with a valve that can be controlled from the pump operator's position.

14.6.2 Each external intake shall be equipped with National Hose threads on the connection, a removable or accessible strainer, and a bleeder valve to bleed off air or water from a hose connected to the intake.

14.6.2.1 Adapters with special threads or other means for hose attachment shall be permitted on any intake connection.

14.6.2.2 All intake connections shall be provided with closures capable of withstanding a hydrostatic gauge pressure of 500 psi (3400 kPa).

14.6.2.2.1 Intake connections having male threads shall be equipped with caps; intake connections having female threads shall be equipped with plugs.

14.6.2.2.2 Where adapters for special threads or other means for hose attachment are provided on the intake connections, closures shall be provided for the adapters in lieu of caps or plugs.

14.6.2.3 Caps or plugs for intake connections smaller than 4 in. (100 mm) shall remain secured to the apparatus when removed from the connection.

14.7* Pump Discharges.

14.7.1 Each pump discharge shall be equipped with a valve that can be controlled from the pump operator's position.

14.7.2 Any discharge that can be supplied from both the auxiliary pump and the fire pump shall have check valves in both supply lines to prevent backflow into the other pump.

14.7.3 Discharge Outlet Connections.

14.7.3.1* All discharge outlet connections shall be equipped with male National Hose threads.

14.7.3.2 Adapters with special threads or other means for hose attachment shall be permitted to be attached to any discharge outlet connection.

14.7.4 All discharge outlet connections, except connections to which a hose will be preconnected, shall be equipped with caps or closures capable of withstanding a hydrostatic gauge pressure of 100 psi (700 kPa) over the maximum pump close-off pressure or 500 psi (3400 kPa), whichever is greater.

14.7.4.1 Where adapters are provided on the discharge outlet connection, the closures shall fit on the adapters.

14.7.4.2 Caps or closures for outlet connections smaller than 4 in. (100 mm) shall remain secured to the apparatus when removed from the connection.

14.7.5 If a water tank fill line is provided, the line shall be connected from the pump discharge manifold directly to the water tank and shall include a valve that can be controlled from the pump operator's position.

14.7.6 If the pump is a high-pressure pump system, the pump shall be equipped with a means that will limit the pump discharge pressure at the maximum discharge pressure capability rating.

14.7.7 If a relief valve is provided that discharges to atmosphere, it shall be directed away from the pump operator's position.

14.8 Pump Operator's Panel.

14.8.1 Each pump control, gauge, and other instrument necessary to operate the auxiliary pump shall be located on a panel known as the pump operator's panel and shall be marked with a label as to its function.

14.8.2 All gauges, instruments, discharge outlets, pump intakes, and controls located on the auxiliary pump operator's panel shall be illuminated in compliance with 7.11.1.

14.9 Pump Controls.

14.9.1 Controls shall be provided for placing the pump in operation.

14.9.2 The control for the pump engagement mechanism shall be marked with a label to indicate when the pump is properly engaged in pumping position.

14.9.3 Parallel/Series Control.

14.9.3.1 With parallel/series centrifugal pumps, the positions for parallel operation (volume) and series operation (pressure) shall be indicated.

14.9.3.2 The control for changing the pump from series to parallel, and vice versa, shall be located on the pump operator's panel.

14.9.4 If more than one discharge outlet is provided, a relief valve or other pressure control device shall be provided that is capable of limiting the pump discharge pressure.

14.9.5 All pump controls and devices shall be installed so as to be protected against mechanical damage or the effects of adverse weather conditions on their operation.

14.9.6 Drain Valve(s).

14.9.6.1 A readily accessible drain valve(s) that is marked with a label as to its function shall be provided to allow the pump and all water-carrying lines and accessories to be drained.

14.9.6.2 The drain valve(s) shall be operational without the operator having to get under the apparatus.

14.9.7 Pump Cooling.

14.9.7.1 A bypass line of not less than ¼ in. (6.4 mm) diameter that has a valve that can be controlled from the pump operator's position or an automatic-type control shall be installed

from the discharge manifold directly to the water tank or ground.

14.9.7.2 If the pump is a high-pressure pump, the pump shall be equipped with an automatic thermal relief valve to protect the pump that releases away from the pump operator or into the tank.

14.10 Pump Drive Systems.

14.10.1 Where the auxiliary pump is driven by the chassis engine, the provisions of 13.10.2 shall apply as applicable.

14.10.2 Where the auxiliary pump is driven by a chassis transmission-mounted (SAE) PTO and the pump system does not conform to 13.4.2, a visible or audible warning device shall be provided on the pump operator's panel that is actuated if the temperature of the lubricant in the chassis transmission exceeds the transmission manufacturer's recommended maximum temperature.

14.10.3* If a separate pumping engine is provided, it shall meet the requirements of 9.2.1.1, 9.2.1.3, 9.2.1.4, 9.2.2, 9.2.5 through 9.2.6, Section 10.2, 10.4.3, 10.4.4, 10.4.4.1, 10.4.4.3, 10.4.4.4, 10.4.5, Section 10.5, and Section 10.6.

14.10.4 Indicator or Light.

14.10.4.1 Where a separate engine is used to drive the auxiliary pump, an indicator or light that is energized when the pump engine is running shall be provided in the driving compartment.

14.10.4.2 The indicator or light shall be marked with a label that reads "Pump Engine Running."

14.11 Engine Controls.

14.11.1 A throttle control that holds its set position shall be provided 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.

14.11.2 This throttle control shall be permitted to be the same throttle control that is used for the main fire pump.

14.12 Gauges and Instruments.

14.12.1 Master Pump Discharge Pressure Gauge. A master discharge pressure gauge shall be provided for the auxiliary pump.

14.12.1.1 It shall read from a gauge pressure of 0 to at least 300 psi (2100 kPa) but not less than 100 psi (700 kPa) higher than the maximum pressure that can be developed by the pump when it is operating with zero intake pressure.

14.12.1.2 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade 1A as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

14.12.1.2.1 Numerals for master gauges shall be a minimum 0.25 in. (6.4 mm) high.

14.12.1.2.2 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa).

14.12.1.2.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

14.12.1.3 If a digital pressure gauge is used, the digits shall be at least 0.25 in. (6.4 mm) high.

14.12.1.3.1 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

14.12.1.3.2 Digital master pressure gauges shall have an accuracy of ± 3 percent over the full scale.

14.12.1.4 Master discharge pressure gauges shall be checked for accuracy while pumping at rated capacity. Any gauge that is off by more than 10 psi (70 kPa) from the calibrated test gauge shall be recalibrated, repaired, or replaced.

14.12.2 Discharge Outlet Instrumentation. If the apparatus is equipped with 1½ in. (38 mm) or larger discharge outlets that can be supplied only by the auxiliary pump, these discharge outlets shall be equipped with pressure gauges or flowmeters.

14.12.2.1 The pressure gauge or flowmeter display shall be located adjacent to the corresponding valve control with no more than 6 in. (150 mm) separating the pressure gauge or flowmeter bezel and the valve control centerline.

14.12.2.2 Pressure gauges shall be connected to the outlet side of the valve.

14.12.2.3 Flowmeters shall display flow in increments not greater than 10 gpm (50 L/min).

14.12.2.4 Where an analog pressure gauge is used, the gauge shall have a minimum accuracy of Grade B as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

14.12.2.4.1 Numerals for gauges shall be a minimum ⅝ in. (4 mm) high.

14.12.2.4.2 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa).

14.12.2.4.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

14.12.2.5 If a digital pressure gauge is used, the digits shall be at least 0.25 in. (6.4 mm) high.

14.12.2.5.1 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

14.12.2.5.2 Digital pressure gauges shall have an accuracy of ± 3 percent over the full scale.

14.12.2.6 Discharge outlet pressure gauges shall be checked for accuracy while pumping at rated capacity. Any gauge that is off by more than 10 psi (70 kPa) from the calibrated test gauge shall be recalibrated, repaired, or replaced.

14.12.2.6.1 Each flowmeter shall be checked for accuracy while pumping water at the flow listed in Table 13.12.3.9 at 100 psi (700 kPa).

14.12.2.6.2 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced.

14.12.3 Protection of Gauges and Instruments. Each pressure gauge or flowmeter and its display shall be mounted and attached so they are protected from accidental damage and excessive vibration.

14.13 Testing. The pump, piping, valves, and caps or plugs shall be hydrostatically tested to 100 psi (700 kPa) above the maximum pump close-off pressure, and the apparatus manufacturer shall certify the test results in writing.

Chapter 15 Fire Apparatus — Pumps for Wildland Firefighting and Associated Equipment (NFPA 1906)

15.1 Application.

15.1.1 If the apparatus is equipped with a pump, the wildland fire apparatus shall include a wildland fire pump as defined in Section 15.2 through 15.13.11.4.4 or a fire pump as defined in Chapter 13.

15.1.2 The purchaser shall refer to the standards applicable to the pump selected.

15.2 Design and Performance Requirements.

15.2.1* One or more wildland fire pumps shall be mounted on the apparatus and rated at one or more of the ratings in Table 15.2.1.

15.2.2 The apparatus shall be designed for pump and roll operations.

15.2.2.1* The vehicle drive engine and drive train shall be arranged so that the pump can deliver at least 20 gpm (80 L/min) at a gauge pressure of 80 psi (550 kPa), while the fire apparatus is moving at 2 mph (3.2 km/hr) or less.

15.2.3 Pumping System Capability.

15.2.3.1 Reserved.

15.2.3.2 Reserved.

15.2.3.3* When dry, the pump system in both parallel and series operation where pumps are of the parallel/series type shall be capable of taking suction under the conditions specified in 15.2.4.1 through 20 ft (6 m) of suction hose of the size specified in Table 15.2.4.1(a) and a strainer and discharging water in not more than 30 seconds.

15.2.3.4 Vacuum.

15.2.3.4.1 The completed pumping system shall be capable of developing a vacuum of 17 in. Hg (57.4 kPa) at altitudes up to 2000 ft (600 m) by means of the pump priming system and sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (34 kPa).

15.2.3.4.2 The requirement in 15.2.3.4.1 shall be met with all intake valves open, with all intakes capped or plugged, with all discharge caps removed and valves closed, and without the use of the pump primer during the 5-minute period.

15.2.3.4.3 The requirement in 15.2.3.4.1 shall also be met with the intake valves closed and caps or plugs removed.

15.2.3.4.4 An automatic method shall be provided to prevent the loss of vacuum through the priming system when the priming device is not being operated.

15.2.3.4.4.1 A manual method shall be provided to shut off the priming system to prevent loss of vacuum, to prevent back-flow, and to prevent outflow when the priming device is not in use.

15.2.3.4.4.2 If the automatic method to shut off the priming system prevents flow in both directions, a separate manual method shall not be required.

15.2.3.4.4.3 The method used to shut off the priming device shall be permitted to be a separate device controlled by the primary control.

15.2.3.4.5 Pump intake plumbing shall be capable of withstanding a minimum vacuum of 30 in. Hg (101.6 kPa) without becoming deformed.

15.2.4 Pumping Suction Capability.

15.2.4.1 The pump manufacturer shall certify that the pump can deliver its rated capacity at rated net pump pressure from draft, under the following conditions:

- (1) At an altitude of 2000 ft (600 m) above sea level
- (2) Through a single intake with 20 ft (6 m) of suction hose of the size specified in Table 15.2.4.1(a) and equipped with a suction hose strainer
- (3) With a lift of 10 ft (3 m)
- (4) At 29.9 in. Hg (101 kPa) atmospheric pressure (corrected to sea level)
- (5) At a water temperature of 60°F (16°C)
- (6) At the entrance and friction loss for the 20 ft (6 m) of suction hose and strainer listed in Table 15.2.4.1(b) or at the entrance and friction loss for the 6 m of suction hose and strainer listed in Table 15.2.4.1(c).

15.2.4.2* The pump manufacturer shall certify that the pump is capable of pumping rated capacity at rated net pump pressure from draft at any of the following special conditions when these conditions are specified by the purchaser:

- (1) At an elevation above 2000 ft (600 m)
- (2) At lifts higher than 10 ft (3 m), through more than 20 ft (6 m) of suction hose, or both

Table 15.2.1 Wildland Fire Apparatus Pump Rating Chart

Minimum Pump Pressure		Minimum Rated Capacity or Flow Rate	
Psi	kPa	gpm	L/min
100	700	50	200
		150	600
150	1000	50	200
		250	1000
250	1700	50	200
		150	600
300	2000	200	800
400	2800	30	120

Table 15.2.4.1(a) Suction Hose Size by Pump Capacity Rating

Flow Rate		Suction Hose Size	
gpm	L/min	in.	mm
30	120	1½	38
50	200	2	52
150	600	2½	65
200	800	2½	65
250	1000	3	75

Table 15.2.4.1(b) Entrance and Friction Loss in 20 ft of Suction Hose, Including Strainer (United States Customary System, USCS units)

Flow Rate (gpm)	Suction Hose Size (in.)									
	1½		2		2½		3		4	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
30	2.7	2.38	0.75	0.66						
50			1.7	1.50	0.5	0.44				
150					4.5	3.97	1.9	1.64		
200					8.0	7.06	3.3	2.91	0.8	0.71
250					13.0	11.47	5.2	4.59	1.3	1.1

Table 15.2.4.1(c) Entrance and Friction Loss in 6 m of Suction Hose, Including Strainer (SI Units)

Flow Rate (L/min)	Suction Hose Size (mm)									
	38		52		65		75		100	
	m water	kPa	m water	kPa	m water	kPa	m water	kPa	m water	kPa
120	0.82	8.1	0.23	2.2						
200			0.52	5.1	0.15	1.5				
600			2.83	27.8	0.91	9.0				
800					2.44	23.9	1.01	9.9	0.24	2.4
1000					3.96	38.9	1.58	15.5	0.4	4

15.3 Pump Engine Requirements.

15.3.1 The apparatus manufacturer shall approve the use of the pumping engine for stationary pumping applications based on the size of the fire apparatus and the rating of the pump being furnished.

15.3.2 Reserved.**15.3.3 Reserved.****15.3.4 Reserved.****15.3.5 Reserved.****15.3.6 Reserved.**

15.3.7 Engine and Engine System Design. If a separate pump engine drives the pump, that engine shall meet the requirements of 15.3.7.1 through 15.3.7.3.

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

15.3.7.2* Automatic engine shutdown systems shall be permitted if they are an integral part of the standard engine management system.

15.3.7.3 Automatic engine shutdown systems shall be permitted to automatically shut down the pump drive engine when the pump is out of water, provided the system is manually armed.

15.3.8 Cooling System.

15.3.8.1 The engine shall be air cooled or liquid cooled with a self-contained cooling system.

15.3.8.2 The engine's cooling system shall maintain a temperature in the engine at or below the engine manufacturer's maximum temperature rating under all conditions for which the fire apparatus is designed.

15.3.8.3 If the engine is liquid cooled, the cooling system shall meet the requirements of 15.3.8.3.1 through 15.3.8.3.4.

15.3.8.3.1 If the cooling system is equipped with drain valves, they shall be installed at the lowest point of the cooling system.

15.3.8.3.2* Drain valves shall be designed or positioned such that they will not open accidentally.

15.3.8.3.3 The radiator shall be mounted to prevent the development of leaks caused by twisting or straining where the apparatus operates over uneven ground.

15.3.8.3.4 A coolant temperature gauge or high-temperature indicator light shall be provided.

15.3.9 Lubrication System.

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

15.3.9.2 If the pump drive engine has a positive pressure lubrication system, a low-oil pressure indicator or oil pressure gauge shall be provided that is visible from the pump operator's position.

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

15.3.10 Fuel and Air System.

15.3.10.1 Diesel Engines.

15.3.10.1.1 Air Intake System.

15.3.10.1.1.1* An air filter shall be provided in the engine's air intake system.

15.3.10.1.1.2 Air inlet restrictions shall not exceed the engine manufacturer's recommendations.

15.3.10.1.1.3 For engines greater than 35 hp (26 kW), if approved by the engine manufacturer, the air inlet shall be equipped with a means of separating water and burning embers from the air intake system such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the air filter element.

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

15.3.10.1.3 Electric Fuel Priming System.

15.3.10.1.3.1 Where an electric fuel priming system is furnished, the valving and piping shall be arranged and marked with a label so that it can be operated only to reprime the fuel system.

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

15.3.10.1.3.3 The priming system shall be marked with a label to indicate proper operation.

15.3.10.2 Gasoline Engines.

15.3.10.2.1 Air Intake System.

15.3.10.2.1.1 An air filter shall be provided in the engine's intake air system.

15.3.10.2.1.2 Air inlet restrictions shall not exceed the engine manufacturer's recommendations.

15.3.10.2.1.3 For engines greater than 35 hp (26 kW), if approved by the engine manufacturer, the air inlet shall be equipped with a means of separating water and burning embers from the air intake system such that burning particulate matter larger than 0.039 in. (1.0 mm) in diameter cannot reach the air filter element.

15.3.10.2.2 Fuel System.

15.3.10.2.2.1 All fuel lines and all filters or strainers shall meet the engine manufacturer's recommendations.

15.3.10.2.2.2 The fuel line(s) shall be located or protected so as not to be subjected to excessive heating from any portion of a vehicle exhaust system.

15.3.10.2.2.3 The line(s) shall be protected from mechanical damage.

15.3.11 Exhaust System.

15.3.11.1 The exhaust piping and its discharge shall be located so as not to expose any portion of the apparatus to excessive heating.

15.3.11.2* Exhaust pipe discharge shall be directed away from the pump operator's position.

15.3.11.3 The exhaust system shall meet the requirements of USDA Forest Service Standard 5100-1 unless 100 percent of the exhaust gases pass through a turbo charger or 100 percent of the exhaust gases pass through a diesel particulate filter (DPF) with a warning when the filter requires regeneration, manual cleaning, or replacement.

15.3.11.4 Exhaust backpressure shall not exceed the limits specified by the engine manufacturer.

15.3.12 Engine Controls.

15.3.12.1* A nonkeyed switch to start or stop the pump engine shall be furnished and shall be located at the pump operator's position.

15.3.12.2 The engine speed shall be permitted to be controlled by an automatic speed controller or a manually adjustable throttle.

15.3.12.2.1 A hand throttle of a type that holds its set position shall be provided where the pump drive engine is not equipped with an automatic throttle control system to control the engine speed.

15.3.12.2.2 Where provided, the throttle shall be located so that it can be manipulated from the pump operator's position with all instrumentation in full view.

15.3.13 Electrical System and Devices.

15.3.13.1 The electrical system on the pump engine shall meet the requirements of Section 10.2.

15.3.13.2 Where a separate battery(s) is provided, the requirements of 15.3.13.2.1 through 15.3.13.2.4 shall apply.

15.3.13.2.1 A built-in means to charge the battery(s) shall be provided.

15.3.13.2.2 The charging system shall have an output adequate to meet the continuous anticipated electrical load of the engine and starting system as manufactured, at 200°F (93°C) operating temperature (within any engine enclosure, if applicable).

15.3.13.2.3 The charging system shall be provided with full automatic regulation.

15.3.13.2.4 The batteries shall meet the requirements of 10.4.4 through 10.4.4.4.

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

15.3.14 Starting Device.

15.3.14.1 An electrical starting device shall be provided.

15.3.14.2 The electrical starting system shall meet the requirements of the engine manufacturer.

15.3.15* Fuel Tanks.

15.3.15.1 The fuel tank(s) shall be of sufficient size to permit operation of the pump at its rated capacity and pressure for at least 1 hour without refilling.

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

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

15.4 Power Train Capability.

15.4.1 All components in the power train from the engine to the wildland fire pump shall be capable of transmitting the torque necessary to power the pump, as installed in the apparatus, for the pump-rated capacity without exceeding the component manufacturer's continuous-duty torque rating.

15.4.2 When pumping continuously at rated capacity, lubricant temperatures in any power train component installed in the apparatus from the engine to the pump shall not exceed the component manufacturer's recommendation for maximum temperature.

15.4.3* A means shall be provided to limit the nominal net engine output during pumping operation to a torque level equal to the nominal continuous-duty torque rating of the weakest component or, if there are multiple devices to be driven simultaneously, to a level equal to the sum of the nominal continuous-duty torque ratings of multiple components.

15.5* Construction Requirements.

15.5.1* Wetted moving parts shall be constructed of a corrosion-resistant material.

15.5.1.1 Where more than one pump is provided, and where the pumps are interconnected so that pressure from one pump can be transmitted to the other pump, check valves, intake or discharge relief valves, pump drive gear ratios, or other automatic means shall be provided to avoid pressurizing either pump beyond the hydrostatic pressure referenced in 15.5.2.1.

15.5.2 Hydrostatic Test.

15.5.2.1 The pump body shall be subjected to a hydrostatic test pressure of 100 psi (700 kPa) above the maximum close-off pressure or to a gauge pressure of 300 psi (2000 kPa), whichever is higher, for 10 minutes.

15.5.2.2 The pump manufacturer shall provide a certificate of completion for the hydrostatic test.

15.5.3 The entire discharge and intake piping system, valves, drain cocks and lines, and intake and outlet closures, excluding the tank-to-pump lines on the tank side of the valve in those lines, shall be subjected to a hydrostatic test pressure of 100 psi (700 kPa) above the maximum close-off pressure or to a gauge pressure of 300 psi (2000 kPa), whichever is higher, for 5 minutes.

15.5.4 The pump shall allow a positive-pressure water source to directly add to the pump's discharge pressure.

15.6* Pump Intake.

15.6.1* Intakes of the same or larger size as specified in Table 15.2.4.1(a) for suction hose size shall be provided.

15.6.1.1* Any intake shall have male threads and any 2½ in. (65 mm) intake or larger shall have National Hose Thread (NH).

15.6.1.2 If the couplings on the suction hose carried on the apparatus are of a different size from that of the pump intake(s) or have means of hose attachment other than that provided on the intake(s), an adapter(s) shall be provided to allow connection of the suction hose to the pump intake(s).

15.6.1.3* Safety sign FAMA25, which warns of the need for training prior to operating the apparatus, shall be located on the pump operator's panel.

15.6.2 Intake Strainer.

15.6.2.1 Each intake shall have a removable or accessible strainer inside the connection.

15.6.2.2* The strainer(s) shall restrict spherical debris that is too large to pass through the pump.

15.6.3 Reserved.

15.6.4 Any 3 in. (76 mm) or larger intake valve except the tank-to-pump valve shall be a slow-operating valve.

15.6.5 Reserved.

15.6.6 Each valved intake having a connection size larger than 3 in. (75 mm) shall be equipped with an adjustable automatic pressure relief device installed on the supply side of the valve to bleed off pressure from a hose connected to the valved intake.

15.6.6.1 The pressure relief device shall discharge to atmosphere, and the discharge shall be piped or directed away from the pump operator's position.

15.6.6.2 The automatic pressure relief device shall be adjustable from a minimum of 90 psi (620 kPa) to at least 185 psi (1275 kPa).

15.6.6.3 The pressure relief device, when preset at 125 psi (860 kPa), shall not allow a pressure rise greater than 60 psi (400 kPa) at the device inlet while flowing a minimum of 150 gpm (570 L/min).

15.6.7 If the pump is equipped with one or more intakes larger than 3 in. (75 mm) that are not valved, an adjustable automatic pressure relief device shall be installed on the pump system to bleed off excess pressure from a hose connected to the pump intake.

15.6.7.1 The automatic pressure relief device shall be adjustable from a minimum of 90 psi (620 kPa) to at least 185 psi (1275 kPa).

15.6.7.2 The pressure relief device, when preset at 125 psi (860 kPa), shall not allow a pressure rise greater than 60 psi (400 kPa) at the device inlet while flowing a minimum of 150 gpm (570 L/min).

15.6.7.3 The pressure relief device shall discharge to atmosphere.

15.6.8 Intake Covers. All intakes shall be provided with caps, plugs, or closures.

15.6.8.1 Intakes having male threads shall be equipped with caps.

15.6.8.2 Intakes having female threads shall be equipped with plugs.

15.6.8.3 Where adapters for special threads or other means for hose attachment are provided on the intakes, closures shall be provided for the adapters in lieu of caps or plugs.

15.6.8.4 Caps, plugs, or closures for 3½ in. (90 mm) and smaller intakes shall remain secured to the apparatus or pumping unit when removed from the intakes.

15.6.9 Reserved.

15.6.10* If the manufacturer or contractor provides a valve, siamese, or adapter on a suction inlet(s) that will remain in place while the apparatus is in motion, that valve, siamese, or adapter shall not project beyond the apparatus running board.

15.7 Pump Discharge Outlets.

15.7.1* Sufficient discharge outlets, including any discharge outlets located in hose storage areas, shall be provided to discharge the rated capacity of the pump at the flow rates as shown in Table 15.7.1.

15.7.2 Discharge Outlet Connections.

15.7.2.1* Each 1½ in. (38 mm) or larger discharge outlet shall be equipped with male National Hose Thread (NH).

15.7.2.2* Adapters with special threads or other means for hose attachment shall be permitted to be furnished on any outlets.

15.7.3 Reserved.

15.7.4 Each discharge outlet, except an outlet to which a hose is to be preconnected, shall be equipped with a cap or closure that is capable of withstanding 100 psi (700 kPa) over the maximum rated pump close-off pressure or 300 psi (2000 kPa) gauge pressure, whichever is higher.

15.7.4.1 Where adapters are provided on the discharge outlet connections, the closures shall fit on the adapters.

15.7.4.2 If a cap or closure is provided, it shall be secured to the pumping unit with a chain or cable.

15.7.4.3 Threaded caps shall automatically release pressure in the discharge outlet before the threads are completely disengaged unless outlet and cap are equipped with drains or bleeder valves.

15.7.4.4 The pressure relief shall discharge to atmosphere, and the discharge shall direct away from the operator's position.

15.7.4.5 Safety sign FAMA18, which warns of cap pressure dangers, shall be placed on each side and back of vehicle where caps are present.

15.7.5* Each discharge outlet shall be equipped with a valve that can be opened and closed smoothly at the flows shown in Table 15.7.1 at pump discharge gauge pressures of 250 psi

(1700 kPa) or of 100 psi (700 kPa) over the pump rated pressure, whichever is greater.

15.7.5.1 The flow-regulating element of each valve shall not change its position under any condition of operation that involves discharge pressures to the maximum pressure of the pump.

15.7.5.2 The means to prevent a change in position shall be incorporated in the operating mechanism and shall be permitted to be manually or automatically controlled.

15.7.5.3* Any 3 in. (76 mm) or larger discharge valve shall be a slow-operating valve.

15.7.6 Reserved.

15.7.7 Any 2½ in. (65 mm) or larger discharge outlet that is located more than 42 in. (1070 mm) above the ground and to which a hose is to be connected, but that is not in a hose storage area, shall be equipped with a sweep elbow of at least 30 degrees downward.

15.7.8 Valves.

15.7.8.1 Reserved.

15.7.8.2 Reserved.

15.7.8.3* A pump cooling/recirculation line of sufficient size to prevent the pump from overheating when no discharge lines are open shall be provided between the pump discharge and the water tank.

15.7.8.3.1* The pump cooling/recirculation line shall be equipped with a strainer with cleanout and a check valve.

15.7.8.3.2 The apparatus shall be provided with a means to verify that the recirculating line is functioning.

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

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

15.7.8.6 Visible quarter-turn valves shall be installed so they are open when the handle is parallel with the run of the pipe and are closed when the handle is perpendicular to the run of the pipe.

15.7.8.7 Blind valves, which are valves behind panels, shall have their open and closed positions marked "Open" and "Closed."

15.7.8.8 Operating mechanisms for valves used on the fire-ground shall be marked as to their function, such as "Intake," "Tank to Pump," "Pump to Tank," and "Discharge."

15.7.8.9 If the apparatus is equipped with a booster reel, the piping, valves, and swivel between the pump and booster reel shall be nominally the same size as or larger than the nominal inside diameter of the hose to be carried on the reel.

15.7.8.9.1 A shutoff valve shall be provided between the pump and the reel.

15.7.8.9.2 High-pressure booster hose of the same nominal size shall be permitted in place of piping.

Table 15.7.1 Flow Rates for Various Outlet Sizes

Outlet Size		Flow Rates	
in.	mm	gpm	L/min
1	25	50	200
1½	38	125	500
2½	65	250	1000

15.7.9* Location of Discharge Outlets.

15.7.9.1 No discharge outlet larger than 2½ in. (65 mm) shall be located at the pump operator's panel.

15.7.9.2 If the apparatus has a top console-type pump operator's panel, vertical discharge outlets larger than 2½ in. (65 mm) shall be permitted at the top midship position of apparatus where the outlets are used for directly connected deck guns or monitors and no fire hose is used for coupling the components.

15.8 Pump Drains.

15.8.1 A readily accessible drain valve(s) that is marked with a label as to its function shall be provided to allow for draining of the pump and all water-carrying lines and accessories.

15.8.2 The drain valve(s) shall be operational without the operator having to get under the apparatus, or a label at the operator's location shall indicate the location of drains that need to be operated from under the apparatus.

15.9 Pump Operator's Location.

15.9.1* The pump controls, gauges, and instruments shall be accessed from ground level, a working platform, or a driver's compartment.

15.9.2 All gauges, discharge outlets, pump intakes, and controls shall be illuminated in compliance with Section 7.11.

15.9.3 Each control, gauge, and instrument shall be marked with a label as to its function.

15.10* Pump Controls.

15.10.1 General Provisions. Provisions shall be made for placing the pump drive system in operation using controls and switches that are identified and within convenient reach of the operator.

15.10.1.1 Where the pump is driven by the chassis engine and engine compression brakes or engine exhaust brakes are furnished, these engine brakes shall be automatically disengaged for pumping operations.

15.10.1.2* Any control device used in the pumping system power train between the engine and the pump, except a manual pump shift override device if provided, shall be equipped with a means to prevent unintentional movement of the control device from its set position in the pumping mode.

15.10.1.3 Where the pump is driven by the chassis engine, a label indicating the chassis transmission shift selector position to be used for pumping shall be provided in the driving compartment and located so that it can be read from the driver's position.

15.10.1.4 Where the pump is driven by the chassis engine and automatic transmission through a split shaft PTO, an interlock system shall be provided to prevent the pump drive system from being shifted out of the "pump engaged" pumping mode of operation when the chassis transmission is in pump gear.

15.10.1.5 Where the power train from engine to pump includes retarders or other auxiliary braking devices, they shall be automatically disengaged for pumping operations.

15.10.2* Interlocks and Indicators. Where the water pump is driven by the chassis engine, an interlock system shall be provided to ensure that the pump drive system components are engaged in the pumping mode of operation so that the pumping system can be operated from the pump operator's position, with indicators to inform the operators of the status of the controls.

15.10.2.1 Required Indicators.

15.10.2.1.1 All apparatus shall have both a "Pump Engaged" indicator and an "OK to Pump" indicator in the driver compartment.

15.10.2.1.2* All apparatus shall have both a "Throttle Ready" indicator and an "OK to Pump" indicator on the pump operator's panel.

15.10.2.1.3 If the apparatus is designed to do pump-and-roll, an "OK to Pump-and-Roll" indicator shall also be in the driver compartment.

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

15.10.2.3 OK to Pump. An "OK to Pump" indicator shall be provided in the driving compartment and on the pump operator's panel to indicate that all of the following conditions have been met to safely operate the pump in stationary mode:

- (1) The pump shift is engaged.
- (2) The parking brake is engaged.
- (3) If the pump is driven from a transfer case PTO or auxiliary transmission PTO, the drive to the wheels is in neutral.
- (4) If the apparatus is equipped with an automatic transmission, the chassis transmission is in the correct pump gear as identified in 15.10.1.3 as follows:
 - (a) If the pump is driven by a PTO after the chassis transmission gearing (e.g., split shaft PTO, transfer case PTO, etc.) the transmission is in the correct forward drive gear.
 - (b) If the pump is driven by a PTO ahead of the chassis transmission gearing (e.g., flywheel PTO, crankshaft PTO, etc.) the transmission is in neutral.
- (5) If the apparatus is equipped with a manual transmission, any gear, including neutral, will allow an "OK to Pump" indicator to come on provided all other conditions are met.

15.10.2.4* OK to Pump and Roll. If the apparatus is designed to be used in both stationary pumping mode and "pump-and-roll" pumping mode, an "OK to Pump and Roll" indicator shall be provided in the driving compartment to indicate that all of the following conditions have been met to safely operate the pump in pump-and-roll mode.

- (1) The pump shift is engaged.
- (2) The parking brake is released.

15.10.2.5 Throttle Ready.

15.10.2.5.1 A "Throttle Ready" indicator shall be provided on the pump operator's panel.

15.10.2.5.2 The "Throttle Ready" indicator shall indicate when the pump is in "OK to Pump" mode.

15.10.2.5.3* The "Throttle Ready" indicator at the pump operator's panel shall be permitted to indicate when the parking brake is engaged and, if the apparatus is equipped with an

automatic transmission, when the chassis transmission is in neutral.

15.10.2.5.4 If there are multiple pumps, generators, hydraulic pumps, or other devices powered off the chassis engine, the “Throttle Ready” indicator shall only indicate when all such devices are in a mode that advancement of the engine throttle is permissible.

15.10.2.6 Engine Speed Control.

15.10.2.6.1 An engine speed control shall be provided at the pump operator’s panel.

15.10.2.6.2 An interlock system shall be provided to prevent advancement of the engine speed at the pump operator’s panel unless the apparatus has a “Throttle Ready” indication.

15.10.2.6.3 Loss of power to the interlock system shall return the engine speed to idle and prevent advancement from the pump operator’s panel.

15.10.2.7 Manual Override. If a pump shift manual override device is provided, the “Pump Engaged,” “OK to Pump,” “OK to Pump and Roll,” and “Throttle Ready” indicators and the pump operator’s panel engine speed advancement interlock system shall be operationally functional when the manual override device is used to shift the pump.

15.10.3 Parallel/Series Control.

15.10.3.1 With parallel/series centrifugal pumps, the control positions for parallel operation (volume) and series operation (pressure) shall be indicated.

15.10.3.2 The control for changing the pump from series to parallel, and vice versa, shall be operable at the pump operator’s position.

15.10.4* Pressure Control System.

15.10.4.1* On pumps with a rated capacity of 200 gpm or 250 gpm (800 L/min or 1000 L/min) a means shall be provided that, when set in accordance with the manufacturer’s instructions, will automatically control the discharge pressure to a maximum of 60 psi (400 kPa) pressure rise above the set pressure(s) when all discharge valves are closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds during the following conditions:

- (1) Over a range of pressures from 70 psi to 300 psi (500 kPa to 2000 kPa) net pump pressure with intake gauge pressure between -10 psi and 185 psi (-70 kPa and 1300 kPa) and discharge gauge pressure between 90 psi and 300 psi (620 kPa and 2000 kPa)
- (2) With initial engine and pump controls set to produce a range of flows from 150 gpm (600 L/min) to the rated capacity of the pump

15.10.4.2 If the pump is equipped with a relief valve system where the system does not control engine speed, the system shall be equipped with a means to indicate when the system is in control of the pressure.

15.10.4.2.1 If the pump is equipped with a governor system that controls engine speed, an indicator shall show when the system is turned on and whether it is controlling the engine speed or pump pressure.

15.10.4.2.2 Either system shall be controllable by one person at the pump operator position.

15.10.4.2.3 If the system discharges water to the atmosphere, the discharge shall be in a manner that will not expose personnel to high-pressure water streams.

15.10.5* Priming System. A priming system shall be provided and controlled from the pump operator’s position.

15.10.5.1 The priming system shall be capable of meeting the requirements of 15.2.3.3 and 15.2.3.4.

15.10.5.2 The priming system shall be capable of operating with no lubricant or with a biodegradable nontoxic lubricant.

15.10.5.3* The priming system shall use one of the following priming methods:

- (1) Prime from the intake with the pump running
- (2) Prime from the discharge with the pump not running

15.10.6 Protection of Pump Controls. All pump controls and devices shall be installed so as to be protected against mechanical damage and the effects of adverse weather conditions on their operation.

15.11 Pump Engine Controls.

15.11.1* A throttle control that holds its set position shall be provided to control the pump engine speed.

15.11.2 The throttle control on vertically (greater than 45 degrees) arranged pump panels shall be located not higher than 72 in. (1680 mm) nor lower than 42 in. (1070 mm) from the operator’s standing position with all instruments in full view.

15.11.3 The throttle control on horizontally (less than 45 degrees) arranged pump panels shall be located not higher than 50 in. (1270 mm) nor lower than 32 in. (810 mm) from the operator’s standing position with all instruments in full view.

15.12 Instrumentation.

15.12.1 Pump Operator’s Panel.

15.12.1.1* The following controls and instruments shall be provided and installed as a group on the pump operator’s panel:

- (1) Master pump intake pressure gauge (if applicable)
- (2) Master pump discharge pressure gauge
- (3) Pumping engine tachometer—if engine is over 35 hp (26 kW)
- (4) Pumping engine coolant temperature gauge—if engine is over 35 hp (26 kW)—unless pumping engine is air cooled or electric
- (5) Pumping engine oil pressure gauge—if engine is over 35 hp (26 kW)—unless pumping engine is air cooled or electric
- (6) Voltmeter—if engine is over 35 hp (26 kW)
- (7) Pump pressure control(s) (if applicable)
- (8) Pumping engine throttle
- (9) Primer control
- (10) Water-tank-to-pump valve control
- (11) Water tank fill valve control
- (12) Water tank level gauge

15.12.1.2 Reserved.

15.12.1.3 Any instrumentation exposed to the elements shall be weatherproof.

15.12.1.4 Where provided, pumping engine oil pressure and engine coolant temperature gauges shall be equipped with audible and visual warnings.

15.12.1.5 Any engine operation gauge on the pump operator's panel shall be in addition to those on the vehicle's instrument panel.

15.12.2* Master Pump Intake and Discharge Pressure Gauges.

15.12.2.1 The following shall be provided:

- (1) A master pump discharge gauge
- (2) A master intake compound gauge [if one or more 3 in. (75 mm) or larger external pump intakes are provided]

15.12.2.1.1 The intake pressure gauge shall read from 30 in. Hg (100 kPa) vacuum to at least a gauge pressure of 300 psi (2000 kPa).

15.12.2.1.2 A master discharge pressure gauge shall read from 30 in. Hg (100 kPa) vacuum to at least a gauge pressure of 300 psi (2000 kPa) or 100 psi (500 kPa) over maximum pump pressure, whichever is greater.

15.12.2.1.3 Pressure gauges shall not be damaged by a 30 in. Hg (100 kPa) vacuum.

15.12.2.1.4 Pressure gauges shall be marked with labels that read "Pump Intake" for the intake pressure gauge and "Pump Discharge" for the discharge pressure gauge.

15.12.2.1.5* The master discharge gauge shall be connected directly at the pump discharge, before any check valves.

15.12.2.2* If analog gauges are used, they shall meet the requirements of 15.12.2.2.1 through 15.12.2.2.7.

15.12.2.2.1 There shall be at least a 1 in. (25 mm) diameter differential in viewing area between the master gauges and individual discharge gauges, with the master gauges being the larger.

15.12.2.2.2 Analog gauges displaying the vacuum portion in 120 degrees of arc or less shall have an accuracy complying with Grade B as defined by ASME B40.100, *Pressure Gauges and Gauge Attachments*.

15.12.2.2.3 Analog gauges displaying the vacuum portion in greater than 120 degrees of arc shall have an accuracy of 3½ percent or better on vacuum and 3½ percent or better on pressure over their entire respective scale.

15.12.2.2.4 Analog gauges displaying the vacuum portion in greater than 120 degrees of arc shall have graduation lines on the vacuum side every 1 in. Hg (5 kPa) with major and immediate graduation lines emphasized and figures at least every 10 in. Hg (50 kPa).

15.12.2.2.5 Numerals for master gauges shall be a minimum of 0.25 in. (6.4 mm) high.

15.12.2.2.6 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa).

15.12.2.2.7 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

15.12.2.3 Digital Gauges. If digital master pressure gauges are used, they shall meet the requirements of 15.12.2.3.1 through 15.12.2.3.3.

15.12.2.3.1 The digits shall be at least ½ in. (12.7 mm) high.

15.12.2.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

15.12.2.3.3 Digital master pressure gauges shall have an accuracy of ±3 percent over the full scale.

15.12.2.4* Cab Gauges. If the pump on the apparatus is driven by the chassis engine through a PTO, and the apparatus is designed for pump-and-roll operations using that chassis engine-driven pump, a second gauge that meets the same requirements as the discharge pressure gauge required by 15.12.2.1.2 shall be mounted in the driving compartment in view of the driver.

15.12.2.4.1 The gauge shall read from 30 in. Hg (100 kPa) vacuum to at least 300 psi (2000 kPa) or 100 psi (500 kPa) over maximum pump pressure, whichever is greater.

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

15.12.2.5 Gauge Mounting. Each pressure gauge or flowmeter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

15.12.3 Discharge Outlet Instrumentation.

15.12.3.1 Reserved.

15.12.3.2* Any discharge outlet that is equipped with a flowmeter shall also be provided with a pressure gauge.

15.12.3.3 The pressure gauge display shall be located adjacent to the corresponding valve control with no more than 6 in. (150 mm) separating the pressure gauge bezel and the valve control midpoint or centerline.

15.12.3.4 If both a flowmeter and a pressure gauge are provided for an individual discharge outlet, the pressure gauges shall be located within 6 in. (150 mm) of the valve control midpoint or centerline, and the flowmeter display shall be adjacent to and within 2 in. (51 mm) of the pressure gauge bezel.

15.12.3.5 Pressure gauges shall be connected to the outlet side of the valve.

15.12.3.6 Flowmeters shall display flow in increments no greater than 10 gpm (50 L/min).

15.12.3.7 Where analog pressure gauges are used, they shall have a minimum accuracy of Grade B as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

15.12.3.7.1 Numerals for gauges shall be a minimum ⅝ in. (4 mm) high.

15.12.3.7.2 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized, and figures at least every 100 psi (500 kPa).

15.12.3.7.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; be freeze protected; and have inter-

nal mechanisms that are factory lubricated for the life of the gauge.

15.12.3.8 If a digital pressure gauge is used, it shall meet the requirements of 15.12.3.8.1 through 15.12.3.8.3.

15.12.3.8.1 The digits shall be at least $\frac{1}{2}$ in. (12.7 mm) high.

15.12.3.8.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

15.12.3.8.3 Digital pressure gauges shall have an accuracy of ± 3 percent over the full scale.

15.12.3.9 Each flowmeter shall be calibrated to an accuracy of ± 5 percent when flowing the amount of water shown in Table 15.12.3.9 for the pipe size in which it is mounted.

15.12.4 Reserved.

15.12.5 Connections for test gauges shall be provided.

15.13 Required Testing.

15.13.1 Apparatus Pump System Certification.

15.13.1.1 General. The pump shall be tested after the pump and all its associated piping and equipment have been installed on the fire apparatus.

15.13.1.1.1 The testing shall include at least the pumping tests in 15.13.2, the priming system test in 15.13.5, the vacuum test in 15.13.6, the water tank-to-pump flow test in 15.13.7, the gauge and flowmeter test in 15.13.9, the piping integrity test in 15.13.10, and the water tank capacity test in 15.13.11.

15.13.1.1.2 Reserved.

15.13.1.1.3 If the fire pump is driven by the chassis engine, the engine speed advancement interlock test shall be included (*see 15.13.8*).

15.13.1.1.4 Reserved.

15.13.1.1.5 Reserved.

15.13.1.1.6 On pumps with a rated flow of 200 gpm (750 L/min) or more and 2 or more discharges of $1\frac{1}{2}$ in. (38 mm) or larger, the pressure control test shall be included (*see 15.13.4*).

15.13.1.2 Reserved.

15.13.1.2.1 Reserved.

15.13.1.2.2 Reserved.

15.13.1.2.3 Reserved.

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

Table 15.12.3.9 Flowmeter Calibration Flow for Each Pipe Size

Pipe Size		Flow	
in.	mm	gpm	L/min
1	25	40	150
$1\frac{1}{2}$	40	90	340
2	50	160	600
$2\frac{1}{2}$	65	250	950
3	80	375	1400

15.13.1.3* Test Label.

15.13.1.3.1 A test label shall be provided at the pump operator's panel that gives the rated discharge and pressure together with the speed of the engine as determined by the certification test for each unit, the position of the parallel/series pump as used, and the governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve.

15.13.1.3.2 The label shall be completely stamped with all information at the factory and attached to the vehicle prior to shipping.

15.13.2 Pumping Tests.

15.13.2.1 Conditions for Tests.

15.13.2.1.1 The test site shall be adjacent to a supply of clear water, with the water level not more than 10 ft (3 m), or less than 3 ft (0.91 m) below the center of the pump intake, and close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water, when connected to the pump by 20 ft (6 m) of suction hose.

15.13.2.1.2* Tests shall be performed when conditions are as follows:

- (1) Air temperature: 0°F to 110°F (−18°C to 43°C)
- (2) Water temperature: 35°F to 90°F (2°C to 32°C)
- (3) Barometric pressure: 29 in. Hg (98.2 kPa), minimum (corrected to sea level)
- (4)* Minimum lift: 3 ft (1 m) from center of pump intake to the surface of the water

15.13.2.1.3 If it is necessary to perform the test outside the air or water temperature ranges stated in 15.13.2.1.2 and the pump passes the certification test, the test results shall be acceptable.

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

15.13.2.1.4.1 If the chassis engine drives the pump, the total continuous electrical loads, excluding those loads associated with the equipment defined in 15.13.2.1.4.3, shall be applied for the entire pumping portion of this test.

15.13.2.1.4.2 If the vehicle is equipped with a fixed power source driven by the same engine that drives the wildland fire pump, the fixed power source shall be running at a minimum of 50 percent of its rated capacity throughout the pumping portion of the pump test.

15.13.2.1.4.3 The following devices shall be permitted to be turned off or not operating during the pump test:

- (1) Reserved
- (2) Foam pump
- (3) Hydraulically driven equipment (other than hydraulically driven line voltage generator)
- (4) Winch
- (5) Windshield wipers
- (6) Four-way hazard flashers
- (7) Compressed air foam system (CAFS) compressor

15.13.2.1.5 All structural enclosures, such as floorboards, gratings, grilles, and heat shields, not furnished with a means for opening them in service shall be kept in place during the tests.

15.13.2.2 Equipment.**15.13.2.2.1 Suction Hose.**

15.13.2.2.1.1 Suction hose shall be of the size specified in Table 15.2.4.1(a) for the rated capacity of the pump.

15.13.2.2.1.2 A suction hose and strainer that will allow flow with total entrance and friction loss not greater than that specified in Table 15.2.4.1(b) or Table 15.2.4.1(c) shall be used.

15.13.2.2.2 One or more lines of fire hose of sufficient diameter shall be provided to allow discharge of the rated capacity of the pump to the nozzle(s) or other flow-measuring equipment, without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) [approximately 193 gpm (730 L/min) for 1½ in. (38 mm) hose or 500 gpm (2000 L/min) for 2½ in. (65 mm) hose].

15.13.2.2.3* Discharge shall be measured using a smoothbore nozzle and pitot tube, a square-edged round orifice and pressure gauge, or other equipment such as flowmeters, volumetric tanks, or weigh tanks.

15.13.2.2.4 Test Gauges.

15.13.2.2.4.1 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.100, and shall be at least size 3½ per ASME B40.100.

15.13.2.2.4.2 The pump intake gauge shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge or 30 in. Hg (100 kPa) vacuum to a gauge pressure of 150 psi (1000 kPa) for a compound gauge.

15.13.2.2.4.3 The discharge pressure gauge shall have a gauge pressure range of 0 psi to 400 psi (0 kPa to 2800 kPa) or be at least 100 psi (700 kPa) over the maximum pump close-off pressure.

15.13.2.2.4.4 Pitot gauges shall have a gauge pressure range of at least 0 psi to 160 psi (0 kPa to 1100 kPa).

15.13.2.2.4.5 All gauges shall be calibrated in the month preceding the tests using a dead-weight gauge tester or a master gauge meeting the requirements for Grade 3A or Grade 4A gauges, as defined in ASME B40.100, that has been calibrated within the preceding year.

15.13.2.2.5 Each test gauge shall include a means for “snubbing,” such as a needle valve, to damp out rapid needle movements.

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

15.13.2.3 Procedure.

15.13.2.3.1 The ambient air temperature, water temperature, vertical lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to and after each pump test.

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

15.13.2.3.3 The pump shall be subjected to a 30-minute pumping test consisting of continuous pumping at rated capacity at rated net pump pressure.

15.13.2.3.4 If the pump is stopped before the test is completed, the entire pump test shall be repeated.

15.13.2.3.5 The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence.

15.13.2.3.6 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

15.13.3 Reserved.

15.13.4 Pressure Control Test. The pump system shall be tested for pressure rise as follows:

- (1) The pump shall be operated at draft, delivering rated capacity at a discharge gauge pressure of 150 psi (1000 kPa).
- (2) If a pressure control system is supplied, it shall be set in accordance with the manufacturer's instructions to maintain the discharge gauge pressure at 150 psi (1000 kPa) $\pm$ 5 percent.
- (3) All discharge valves shall be closed not more rapidly than in 3 seconds and not more slowly than in 10 seconds.
- (4) The rise in discharge pressure shall not exceed 60 psi (400 kPa) and shall be recorded.

15.13.5 Priming System Test. With the apparatus or pumping unit set up for the pumping test, the priming system shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water.

15.13.5.1 This test shall be permitted to be performed in connection with priming the pump for the pumping test.

15.13.5.2 The interval from the time the primer is started until the time the pump is discharging water shall be noted.

15.13.5.3 The time required to prime the pump shall not exceed 30 seconds.

15.13.5.4 Only biodegradable products shall be permitted to be discharged onto the ground.

15.13.6 Vacuum Test. The vacuum test shall consist of subjecting the interior of the pump, with all intake valves open, all intakes capped or plugged, and all discharge caps removed and valves closed, to a vacuum of 17 in. Hg (57.6 kPa) by means of the pump priming system.

15.13.6.1 At altitudes above 2000 ft (600 m), the vacuum attained shall be permitted to be less than 17 in. Hg (57.6 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (300 m) of altitude above 2000 ft (600 m).

15.13.6.2 The primer shall not be used after the 5-minute test period has begun.

15.13.6.3 The engine shall not be operated at any speed greater than the governed speed during this test.

15.13.6.4 The vacuum shall not drop more than 10 in. Hg (34 kPa) in 5 minutes.

15.13.6.5* The vacuum test shall then be repeated with all intake valves closed and the caps or plugs on all gated intakes removed.

15.13.7 Water Tank-to-Pump Flow Test.

15.13.7.1 A water tank-to-pump flow test shall be conducted as follows:

- (1) The apparatus shall be placed on level ground and the water tank filled until it overflows.
- (2) All intakes to the pump shall be closed.
- (3) The tank fill line and bypass cooling line, if supplied, shall be closed.
- (4) A hose line(s) and nozzle(s) for discharging water at the rated tank-to-pump flow rate shall be connected to one or more discharge outlets.
- (5) The tank-to-pump valve(s) and the discharge valve(s) leading to the hose line(s) and nozzle(s) shall be fully opened.
- (6) The engine throttle shall be adjusted until the required flow rate, ± 5 percent, is established.
- (7) The discharge pressure shall be recorded.
- (8) The discharge valves shall be closed and the water tank refilled.
- (9) The bypass cooling line shall be permitted to be opened temporarily, if needed, to keep the water temperature in the pump within acceptable limits.
- (10) The discharge valves shall be fully reopened and the time noted.
- (11) If necessary, the engine throttle shall be adjusted to maintain the discharge pressure recorded as noted in 15.13.7.1(7).
- (12) When the discharge pressure drops by 10 psi (70 kPa) or more, the time shall be noted and the elapsed time from the opening of the discharge valves shall be calculated and recorded.

15.13.7.2 Volume Discharge Calculation.

15.13.7.2.1 The volume discharged shall be calculated by multiplying the rate of discharge in gallons per minute (liters per minute) by the time in minutes elapsed from the opening of the discharge valves until the discharge pressure drops by at least 10 psi (70 kPa).

15.13.7.2.2 Other means shall be permitted to be used to determine the volume of water pumped from the tank such as a totalizing flowmeter, weighing the fire apparatus before and after, or refilling the tank using a totalizing flowmeter.

15.13.7.2.3 The rated tank-to-pump flow rate as defined in 17.3.2 shall be maintained until 80 percent of the rated capacity of the tank has been discharged.

15.13.8* Engine Speed Advancement Interlock Test. If the pump is driven by the chassis engine, the engine speed advancement interlock system shall be tested to verify that engine speed cannot be increased at the pump operator's panel unless the proper conditions are met.

15.13.8.1 If the apparatus is equipped with a pump driven through split-shaft PTO, the test shall verify that for each of the conditions specified in the first four columns of Table 15.13.8.1, the indicators and engine speed controls operate as specified in the last four columns.

15.13.8.2 If the apparatus is equipped with a pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, that is designed for stationary pumping only the test shall verify that for each of the conditions specified in the first four columns of Table 15.13.8.2, the indicators and engine speed controls operate as specified in the last four columns.

15.13.8.3 If the apparatus is equipped with a pump driven by the chassis engine designed for both stationary pumping and pump-and-roll, the test shall verify that for each of the conditions specified in the first four columns of Table 15.13.8.3, the indicators and engine speed controls operate as specified in the last four columns.

15.13.8.4 If the apparatus is equipped with a pump driven through transfer case PTO or auxiliary transmission PTO designed for stationary pumping only, the test shall verify that for each of the conditions specified in the first five columns of Table 15.13.8.4, the indicators and engine speed controls operate as specified in the last four columns.

15.13.9 Gauge and Flowmeter Test.

15.13.9.1 Pump intake and discharge pressure gauges shall be checked for accuracy while water is pumping at rated capacity at pump rated pressure.

15.13.9.2 Any gauge that is off by more than 10 psi (70 kPa) from the calibrated test gauge shall be recalibrated, repaired, or replaced.

15.13.9.3 Each flowmeter shall be checked for accuracy while water is being pumped at the flow rate listed in Table 15.13.9.3 at 100 psi (700 kPa).

15.13.9.4 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced.

15.13.10* Manufacturer's Predelivery Test.

15.13.10.1 Piping Integrity Test. The pump and its connected piping system shall be hydrostatically tested to a gauge pressure of 250 psi (1700 kPa) or 100 psi (700 kPa) above the maximum pump close-off pressure, whichever is greater, up to 500 psi (3400 kPa).

15.13.10.2 The hydrostatic test shall be conducted with the tank fill line valve closed, the tank-to-pump valve closed, and the pump bypass line return to the water tank valve closed, if equipped, or the line disconnected and capped.

15.13.10.3 All discharge valves shall be open and the outlets capped.

15.13.10.4 All intake valves shall be closed, and nonvalved intakes shall be capped.

15.13.10.5 The pressure shall be maintained for 3 minutes.

Table 15.13.8.1 Pump Driven Through Split- Shaft PTO

Test Conditions				Verifications			
Transmission Type	Chassis Transmission Gear Selected	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Pump Indicator Status (Driving Compartment)	Pump Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^b	On	Road	None	None ^c	Yes	No ^c
Either	Neutral ^b	On	Road	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Off	Road	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" ^e	None ^c	Yes	No ^c
Automatic	Neutral	On	Engaged	"Pump Engaged" ^e	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Automatic	Neutral	Off	Engaged	"Pump Engaged" ^e	None	Yes	No
Automatic	Pump gear ^f	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Automatic	Pump gear ^f	Off	Engaged	"Pump Engaged" ^e	None	Yes	No
Automatic	Pump gear ^f	On	Road	None	None	Yes	No
Automatic	Pump gear ^f	Off	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	On	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Off	Road	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	On	Engaged	"Pump Engaged" ^e	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Off	Engaged	"Pump Engaged" ^e	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" ^e	None	Yes	No

^aRefers to the physical position of the pump shift control, (or status of an electrical control action), in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bA manual transmission can be in any gear or neutral.

^cEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^dSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^eSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

^fThe chassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.

^gThe chassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.

Table 15.13.8.2 Pump Driven Through Transmission-Mounted PTO, Front-of-Engine Crankshaft PTO, or Engine Flywheel PTO Designed for Stationary Pumping Only

Test Conditions				Verifications			
Transmission Type	Chassis Transmission Gear Selected	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^b	On	Disengaged	None	None ^c	Yes	No ^c
Either	Neutral ^b	On	Disengaged	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Automatic	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral	Off	Disengaged	None	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bA manual transmission can be in any gear or neutral.

^cEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^dSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^eSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

15.13.11 Water Tank Capacity Test. The water tank shall be tested for usable water capacity by either a totalizing flowmeter method or a truck weight method.

15.13.11.1 The water tank shall be filled until it overflows.

15.13.11.2 If the unit is equipped with an automatic shutdown due to a low-pressure feature, the feature shall be engaged.

15.13.11.3 If a totalizing flowmeter is used, the meter shall be connected to a discharge valve and set to zero.

15.13.11.3.1 The discharge valve to which the totalizing flowmeter is connected shall be opened and the unit run at between 25 and 35 percent of the pump's rated flow at 100 psi (700 kPa) until it automatically shuts down or the pressure drops below 30 psi (200 kPa).

15.13.11.3.2 The total volume that was discharged shall be recorded.

15.13.11.4 If the truck weight method is used, the truck shall be weighed and the weight recorded.

15.13.11.4.1 The pump shall be started and brought up to a flow rate of between 25 and 35 percent of the pump's rated flow at 100 psi (700 kPa) by partly opening a discharge valve.

15.13.11.4.2 The discharge valve shall be closed when the unit automatically shuts down or the pump pressure drops below 30 psi (200 kPa).

15.13.11.4.3 The truck shall be reweighed.

15.13.11.4.4 The water tank empty weight shall be subtracted from water tank full weight, and the result divided by 8.33 lb/gal to obtain the usable water volume in gallons.

Table 15.13.8.3 Stationary Pumping and Pump-and-Roll

Test Conditions				Verifications			
Transmission Type	Chassis Transmission Gear Selected	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment) ^b	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^c	On	Disengaged	None	None ^d	Yes	No ^d
Either	Neutral ^c	On	Disengaged	None	"Throttle Ready" ^d	Yes or No ^e	Yes ^d
Either	Neutral ^c	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^e	Yes
Automatic	Neutral	Off	Engaged	"Pump Engaged" and "OK to Pump and Roll" ^f	None	Yes	No
Automatic	Any gear other than neutral	On	Engaged	"Pump Engaged" ^b	None	Yes	No
Automatic	Any gear other than neutral	Off	Engaged	"Pump Engaged" and "OK to Pump and Roll"	None	Yes	No
Automatic	Any gear other than neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral	Off	Disengaged	None	None	Yes	No
Manual	Any gear or neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^e	Yes
Manual	Any gear or neutral	Off	Engaged	"Pump Engaged" and "OK to Pump and Roll"	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

^cA manual transmission can be in any gear or neutral.

^dEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^eSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^f"OK to Pump and Roll" stays on in neutral to allow shifting to neutral when temporarily stopped with the foot brake applied. This allows additional throttle to be applied for greater pump speed. Do not shift to neutral while the vehicle is moving; this is a prohibited operation in at least 17 states.

Table 15.13.8.4 Pump Driven Through Transfer Case PTO or Auxiliary Transmission PTO Designed for Stationary Pumping Only

Test Conditions					Verifications			
Transmission Type	Chassis Transmission Gear Selected	Transfer Case	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Either	Neutral ^b	Neutral	On	Disengaged	None	None ^c	Yes	No ^c
Either	Neutral ^b	Engaged	On	Disengaged	None	None ^c	Yes	No ^c
Either	Neutral ^b	Neutral	On	Disengaged	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Engaged	On	Disengaged	None	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Either	Neutral ^b	Neutral	Off	Disengaged	None	None	Yes	No
Either	Neutral ^b	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Neutral	Neutral	On	Engaged	"Pump Engaged" ^c	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Automatic	Neutral	Engaged	On	Engaged	"Pump Engaged" ^c	"Throttle Ready" ^c	Yes or No ^d	Yes ^c
Automatic	Neutral	Neutral	Off	Engaged	"Pump Engaged" ^c	None ^c	Yes	No ^c
Automatic	Neutral	Engaged	Off	Engaged	"Pump Engaged" ^c	None ^c	Yes	No ^c
Automatic	Pump gear ^f	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Automatic	Pump gear ^f	Engaged	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Pump gear ^f	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Pump gear ^f	Engaged	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Pump gear ^f	Neutral	On	Disengaged	None	None	Yes	No
Automatic	Pump gear ^f	Engaged	On	Disengaged	None	None	Yes	No
Automatic	Pump gear ^f	Neutral	Off	Disengaged	None	None	Yes	No
Automatic	Pump gear ^f	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Engaged	On	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Engaged	Off	Disengaged	None	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No

(continues)

Table 15.13.8.4 *Continued*

Test Conditions					Verifications			
Transmission Type	Chassis Transmission Gear Selected	Transfer Case	Parking Brake Status	Pump Shift Control Action Status (Driving Compartment) ^a	Indicator Status (Driving Compartment)	Indicator Status (Pump Operator's Panel)	Engine Speed Control in Cab	Engine Speed Control at Pump Operator's Panel
Automatic	Any gear other than neutral and pump gear ^g	Engaged	On	Engaged	"Pump Engaged" ^c	None	Yes	No
Automatic	Any gear other than neutral and pump gear ^g	Engaged	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Manual	Any gear or neutral	Neutral	On	Engaged	"Pump Engaged" and "OK to Pump"	"Throttle Ready" and "OK to Pump"	Yes or No ^d	Yes
Manual	Any gear or neutral	Engaged	On	Engaged	"Pump Engaged" ^c	"Throttle Ready" ^c	Yes or No ^d	Yes ^e
Manual	Any gear or neutral	Neutral	Off	Engaged	"Pump Engaged" ^c	None	Yes	No
Manual	Any gear or neutral	Engaged	Off	Engaged	"Pump Engaged" ^c	None	Yes	No

^aRefers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.

^bA manual transmission can be in any gear or neutral.

^cEngine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.

^dSome apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.

^eSome apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.

^fChassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.

^gChassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.

Table 15.13.9.3 Flowmeter Test Flows

Discharge Size		Test Flow	
in.	mm	gpm	L/min
1	25	40	150
1½	40	90	340
2½	65	250	950

Chapter 16 Fire Apparatus — Ultra-High Pressure Fire Pumps and Associated Equipment (NFPA 1901/1906)

16.1 Application. If the apparatus is equipped with an ultra-high pressure fire pump, the provisions of this chapter shall apply.

16.2 Pump Performance.

16.2.1 An ultra-high pressure fire pump shall have a minimum rated capacity of 6 gpm (25 L/min) and shall have a rated discharge pressure greater than or equal to 1100 psi (7600 kPa).

16.2.2 The rating for ultra-high pressure fire pumps shall be based on the pump taking water from the apparatus water tank.

16.2.3 If the completed pumping system is capable of taking suction, it shall do so within 30 seconds under the following conditions:

- (1) At an altitude of 2000 ft (600 m) above sea level
- (2) Through 10 ft (3 m) of suction hose of the size specified in Table 16.2.3 and equipped with a suction hose strainer
- (3) With a lift of 3 ft (1 m)
- (4) At 29.9 in. Hg (101 kPa) atmospheric pressure (corrected to sea level)
- (5) At a water temperature of 60°F (16°C)

16.2.4* The pump manufacturer shall certify for each ultra-high-pressure fire pump the rated capacity in gpm (L/min), rated discharge pressure in psi (kPa), and net positive suction head required (NPSHR) in ft (m) of water at 60°F (16°C).

16.2.5 Vacuum.

16.2.5.1 If the completed pumping system is capable of taking suction per 16.2.3, it shall be capable of developing a vacuum of 17 in. Hg (57.4 kPa) at altitudes up to 2000 ft (600 m) by means of the pump priming system and sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (34 kPa).

16.2.5.2 The requirements of 16.2.5.1 shall be met with all intake valves open, with all intakes capped or plugged, with all discharge caps removed and valves closed, and without the use of the pump primer during the 5-minute period.

16.3 Power Train Capability.

16.3.1 All components in the power train from the engine to the pump shall be capable of transmitting the continuous duty power required by the pump for at least 30 minutes at the pump's rated capacity and pressure.

16.3.2 When pumping rated capacity and pressure, lubricant temperatures in any power train component shall not exceed the component manufacturer's recommendation for maximum temperature.

16.4 Construction Requirements.

16.4.1 The pump body, discharge piping, and valves, excluding the tank fill line on the tank side of the valve, shall be capable of withstanding a minimum hydrostatic pressure of 1.4 times the rated discharge pressure.

16.4.2 The pump intake, tank fill line on the tank side of the valve, and associated plumbing and valves, excluding the tank-to-pump line on the tank side of the valve, shall be capable of withstanding a minimum hydrostatic pressure of 250 psi (1700 kPa).

16.4.3 The pump, piping, and valves shall be capable of delivering the rated capacity at the rated discharge pressure of the pump and withstanding closure of all discharges.

16.4.4 Pump Body Integrity Test. The pump body shall be subjected to either a hydrostatic test per 16.4.4.1 or a hydrodynamic test per 16.4.4.2.

16.4.4.1 If the pump body is subjected to a hydrostatic test, it shall be hydrostatically tested to a gauge pressure of 1.4 times the rated discharge pressure for a minimum of 10 minutes.

16.4.4.2 If the pump body is subjected to a hydrodynamic test, it shall be hydrodynamically tested to a gauge pressure of 1.4 times the rated discharge pressure for a minimum of 10 minutes.

16.4.4.3 The pump manufacturer shall provide a certificate of completion for the hydrostatic or hydrodynamic test.

16.5 Pump Intakes.

16.5.1 Each pump intake shall be sized to permit the full rated performance of the pump.

16.5.2* For any pump intake equipped with a valve, the valve shall be controlled from the pump operator's position.

16.5.3* Each external intake shall be equipped with National Hose (NH) threads on the connection with a removable or accessible strainer.

16.5.3.1 Adapters with special threads or other means for hose attachment shall be permitted on any intake connection.

16.5.3.2 Each external valved intake larger than 1 ½ in. shall be equipped with a bleeder valve to bleed off air or water from a hose connected to the intake.

16.5.3.3 All intake connections shall be provided with closures, caps, or plugs capable of withstanding a hydrostatic gauge pressure of 250 psi (1730 kPa).

16.5.3.3.1 Intake connections having male threads shall be equipped with caps.

16.5.3.3.2 Intake connections having female threads shall be equipped with plugs.

16.5.3.3.3 Where adapters for special threads or other means for hose attachment are provided on the intake connections, closures shall be provided for the adapters in lieu of caps or plugs.

Table 16.2.3 Suction Hose Size by Pump Capacity Rating

Flow Rate		Minimum Suction Hose Size	
gpm	L/min	in.	mm
20 and less	80 or less	1	25
30	120	1½	38
50	200	2	52
100	400	2½	65
150	600	2½	65
200	800	2½	65
250	1000	3	75
300	1200	3	75

16.5.3.4 Caps or closures for intake connections 3 in. (75 mm) and smaller shall remain secured to the apparatus when removed from the connection.

16.5.4 The pump shall have a means to restrict debris that is too large to pass through the pump.

16.6 Pump Discharges.

16.6.1* Each pump discharge shall be equipped with a valve that can be controlled from a pump operator's position.

16.6.2 Any discharge that can be supplied from another pump system on the apparatus shall have check valves in both supply lines to prevent backflow into either pump.

16.6.3 Discharge Outlet Connections.

16.6.3.1 All discharge outlets, except connections to which a hose will be preconnected, shall be equipped with connectors that permit hose attachment or removal within 30 seconds.

16.6.3.2 Adapters with special threads or other means for hose attachment shall be permitted to be attached to any discharge outlet connection.

16.6.3.3 Discharge outlet connections shall not be permitted to be equipped with NH threads.

16.6.4 All discharge outlet connections, except connections to which a hose will be preconnected, shall be equipped with caps or closures capable of withstanding a hydrostatic gauge pressure of 1.4 times the rated discharge pressure.

16.6.4.1 If the apparatus has more than one discharge, the caps or closures shall be capable of withstanding closure of all discharges when pump controls are set to deliver rated capacity at rated discharge pressure.

16.6.4.2 Where adapters are provided on the discharge outlet connection, the closures shall fit on the adapters.

16.6.4.3 Caps or closures for outlet connections 3 in. (75 mm) and smaller shall remain secured to the apparatus when removed from the connection.

16.6.5 All preconnected hose connections and preconnected hoses shall be capable of withstanding a hydrostatic gauge pressure of 1.4 times the maximum discharge pressure.

16.6.6 All preconnected hose connections and preconnected hoses shall be capable of withstanding closure of all discharges when pump controls are set to deliver rated capacity at rated discharge pressure.

16.6.7* If a water tank fill line is provided, the line shall be connected from the pump discharge manifold directly to the water tank.

16.6.8 If a water tank fill line is provided, the line shall include a valve that can be controlled from the pump operator's position.

16.7 Pump Operator's Panel.

16.7.1 Each pump control, gauge, and other instrument necessary to operate the ultra-high pressure fire pump shall be marked with a label as to its function.

16.7.2 All gauges, instruments, and controls located on the ultra-high pressure fire pump operator's panel shall be illuminated to a minimum lighting level of 5 fc (54 lx).

16.7.3 Safety sign FAMA25, which warns of the need for training prior to operating the apparatus, shall be located on the pump operator's panel.

16.7.4 Safety sign FAMA20, which warns of the hazards of ultra-high pressure, shall be located in a visible location adjacent to any discharge outlet.

16.8 Pump Controls.

16.8.1* Controls shall be provided for placing the pump in operation.

16.8.2 If the pump requires engagement to operate, the control for the pump engagement mechanism shall be marked with a label to indicate when the pump is properly engaged in pumping position.

16.8.3 Pressure Control System.

16.8.3.1 A system shall be provided or the pump shall have operating characteristics that are capable of limiting the increase of net pump pressure to a maximum pressure rise of 40 percent over the rated pump pressure when all discharges are closed when the engine and pump controls are set to produce the rated capacity at the rated net pump pressure of the pump.

16.8.3.2 If the pump is equipped with a governor system that controls engine speed, an indicator shall show when the system is turned on and whether it is controlling the engine speed or pump pressure.

16.8.3.3 If the pump is equipped with a governor system, it shall be controllable by one person at the pump operator position.

16.8.4 All pump controls and devices shall be installed so as to be protected against mechanical damage or the effects of adverse weather conditions on their operation.

16.8.5 Drain Valve(s).

16.8.5.1* An accessible drain valve(s) that is marked with a label as to its function shall be provided to allow the pump and all water-carrying lines and accessories to be drained.

16.8.5.2 The drain valve(s) shall be operational without the operator having to get under the apparatus.

16.8.6 Pump Cooling.

16.8.6.1* A pump cooling/recirculation line of sufficient size to prevent the pump from overheating when no discharge lines are open shall be provided between the pump discharge and the water tank.

16.8.6.2 Where the pump is of a positive displacement type an automatic bypass relief valve shall be permitted to be provided in place of the recirculation line.

16.9 Pump Drive Systems.

16.9.1 Where the pump is driven by the chassis engine, the provisions of 13.10.2 shall apply as applicable.

16.9.2 When pumping at the rated capacity and discharge pressure specified in 16.2.4, lubricant temperature in any pump drive system component shall not exceed the manufacturer's recommended maximum temperature.

16.9.3 If a separate pumping engine is provided, it shall meet the requirements of 9.2.1.1, 9.2.1.3, 9.2.1.4, 9.2.2, 9.2.5 through 9.2.6, Section 10.2, 10.4.3, 10.4.4, 10.4.4.1, 10.4.4.3, 10.4.4.4, 10.4.5, Section 10.5 and Section 10.6.

16.10* Engine Controls.

16.10.1 A throttle control shall be provided to control the engine speed.

16.10.2 This throttle control shall be permitted to be the same throttle control that is used for the main fire pump.

16.11 Gauges and Instruments.

16.11.1 Master Pump Discharge Pressure Gauge. A master discharge pressure gauge shall be provided.

16.11.1.1 The master discharge pressure gauge shall read from a gauge pressure of 0 to not less than 500 psi (3500 kPa) higher than the maximum pressure that can be developed by the pump when it is operating with zero intake pressure.

16.11.1.2 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade 1A as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

16.11.1.2.1 Numerals for master gauges shall be a minimum 0.25 in. (6.4 mm) high.

16.11.1.2.2 There shall be graduation lines showing at least every 50 psi (200 kPa), with major and intermediate graduation lines emphasized and figures at least every 500 psi (2000 kPa).

16.11.1.2.3 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

16.11.1.3 If a digital pressure gauge is used, the digits shall be at least 0.25 in. (6.4 mm) high.

16.11.1.3.1 Digital pressure gauges shall display pressure in increments of not more than 50 psi (200 kPa).

16.11.1.3.2 Digital master pressure gauges shall have an accuracy of ± 3 percent over the full scale.

16.11.2 Protection of Gauges and Instruments. Each pressure gauge or flowmeter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

16.11.3 Cab Gauges. If the apparatus is designed for pump-and-roll operations, a second gauge that meets the same requirements as the discharge pressure gauge required by 16.11.1 shall be mounted in the driving compartment in view of the driver.

16.12 Required Testing.

16.12.1 Apparatus Pump System Certification.

16.12.1.1 General. The UHP pump shall be tested after the pump and all its associated piping and equipment have been installed on the fire apparatus.

16.12.1.1.1 The testing shall include at least the 30-minute pumping test in 16.12.5, the pressure control test in 16.12.7, the gauge and flowmeter test in 16.12.11, the manufacturer's predelivery test in 16.12.12, the and the water tank capacity test in 16.12.13.

16.12.1.1.2 If the 30-minute pumping test is not performed from the apparatus water tank, the water tank-to-pump flow test in 16.12.6 shall be included.

16.12.1.1.3 If the pumping system is equipped with a priming system, the priming system test in 16.12.8 and the vacuum test in 16.12.9 shall be included.

16.12.1.1.4 If the UHP pump is driven by the chassis engine, the engine speed advancement interlock test in 16.12.10 shall be included.

16.12.1.1.5 The test results shall be certified by the manufacturer.

16.12.1.2* Test Label.

16.12.1.2.1 A test label shall be provided at the pump operator's position that gives the rated discharges and pressures.

16.12.1.2.2 If powered by an engine, the speed of the engine as determined by the certification test for each unit and the governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve shall be provided on the test label.

16.12.1.2.3 The label shall be stamped with all information at the factory and attached to the vehicle prior to shipping.

16.12.2 Conditions for Tests.

16.12.2.1 Tests shall be performed when conditions are as follows:

- (1) Air temperature: 0°F to 110°F (–18°C to 43°C)
- (2) Water temperature: 35°F to 90°F (2°C to 32°C)
- (3) Barometric pressure: 29 in. Hg (98.2 kPa), minimum (corrected to sea level)

16.12.2.2 If it is necessary to perform the test outside the air or water temperature ranges or the minimum barometric pressure stated in 16.12.2.1 and the pump passes the certification test, the test results shall be acceptable.

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

16.12.2.3.1 If the chassis engine drives the UHP pump, the total continuous electrical loads, excluding those loads associated with the equipment defined in 16.12.2.3.3, shall be applied for the entire pumping portion of this test.

16.12.2.3.2 If the vehicle is equipped with a fixed power source driven by the same engine that drives the ultra-high pressure fire pump, the fixed power source shall be running at a minimum of 50 percent of its rated capacity throughout the pumping portion of the pump test.

16.12.2.3.3 The following devices shall be permitted to be turned off or not operating during the pump test:

- (1) Foam pump
- (2) Hydraulically driven equipment (other than hydraulically driven line voltage generator)
- (3) Winch
- (4) Windshield wipers
- (5) Four-way hazard flashers
- (6) Compressed air foam system (CAFS) compressor

16.12.2.3.4 All structural enclosures, such as floorboards, gratings, grilles, and heat shields not furnished with a means

for opening them in normal service shall be kept in place during the tests.

16.12.3 Equipment.

16.12.3.1 One or more lines of UHP hose of sufficient diameter shall be provided to allow discharge of the rated capacity of the pump without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) through the hose.

16.12.3.2 Discharge rate shall be measured using equipment such as flowmeters, volumetric tanks, or weigh tanks.

16.12.3.3 Test Gauges.

16.12.3.3.1 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.100 and shall be at least size 3½ per ASME B40.100, *Pressure Gauges and Gauge Attachments*.

16.12.3.3.2 The pump intake gauge shall have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge or 30 in. Hg (100 kPa) vacuum to a gauge pressure of 150 psi (1000 kPa) for a compound gauge.

16.12.3.3.3 The discharge pressure gauge shall have a gauge pressure range of 0 psi (0 kPa) to not less than 500 psi (3500 kPa) over the rated pump discharge pressure.

16.12.3.3.4 All gauges shall have been calibrated in the year preceding the tests using a deadweight gauge tester or a master gauge meeting the requirements for Grade 3A or Grade 4A gauges, as defined in ASME B40.100, that has been calibrated within the preceding year.

16.12.3.3.5 Each test gauge shall include a means for snubbing, such as a needle valve, to damp out rapid needle movements.

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

16.12.4 Procedure.

16.12.4.1 The ambient air temperature, water temperature, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to the pump test.

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

16.12.5 Thirty-Minute Pumping Test.

16.12.5.1 The UHP pump shall be subjected to a 30-minute pumping test consisting of continuous pumping at rated capacity at rated pump discharge pressure.

16.12.5.2 The 30-minute pumping test shall be permitted to be performed from the apparatus water tank with provisions to maintain tank level during the duration of the test.

16.12.5.3 The 30-minute pumping test shall be permitted to be performed with water supplied to the pump intake from a separate water supply that provides positive pressure to the pump intake.

16.12.5.4 If the 30-minute pumping test is performed with water supplied to the pump that provides positive pressure at the pump intake, the net pump pressure shall be equal to the rated pump discharge pressure.

16.12.5.5 The 30-minute pumping test shall be permitted to be run at a test site that provides a supply of clear water and is close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water when connected to the pump by a minimum of 10 ft (3 m) of suction hose.

16.12.5.6 If the pump is stopped before the test is completed, the entire pump test shall be repeated.

16.12.5.7* The flow discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence.

16.12.5.8 The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

16.12.6 Water Tank-to-Pump Flow Test.

16.12.6.1 If the 30-minute pumping test in 16.12.5 is not performed from the apparatus water tank, a water tank-to-pump flow test shall be performed with water supplied from the apparatus water tank to verify the tank to pump flow capability.

16.12.6.2 The test shall consist of 5 minutes of continuous pumping at rated capacity at rated pump pressure taking water from the apparatus water tank.

16.12.6.3 The flow, discharge pressure, and engine speed shall be recorded at the beginning and end of the test.

16.12.7 Pressure Control Test. The pressure control system of an ultra-high pressure fire pump shall be tested for pressure rise as follows:

- (1) The ultra-high pressure fire pump shall be operated to deliver rated capacity at rated discharge gauge pressure.
- (2) If a pressure control system is supplied, it shall be set in accordance with the manufacturer's instructions.
- (3) All discharge valves shall be closed.
- (4) Any rise in discharge pressure shall not exceed 40 percent of the rated discharge pressure.
- (5) The pump shall be operated with the discharge lines closed for 3 minutes without the temperature of the pump exceeding 140°F (60°C).
- (6) The final discharge pressure, any rise in discharge pressure, and the final pump temperature shall be recorded.

16.12.8 Priming System Test. If the UHP pumping system is equipped with a priming system, it shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water.

16.12.8.1 The interval from the time the priming system is started until the time the pump is discharging water shall be noted.

16.12.8.2 The time required to prime the pump shall not exceed 30 seconds.

16.12.8.3 Only biodegradable products shall be permitted to be discharged onto the ground.

16.12.9 Vacuum Test. If the UHP pumping system is equipped with a priming system, a vacuum test shall be performed that consists of subjecting the interior of the pump, with all intake valves open, with all intakes capped or plugged, and with all discharge caps removed, to a vacuum of 17 in. Hg (57.6 kPa) by means of the pump priming system.

16.12.9.1 At altitudes above 2000 ft (600 m), the vacuum attained shall be permitted to be less than 17 in. Hg (57.6 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (300 m) of altitude above 2000 ft (600 m).

16.12.9.2 The primer shall not be used after the 5-minute test period has begun.

16.12.9.3 The engine shall not be operated at any speed greater than the governed speed during this test.

16.12.9.4 The vacuum shall not drop more than 10 in. Hg (34 kPa) in 5 minutes.

16.12.9.5 The vacuum test shall then be repeated with all intake valves closed and the caps or plugs on all gated intakes removed.

16.12.10* Engine Speed Advancement Interlock Test. If the UHP pump is driven by the chassis engine, the engine speed advancement interlock system shall be tested to verify that engine speed cannot be increased at the pump operator's panel unless there is throttle-ready indication.

16.12.10.1 If the apparatus is equipped with a stationary UHP pump driven through a split shaft PTO, the test shall verify that the engine speed control at the pump operator's panel cannot be advanced when either of the following conditions exists:

- (1) The chassis transmission is in neutral, the parking brake is off, and the UHP pump shift in the driving compartment is in the road position.
- (2) The chassis transmission has been placed in the position for pumping as indicated on the label provided in the driving compartment, the parking brake is on, and the UHP pump shift in the driving compartment is in the road position.

16.12.10.2 If the apparatus is equipped with a stationary UHP pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, the test shall verify that the engine speed control on the pump operator's panel cannot be advanced when either of the following conditions exists:

- (1) The chassis transmission is in neutral, the parking brake is off, and the UHP pump shift status in the driving compartment is disengaged.
- (2) The chassis transmission is in any gear other than neutral, the parking brake is on, and the UHP pump shift in the driving compartment is in the "Pump Engaged" position.

16.12.10.3 If the apparatus is equipped with a UHP pump driven by the chassis engine designed for both stationary pumping and pump-and-roll, the test shall verify that the engine speed control at the pump operator's panel cannot be advanced when any of the following conditions exists:

- (1) The chassis transmission is in neutral, the parking brake is off, and the UHP pump shift status in the driving compartment is disengaged.
- (2) The chassis transmission is in any gear other than neutral, the parking brake is on, and the UHP pump shift in the driving compartment is in the "Pump Engaged" position.
- (3) The chassis transmission is in any gear other than neutral, the parking brake is off, the UHP pump shift in the driving compartment is in the "Pump Engaged" position, and the "OK to Pump-and-Roll" indicator is on.

16.12.10.4 If the apparatus is equipped with a stationary UHP pump driven through a transfer case PTO, the test shall verify that the engine speed control on the pump operator's panel cannot be advanced when one of the following conditions exists:

- (1) The chassis transmission is in neutral, the transfer case is in neutral, the parking brake is off, and the UHP pump shift in the driving compartment is in the road position.
- (2) The chassis transmission is in neutral, the transfer case is engaged, the parking brake is off, and the UHP pump shift in the driving compartment is in the road position.
- (3) The chassis transmission has been placed in the position for pumping as indicated on the label provided in the driving compartment, the parking brake is on, and the UHP pump shift in the driving compartment is in the road position.

16.12.11 Gauge and Flowmeter Test.

16.12.11.1 Pump intake and discharge pressure gauges shall be checked for accuracy while pumping at rated capacity at pump rated pressure.

16.12.11.2 Any gauge that does not meet Grade B ASME B40.100, *Pressure Gauges and Gauge Attachments*, requirements as compared to the calibrated test gauge shall be recalibrated, repaired, or replaced.

16.12.11.3 Each flowmeter shall be checked for accuracy while pumping at rated capacity at pump rated pressure.

16.12.11.4 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced.

16.12.12 Manufacturer's Predelivery Test.

16.12.12.1 Piping Integrity Test. The UHP pump and its connected piping system shall be subjected to both a hydrostatic test per 16.12.12.2 and a hydrodynamic test per 16.12.12.3.

16.12.12.2 Hydrostatic Test. All system plumbing that will be exposed to rated pump discharge pressure shall be hydrostatically tested to at least 1.4 times the rated pump discharge pressure.

16.12.12.2.1 The following system components shall not be required to be hydrostatically tested under this section:

- (1) Pump intake plumbing
- (2) Portions of a discharge path that vent to atmosphere
- (3) The pump body and any permanently mounted plumbing supplied by the pump manufacturer

16.12.12.2.2 If the complete plumbing system is capable of withstanding the hydrostatic test pressure, or if the items listed in 16.12.12.2.1 can be isolated from hydrostatic test pressure through the use of permanently installed valves, the test procedure shall be as follows:

- (1) Establish the system boundaries by shutting all valves to components listed in 16.12.12.2.1. All other valves must be open with the discharge outlet capped, plugged, flanged, or otherwise sealed.
- (2) Fill the system with water and bleed all air from the system.
- (3) Use a hydrostatic test pump to establish a test pressure of at least 1.4 times the rated pump discharge pressure.

- (4) Maintain the hydrostatic test pressure for at least 3 minutes.

16.12.12.2.3* If the design of the system will not allow the components listed in 16.12.12.2.1 to be isolated from hydrostatic test pressure when installed on the completed apparatus, and such components are not designed to withstand hydrostatic test pressure, the hydrostatic test shall be permitted to be performed on the discharge plumbing prior to installation on the apparatus.

16.12.12.2.3.1 The plumbing connections that connect to the components listed in 16.12.12.2.1 shall be capped or plugged during the hydrostatic test.

16.12.12.2.3.2 Once the section is isolated, the test procedure shall be as listed in 16.12.12.2.2(2) through 16.12.12.2.2(4).

16.12.12.3 Hydrodynamic Test. As installed on the apparatus, all piping that will be exposed to rated pump discharge pressure shall be hydrodynamically tested.

16.12.12.3.1 The test procedure shall be as follows:

- (1) Establish the system boundaries by shutting all discharge valves
- (2) Establish a water supply to the UHP pump, either from the tank or from an external source
- (3) Fill the system with water and bleed all air from the system
- (4) Use the UHP pump to establish the maximum pump discharge pressure without disabling relief valves, governors, or automatic shutdown systems
- (5)* Conduct the hydrodynamic test, which can be conducted with a bypass valve, relief valve, or discharge valve open as necessary to maintain pump temperature during the test
- (6) Maintain the hydrodynamic test pressure for a minimum of 5 minutes
- (7) Verify there is no leakage in any of the plumbing

16.12.12.3.2 The hydrodynamic test in 16.12.12.3.1 shall be permitted to be performed in conjunction with the 30-minute pumping test in 16.12.5.

16.12.13 Water Tank Capacity Test. The water tank shall be tested for usable water capacity by either a totalizing flowmeter method or truck weight method.

16.12.13.1 The water tank shall be filled until it overflows.

16.12.13.2 If the unit is equipped with an automatic shutdown due to a low pressure feature, the feature shall be engaged.

16.12.13.3 If a totalizing flowmeter is used, the meter shall be connected to a discharge and set to zero.

16.12.13.3.1 If the totalizing flowmeter is connected to a discharge valve, the valve shall be opened and the unit run at between 50 and 100 percent of the pump's rated flow until it automatically shuts down or the pressure drops below 1000 psi (7000 kPa).

16.12.13.3.2 The total volume that was discharged shall be recorded.

16.12.13.4 If the truck weight method is used, the truck shall be weighed and the weight recorded.

16.12.13.4.1 The pump shall be started and brought up to a flow rate of between 25 percent and 35 percent of the pump's

rated flow by partly opening a discharge valve or by reducing the speed of the pump.

16.12.13.4.2 The discharge valve shall be closed when the unit automatically shuts down or the pump pressure drops below 1000 psi (7000 kPa).

16.12.13.4.3 The truck shall be reweighed.

16.12.13.4.4 The water tank empty weight shall be subtracted from water tank full weight and the result divided by 8.33 lb/gal to obtain the usable water volume in gallons.

Chapter 17 Fire Apparatus — Water Tanks (NFPA 1901/1906)

17.1 Application. If the fire apparatus is equipped with a water tank, the provisions of this chapter shall apply.

17.2 Tank Construction.

17.2.1 All water tanks shall be constructed of noncorrosive material or other materials that are protected against corrosion and deterioration.

17.2.2 Water tanks exposed to sunlight shall be opaque to prevent light from entering, with the exception of the water level visual indicator panel, if equipped.

17.2.3* The water tanks shall have a means to permit flushing of the tank.

17.2.4* If the water tank is independent of the body and compartments, it shall be equipped with a method for removing the tank(s) from the chassis.

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

17.2.6* All water tanks shall be provided with baffles or swash partitions to form containment cells or dynamic water movement control.

17.2.6.1 If a containment method of baffling is used, the baffles shall meet the requirements of 17.2.6.1.1 through 17.2.6.1.4.

17.2.6.1.1 At least one baffle running longitudinal to the axis of the apparatus shall be provided in all water tanks.

17.2.6.1.2 At least one transverse baffle shall be provided in tanks of 100 gal (380 L) or more.

17.2.6.1.3 There shall be a maximum distance of 51 in. (1295 mm) between any combination of tank vertical walls and baffles or between parallel baffles.

17.2.6.1.4 Each baffle shall cover at least 75 percent of the area of the plane that contains the baffle.

17.2.6.2 If a dynamic method of partitioning is used, the baffles shall meet the requirements of 17.2.6.2.1 through 17.2.6.2.4.

17.2.6.2.1 The tank shall contain vertical transverse and longitudinal partitions.

17.2.6.2.2 The vertical partitions shall be secured to the top and bottom of the tank.

17.2.6.2.3 The longitudinal partitions shall extend a minimum of 75 percent of the tank length.

17.2.6.2.4 The partitions shall be arranged in such a manner that the vertical plane of each partition shall create cells no dimension of which shall exceed 48 in. (1220 mm).

17.2.7 Cleanout Sumps.

17.2.7.1 If the water tank is greater than 500 gal (2000 L) or in a structural fire apparatus, one or more cleanout sumps shall be provided.

17.2.7.2 A means of access 3 in. (75 mm) diameter or larger shall be furnished for each sump to facilitate cleaning.

17.2.7.3 If the sump is used for the tank-to-pump line connection, the design shall prevent sludge or debris in the sump from entering the pump.

17.2.8 Water Level Indicator.

17.2.8.1 An indicator shall be provided that shows the level or amount of water in the tank(s).

17.2.8.2 If the apparatus is not equipped with a pump, the indicator shall be visible at the inlet valve position.

17.3 Tank-to-Pump Intake Line.

17.3.1 If the apparatus is equipped with a pump, the water tank shall be connected to the intake side of the pump with a valve controlled at the pump operator's position.

17.3.2 Tank-to-Pump Flow Rate. The flow required by 17.3.2.1 and 17.3.2.3 shall be sustainable while pumping a minimum of 80 percent of the certified tank capacity with the apparatus on level ground.

17.3.2.1 If the water tank on a structural fire apparatus has a certified capacity of less than 500 gal (2000 L), the piping and valve arrangement shall be capable of delivering water to the pump at a minimum rate of 250 gpm (1000 L/min).

17.3.2.2 If the water tank on a structural fire apparatus has a certified capacity of 500 gal (2000 L) or greater, the piping and valve arrangement shall be capable of delivering water to the pump at a minimum rate of 500 gpm (2000 L/min) or the rated capacity of the pump, whichever is less.

17.3.2.3 On wildland fire apparatus, the piping and valve arrangement shall be capable of flowing water from the tank at the rated capacity of the pump up to 250 gpm (1000 L/min).

17.3.3* On all structural fire apparatus or wildland fire apparatus with a pump rating greater than 500 gpm (2000 L/min), an automatic means shall be provided in the tank-to-pump line that prevents unintentional backfilling of the water tank through that line.

17.3.4 Connections or outlets from the tank(s) to the pump shall be designed to prevent air from being entrained while pumping water from the tank.

17.4 Filling and Venting.

17.4.1* Fill Opening. A readily accessible, covered fill opening designed to prevent spillage shall be provided.

17.4.1.1* The fill opening shall have a minimum inside diameter of 3¼ in. (83 mm).

17.4.1.2 The cover shall be marked with a label that reads "Water Fill."

17.4.1.3 A screen that is easily removed and cleaned shall be installed in the opening.

17.4.1.4* The cover or another device shall open as a vent to release pressure buildup in the tank.

17.4.2 Vent/Overflow Outlet.

17.4.2.1 Size.

17.4.2.1.1* On structural fire apparatus, a vent/overflow outlet that is sized to allow water to be drawn from the tank at a rate at least equal to that required in 17.3.2 shall be provided.

17.4.2.1.2 On wildland fire apparatus, a vent/overflow outlet that is sized to allow water to be drawn from the tank at a rate at least equal to the rated capacity of the pump or 250 gpm (1000 L/min), whichever is lower, shall be provided.

17.4.2.2 Discharge.

17.4.2.2.1* On structural fire apparatus, the vent/overflow outlet shall be designed to direct any water to behind the rear axle so as not to interfere with rear tire traction.

17.4.2.2.2 On wildland fire apparatus, the tank vent/overflow pipe shall be positioned to discharge any liquid overflow not less than 12 in. (30.5 cm) behind the centerline of the rear axle.

17.4.3 Tank Fill Line. If the apparatus is equipped with a pump, a valved tank fill line shall be provided.

17.4.3.1* Where the water tank on a structural fire apparatus has a capacity of 1000 gal (4000 L) or less, the tank fill line shall be at least 1 in. (25 mm) nominal inside diameter.

17.4.3.2* Where the water tank on a structural fire apparatus has a capacity greater than 1000 gal (4000 L), the fill line shall be at least 2 in. (52 mm) nominal inside diameter.

17.4.3.3* The tank fill line on wildland fire apparatus shall be sized in accordance with Table 17.4.3.3.

17.4.3.4* The valve shall be capable of regulating flow.

17.4.3.5 The valve shall be controllable from the pump operator's position.

17.5 Mobile Water Supply Apparatus. If the apparatus is designed to be a mobile water supply apparatus, the requirements of this section shall apply.

17.5.1 External Fill. An external fill connection leading directly to the tank shall be provided.

17.5.1.1* The external fill connection shall permit a minimum filling rate of 1000 gpm (4000 L/min) from sources external to the unit.

17.5.1.2 The external fill connection shall be provided with a removable or accessible strainer; a shutoff valve capable of being throttled, a minimum 30-degree sweep elbow positioned downward, and a closure cap or plug.

17.5.1.3 Any 3 in. (75 mm) or larger valve shall be a slow-operating valve.

Table 17.4.3.3 Size of Wildland Fire Apparatus Tank Fill Line (Pump to Tank)

Pump Size		Tank Size					
		250 gal or less (950 L or less)		251 gal to 999 gal (951 L to 3784 L)		1000 gal or more (3785 L or more)	
		in.	mm	in.	mm	in.	mm
50 or less	190 or less	¾	20	1	25	1	25
51–199	191–753	1	25	1½	40	1½	40
200 or greater	754 or greater	1½	40	1½	40	2	50

17.5.1.4 A check-type device shall be permitted to be substituted for the modulating and slow-operating valve in those operations where the flow rate is to be controlled at the source.

17.5.2* Water Transfer. Single or multiple tank connections that meet the requirements of 17.5.2.1 and 17.5.2.2 shall be provided.

17.5.2.1 The tank connection(s) shall be capable of allowing water to be transferred from the tank to an external use to the right, left, and rear of the fire apparatus.

17.5.2.2* Each tank connection shall be capable of emptying 90 percent of the tank capacity at a minimum average rate of 1000 gpm (4000 L/min) with the apparatus on level ground.

17.6 Water Tank Capacity Certification.

17.6.1* The manufacturer shall certify the capacity of the water tank prior to delivery of the apparatus.

17.6.2 The certified capacity shall be recorded on the manufacturer's record of construction (*see 7.21.1*), and the certification shall be delivered with the fire apparatus.

Chapter 18 Fire Apparatus — Foam Proportioning Systems (NFPA 1901/1906)

18.1 Application.

18.1.1* If the fire apparatus is equipped with a proportioning system for foam or other water additives, it shall comply with the applicable sections of this chapter.

18.1.2 References in this chapter to foam proportioning systems shall include systems to proportion all water additives.

18.2* Requirements by Type of Foam Proportioning System.

18.2.1* Eductor System. An eductor foam proportioning system shall meet the requirements of 18.3.1 through 18.3.7, 18.3.9, and Sections 18.4 through 18.6 and 18.9 through 18.11.

18.2.2* Self-Educting Master Stream Nozzle. A self-educting master stream nozzle shall meet the requirements of Sections 18.3, 18.4, 18.6, and 18.9 through 18.11.

18.2.3* Intake-Side System. An intake-side foam proportioning system shall meet the requirements of Sections 18.3 through 18.6 and 18.9 through 18.11.

18.2.4* Around-the-Pump System. An around-the-pump foam proportioning system shall meet the requirements of Sections 18.3 through 18.6 and 18.9 through 18.11.

18.2.5* Balanced Pressure System. A balanced pressure foam proportioning system shall meet the requirements of Sections 18.3 through 18.11.

18.2.6* Direct Injection System. A direct injection foam proportioning system shall meet the requirements of Sections 18.3 through 18.7 and 18.9 through 18.11.

18.2.7* Water-Powered Direct Injection Foam Proportioning System. A water motor or water turbine foam proportioning system shall meet the requirements of Sections 18.3 through 18.7 and 18.9 through 18.11.

18.3 Design and Performance Requirements of a Foam Proportioning System.

18.3.1* The foam proportioning system shall be capable of proportioning foam concentrate(s) in accordance with the foam concentrate manufacturer's recommendations for the type of foam concentrate used in the system over the system's design range of flow and pressures.

18.3.2 The purchaser shall specify the following:

- (1) Range of waterflows and pressures
- (2) Proportioning rates
- (3) Types of concentrate(s) (Class A, Class B, etc.)
- (4) Brand and viscosity of concentrate

18.3.3 The fire apparatus shall be capable of supplying the power required by the foam proportioning system in addition to the requirements of the other power-dependent systems installed on the apparatus.

18.3.4* Components of the foam proportioning system that are continuously wetted with foam concentrate shall be constructed of materials that will not be damaged in form, fit, or function when exposed to foam concentrates, including the adverse effects of corrosion, formation of harmful solids, deterioration of gaskets and seals, binding of moving parts, and deterioration of the foam concentrate caused by contact with incompatible materials.

18.3.5 The foam proportioning system components that can be flushed with water after use shall be constructed of materials that do not corrode after being flushed with water and allowed to dry. These components shall also be constructed of materials resistant to deterioration by foam concentrates.

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

18.3.7* Backflow.

18.3.7.1 A means shall be provided to prevent water backflow into the foam proportioning system and the foam concentrate storage tank.

18.3.7.2 On wildland fire apparatus, a means shall be provided to prevent foam solution backflow through the foam proportioning system into the water source.

18.3.8 A device that consists of a removable element that does not restrict the full flow capacity of the foam concentrate supply line shall be provided on the foam concentrate supply side of the foam proportioning system to prevent any debris that might affect the operation of the foam proportioning system from entering the system.

18.3.9 Flush Lines.

18.3.9.1 A flush line(s) shall be provided as required by the foam proportioning system manufacturer to flush foam concentrate from the system.

18.3.9.2 A means shall be provided in the flush line(s) to prevent water backflow into the foam concentrate tank or water tank during the flushing operation.

18.3.9.3 Where the foam proportioning system is connected to more than one foam concentrate storage tank, provisions shall be made to flush all common lines to avoid contamination of dissimilar foam concentrates.

18.3.10 Substitute Fluids.

18.3.10.1 A test connection shall be provided to allow use of substitute fluids when conducting the testing described in Section 18.11, except as provided in 18.3.10.2.

18.3.10.2 If the requirement in 18.3.10.1 cannot be met, a means shall be provided for testing the system that does not require flowing foam solution into the environment.

18.4 Controls for Foam Proportioning Systems.

18.4.1* The foam proportioning system operating controls shall be located at the pump operator's position and shall be identified as required by 18.9.2.

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

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

18.4.4 Foam proportioning systems that incorporate automatic proportioning features shall be equipped with controls that enable the operator to isolate the automatic feature and operate the system.

18.5 Foam Proportioning System Pressure Gauges, Flowmeters, and Indicators.

18.5.1 The displays of all pressure gauges or flowmeters and other indicators (e.g., fluid-level indicators) shall be located so that they are visible from the pump operator's position and shall meet the requirements of 7.11.3.

18.5.2 If an analog pressure gauge is used, it shall meet the requirements of 18.5.2.1 through 18.5.2.4.

18.5.2.1 The gauge shall have a minimum accuracy of Grade B as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

18.5.2.2 Numerals for master gauges shall be a minimum of $\frac{5}{32}$ in. (4 mm) high.

18.5.2.3 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa).

18.5.2.4 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; be freeze protected; and have internal mechanisms that are factory lubricated for the life of the gauge.

18.5.3 If digital pressure gauges are used, they shall meet the requirements of 18.5.3.1 through 18.5.3.3.

18.5.3.1 The digits shall be at least 0.25 in. (6.4 mm) high.

18.5.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

18.5.3.3 Digital pressure gauges shall have an accuracy of ± 3 percent over the full scale.

18.5.4 Each pressure gauge or flowmeter and its respective display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

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

18.6 Atmospheric Foam Concentrate Tank. If the foam proportioning system incorporates an atmospheric foam concentrate tank, the requirements of 18.6.1 through 18.6.12 shall apply.

18.6.1 The foam concentrate tank(s) shall be constructed of noncorrosive materials or other materials that are protected against corrosion or deterioration and that will not be adversely affected by the foam concentrate to be stored in the tank.

18.6.2 Swash Partitions.

18.6.2.1 All foam concentrate tanks shall be provided with swash partitions arranged such that the maximum dimension perpendicular to the plane of any partition shall not exceed 36 in. (900 mm).

18.6.2.2 The swash partition(s) shall extend from wall to wall and cover at least 75 percent of the area of the plane of the partition.

18.6.3 The foam concentrate tank shall be provided with a fill tower or expansion compartment having a minimum area of 12 in.² (7500 mm²) and having a volume of not less than 1 percent of the total tank volume.

18.6.3.1 The fill tower opening shall be protected by a completely sealed airtight cover.

18.6.3.2* The cover shall be attached to the fill tower by mechanical means.

18.6.3.3 The fill opening shall incorporate a removable screen with a mesh not to exceed 0.25 in. (6 mm).

18.6.3.4 The fill tower shall be arranged so that foam concentrate from a standard container (5 gal, or up to 25 L) can be poured directly into the tank without the use of funnels or other special devices.

18.6.4 The fill tower shall be equipped with a pressure/vacuum vent that enables the tank to compensate for changes in pressure or vacuum when filling or withdrawing foam concentrate from the tank.

18.6.4.1 The pressure/vacuum vent shall not allow atmospheric air to enter the foam tank except during operation or to compensate for thermal fluctuations.

18.6.4.2 The vent shall be protected to prevent foam concentrate from escaping or directly contacting the vent at any time.

18.6.4.3 The vent shall be of sufficient size to prevent tank damage during filling or foam withdrawal.

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

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

18.6.7 Tank Drain.

18.6.7.1 A minimum 1 in. (25 mm) inside diameter full flow drain valve and piping shall be provided at the lowest point of any foam concentrate tank.

18.6.7.2 The drain shall be piped to drain directly to the surface beneath the apparatus without contacting other body or chassis components.

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

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

18.6.10 Labels.

18.6.10.1 A label that reads "Foam Tank Fill" shall be placed at or near any foam concentrate tank fill opening.

18.6.10.2* A label that specifies the following shall be placed at or near any foam concentrate tank fill opening:

- (1) Type(s) of foam concentrate the system is designed to use
- (2) Any restrictions on the type of foam concentrate that can be used with the system
- (3) A warning message that reads "Warning: Do Not Mix Brands and Types of Foam"

18.6.11 The foam concentrate tank outlet connection shall be designed and located to prevent aeration of the foam concentrate and shall allow withdrawal of 80 percent of the foam concentrate tank storage capacity under all operating conditions with the fire apparatus on level ground.

18.6.12* Tank Inlet.

18.6.12.1 A minimum 0.75 in. (20 mm) inside-diameter full-flow inlet valve and piping shall be provided to any foam concentrate tank.

18.6.12.2 The foam concentrate tank inlet connection shall prevent aeration of the foam concentrate under all operating conditions.

18.7* Foam Concentrate Pump. If the foam proportioning system is equipped with a foam concentrate pump, the requirements of 18.7.1 through 18.7.5 shall apply.

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

18.7.2* The materials of construction for the foam concentrate pump shall be corrosion resistant and compatible with the type of foam concentrate(s) listed on the label required in 18.9.3.

18.7.3 Drivetrain components that transmit power to the foam concentrate pump shall be in accordance with the fire apparatus manufacturer's design performance provided on the label required in 18.9.3.

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

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

18.8 Pressure Vessel Foam Concentrate or Foam Solution Tanks. If the foam proportioning system incorporates a pressure vessel foam concentrate tank, or the foam solution is contained in a pressure vessel, the requirements of 18.8.1 through 18.8.8 shall apply.

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

18.8.2 Foam proportioning system piping and components shall be designed to withstand a minimum of 1½ times the maximum working pressure of the pressure vessel and shall be tested to the working pressure of the pressure vessel after installation.

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

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

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

18.8.4.2 Special wrenches or tools required to tighten the fill cap shall be supplied by the manufacturer and shall be mounted adjacent to the fill cap.

18.8.4.3 A safety vent hole shall be located in the fill cap so that it vents the tank pressure while at least 3½ threads remain engaged.

18.8.5 A minimum ½ in. (13 mm) manually operated valved vent shall be provided on all pressure vessel tanks.

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

18.8.7 A minimum 1 in. (25 mm) inside diameter full flow drain valve and piping shall be provided on all pressure vessel tanks.

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

18.9 Labels and Instruction Plates.

18.9.1 An instruction plate shall be provided for the foam proportioning system that includes, at a minimum, a piping schematic of the system and basic operating instructions.

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

18.9.3 A label located at the operator's position shall provide the following information pertaining to the performance operating specifications of the foam proportioning system:

- (1) Foam classification type
- (2) Maximum and minimum proportioning rates (percent)
- (3) Maximum and minimum waterflow [gpm (L/min)]
- (4) Maximum and minimum operating pressures
- (5)* The statement "Use only concentrates that are compatible with this foam proportioning system. Refer to the foam proportioning system manufacturer's operating manual."

18.9.3.1 If an in-line eductor system is provided on the apparatus, the following information shall also be provided on the plate:

- (1) Maximum hose length using 1½ in., 1¾ in., and 2 in. (38 mm, 45 mm, and 52 mm) hose
- (2) Allowable elevation changes
- (3) The statement "The flow rate of the nozzle must match the flow rate of the system."

18.9.3.2 If an around-the-pump system is provided on the apparatus, the following information shall also be provided on the plate:

- (1) Maximum intake pressure or required intake to discharge pressure differential
- (2) A table to indicate flow rate and the corresponding metering valve setting

18.9.4 Operations and Maintenance Manual.

18.9.4.1 Two copies of an operations and maintenance manual shall be provided.

18.9.4.2 The manual shall include a complete diagram of the system, operating instructions, system foam concentrate capabilities, original system calibration, and details outlining all recommended maintenance procedures.

18.10* Foam Proportioning System Accuracy.

18.10.1* The foam proportioning system shall be type tested and certified by the foam proportioning system manufacturer to be accurate throughout the foam proportioning system's declared range of waterflow, water pressure, foam percentage

(or foam proportioning system capacity), and concentrate viscosity.

18.10.1.1 At a minimum, this declaration shall include the test points listed in Table 18.10.1.1.

18.10.1.2* Calibration at midrange shall be established by the foam proportioning system manufacturer.

18.10.1.3 When testing to the maximum for waterflow and foam percentage or foam proportioning system capacity, the test shall be at the limits of the foam proportioning system or the water pump, whichever is more restrictive.

18.10.2 Systems designed to produce foam solution at ratios of less than 1 percent shall proportion foam concentrate to an accuracy of -0/+40 percent.

18.10.3 Systems designed to produce foam solution at ratios of 1 percent or greater shall proportion foam concentrate to an accuracy of -0/+30 percent or 1 percentage point, whichever is less.

18.10.4 The foam proportioning system manufacturer shall provide the certification required by Section 18.10 to the final-stage apparatus manufacturer.

18.10.4.1 The certification shall include the foam proportioning system manufacturer's viscosity performance specifications.

18.10.4.2 The final-stage apparatus manufacturer shall deliver a copy of the certification with the fire apparatus.

18.11 Testing and Documentation.

18.11.1 The final installer shall test and certify the following:

- (1) The foam proportioning system, as installed, complies with the foam equipment manufacturer's installation recommendations.
- (2)* The foam proportioning system has been calibrated and tested to meet the foam equipment manufacturer's and the purchaser's performance specifications.
- (3)* At a minimum, the foam proportioning system has been tested at the points defined in Table 18.11.1 for each foam system injection point.

18.11.2 The final installer shall deliver documentation with the fire apparatus declaring the foam proportioning system as installed meets the requirements of 18.10.2 or 18.10.3 across the foam proportioning system manufacturer's declared range of waterflow, water pressure, foam percentage (or foam proportioning system capacity), and concentrate viscosity at the test points defined in Table 18.11.1.

Table 18.10.1.1 Test Points for Certification of Foam Proportioning System Performance

Waterflow	Water Pressure	Foam Percentage or Foam Proportioning System Capacity
Minimum	Minimum	Minimum
Maximum	Maximum	Maximum*
Minimum	Maximum	Minimum
Maximum	Minimum	Maximum
Midrange	Midrange	Midrange†

* See 18.10.1.3.

† See 18.10.1.2.

Table 18.11.1 Test Points for Installation Testing of Foam Proportioning System Performance

Waterflow	Water Pressure	Foam Percentage or Foam Proportioning System Capacity
Minimum	Minimum	Minimum
Maximum	Maximum	Maximum*
Midrange	Midrange	Midrange†

* See 18.10.1.3.

† See 18.10.1.2

Chapter 19 Fire Apparatus — Compressed Air Foam Systems (CAFS) (NFPA 1901/1906)

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

19.2 General Requirements.

19.2.1 An automatic regulating foam proportioning system shall be used and shall comply with the applicable requirements of Chapter 18.

19.2.2 The total CAFS rating shall be expressed in terms of airflow and waterflow.

19.2.2.1* The airflow shall be expressed in standard cubic feet per minute (SCFM) [standard cubic meters per minute (SCMM)] and shall be based on the continuous flow capacity of the compressed air source(s) at a minimum gauge pressure of 125 psi (862 kPa).

19.2.2.2 The waterflow shall be expressed in gallons per minute (gpm) [liters per minute (L/min)] at a gauge pressure of 125 psi (862 kPa).

19.2.3 The fire apparatus shall be capable of supplying power for operating the CAFS at its rated capacity while simultaneously providing power to all other power-dependent systems installed on the apparatus.

19.2.4 On a CAFS, the air pressures shall be automatically balanced to the water pressure to within -0/+10 percent throughout the operational range of the CAFS.

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

19.3 Compressed Air System.

19.3.1 The compressed air system operating in clean environmental conditions shall be designed to provide a continuous rated air supply for a duration of 6 hours without needing adjustment, additional lubrication, or air filters changed.

19.3.2 Relief Valve.

19.3.2.1 The compressed air system shall be equipped with a relief valve that is set to prevent the compressed air system from exceeding 110 percent of the maximum allowable working pressure of the system.

19.3.2.2 The outlet of the relief valve shall be routed to an area that does not expose personnel to air blasts or cause the creation of dust.

19.3.3 If the possibility exists for moisture to build up in the compressed air system, the system shall be equipped with moisture traps and drains.

19.3.4 If an air receiver or holding, surge, or separator tank is provided and is 6 in. (150 mm) nominal pipe size or less, the tank shall be subjected to a hydrostatic test to a gauge pressure of 500 psi (3400 kPa) for a minimum of 10 minutes.

19.3.4.1 The tank manufacturer shall provide a certificate of completion for the hydrostatic test.

19.3.4.2 For air receiver or holding, surge, or separator tanks larger than 6 in. (150 mm) nominal pipe size, the tank shall be designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the maximum working pressure.

19.3.4.3 Transportable air tanks shall comply with 49 CFR 178.37, "Specification 3AA and 3AAX seamless steel cylinders," or 29 CFR 1910.169.

19.3.4.4 Relief valves on transportable air tanks shall be of the ASME type on ASME cylinders and of the DOT type on DOT cylinders or equal for the rated pressure.

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

19.3.4.6 If the installation utilizes cylinders that require periodic testing, a label shall be placed on the operator's panel indicating the test date stamped on the cylinders and the date the cylinders will next require testing.

19.4* Air Mixing.

19.4.1 An automatic means shall be provided to prevent the backflow of water or foam solution into the compressed air system or of air into the water pump or the foam proportioning equipment.

19.4.2* A means of mixing air and foam solution that provides for a homogeneous mixture of compressed air and foam solution shall be provided on the CAFS.

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

19.6 Air System Controls.

19.6.1 All compressed air system controls shall be both located on the pump operator's panel and identified with an instruction plate in accordance with the requirements of 19.8.1.

19.6.2 Compressed air systems that require flushing after use shall be provided with controls that are accessible to the operator and enable the operator to completely flush the system with water according to the manufacturer's instructions.

19.7 Foam System Pressure Gauges, Flowmeters, and Indicators.

19.7.1 The displays of all pressure gauges, flowmeters, and indicators (e.g., fluid level indicators) shall be located so they are visible from the pump operator's position and shall meet the requirements of 7.11.3.

19.7.2 Where analog pressure gauges are used, they shall meet the requirements of 19.7.2.1 through 19.7.2.4.

19.7.2.1 Analog pressure gauges shall have a minimum accuracy of Grade B as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

19.7.2.2 Numerals for master gauges shall be a minimum of $\frac{5}{32}$ in. (4 mm) high.

19.7.2.3 There shall be graduation lines showing at least every 10 psi (50 kPa), with major and intermediate graduation lines emphasized and figures at least every 100 psi (500 kPa).

19.7.2.4 Analog pressure gauges shall be vibration and pressure pulsation dampened; be resistant to corrosion, condensation, and shock; and have internal mechanisms that are factory lubricated for the life of the gauge.

19.7.3 If digital pressure gauges are used, they shall meet the requirements of 19.7.3.1 through 19.7.3.3.

19.7.3.1 The digits shall be at least 0.25 in. (6.4 mm) high.

19.7.3.2 Digital pressure gauges shall display pressure in increments of not more than 10 psi (50 kPa).

19.7.3.3 Digital pressure gauges shall have an accuracy of ± 3 percent over the full scale.

19.7.4 Each pressure gauge and flowmeter and its display shall be mounted and attached so it is protected from accidental damage and excessive vibration.

19.7.5* If flowmeters are provided, they shall meet the requirements of 19.7.5.1 and 19.7.5.2.

19.7.5.1 Flowmeter displays shall indicate the airflow in standard cubic feet per minute (SCFM) [standard cubic meters per minute (SCMM)] and indicate the waterflow in gallons per minute (gpm) [liters per minute (L/min)].

19.7.5.2 Flowmeters shall be rated to a hydrostatic burst gauge pressure of 500 psi (3400 kPa) if located on the pressure side of the system.

19.7.6 A pressure gauge shall be provided for the compressed air system.

19.8 Labels and Instruction Plates.

19.8.1 An instruction plate indicating the identification, function, and operation shall be provided for each control, gauge, and indicator required to operate the CAFS.

19.8.2 A label shall be provided that is visible from the pump operator's position that gives the rated continuous flow capacity of the compressed air system at a gauge pressure of 125 psi (862 kPa).

19.8.3 An instruction plate shall be provided that is visible from the pump operator's position and states the following:

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

19.8.4 Operations and Maintenance Manual.

19.8.4.1 Two copies of an operations and maintenance manual shall be provided.

19.8.4.2 The manual shall include a complete diagram of CAFS, operating instructions, the system rating, and details outlining all recommended maintenance procedures.

19.9* Manufacturer's Predelivery Tests. The manufacturer shall conduct the tests in 19.9.1 and 19.9.2 prior to delivery of the fire apparatus and deliver documentation of the test results with the fire apparatus.

19.9.1 CAFS Capacity Rating Test.

19.9.1.1 The operation of the water pump and the compressed air source shall be tested simultaneously to determine the integrity of the system and to ensure that the power available is capable of operating these components of CAFS simultaneously.

19.9.1.1.1* The compressed air system shall be operated at its flow capacity at a minimum gauge pressure of 125 psi (862 kPa), and the water pump shall discharge a minimum of 2 gpm of water at 125 psi net pump pressure for every 1 SCFM (250 L/min of water at 862 kPa net pump pressure for every 1 SCMM) of compressed air discharge.

19.9.1.1.2 The discharge shall be through at least two separate discharge openings, one discharging air only and the other discharging water only.

19.9.1.2 One or more lines of fire hose of sufficient diameter shall be provided to allow discharge of the required amount of water from the pump to a nozzle or other flow-measuring equipment without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) [approximately 500 gpm (2000 L/min) for 2½ in. (65 mm) hose].

19.9.1.2.1 The discharge shall be measured using a smooth-bore nozzle and pitot tube or other equipment such as flowmeters, volumetric tanks, or weigh tanks.

19.9.1.2.2 Test gauges shall meet the requirements of 13.13.2.2.4 and 13.13.2.2.5.

19.9.1.3 The airflow rate shall be measured using a pressure and temperature compensated flow-measuring device.

19.9.1.3.1 The airflow shall be measured in standard cubic feet per minute (SCFM) [standard cubic meters per minute (SCMM)] at a minimum gauge pressure of 125 psi (862 kPa).

19.9.1.3.2 The airflow-measuring device shall have been calibrated for accuracy within the previous 3 months.

19.9.1.3.3* The air discharge outlet shall have nothing attached directly to it except the test device(s).

19.9.1.4 The water pump and the compressed air system shall be started, and the rated flows and pressures as specified in 19.9.1.1.1 shall be established and maintained.

19.9.1.4.1 The system shall be run for 1 hour.

19.9.1.4.2 Readings of the airflow rate and pressure and the water pump pressure and discharge rate shall be taken at least every 10 minutes.

19.9.1.5 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.

19.9.2 Standby Run Test.

19.9.2.1 One 200 ft (60 m) line of 1½ in. (38 mm) hose shall be connected to the discharge of the CAFS and shall be stretched out on level ground.

19.9.2.2 A quarter-turn valve of the same nominal size as the hose shall be installed at the discharge end.

19.9.2.3 The hose shall be restrained immediately behind the valve at the discharge end to prevent uncontrolled movement when the valve is opened.

19.9.2.4 Operating as a CAFS, with a gauge pressure air output at 125 psi (862 kPa), a foam flow shall be established in the hose line.

19.9.2.5 With the water tank at the half-full level, the valve at the discharge end of the hose shall be shut no faster than in 3 seconds and no slower than in 10 seconds.

19.9.2.6 The engine's speed shall be maintained for 10 minutes without discharging water, air, or foam solution from the CAFS and without operator intervention.

19.9.2.7 A bypass line shall be permitted to be opened temporarily, if needed, to keep the water temperature in the pump within acceptable limits.

19.9.2.8 At the end of 10 minutes, the valve shall be reopened no faster than in 3 seconds and no slower than in 10 seconds.

19.9.2.9 Damage to the CAFS that affects its rated performance characteristics or the lack of a fire stream immediately upon opening the hose line shall constitute failure of this test.

Chapter 20 Fire Apparatus — Aerial Devices (NFPA 1901)

20.1* General Requirements.

20.1.1 If the apparatus is equipped with an aerial ladder, the aerial device and apparatus shall meet the requirements of Sections 20.2 through 20.13 and Sections 20.24 through 20.32.

20.1.2 If the apparatus is equipped with an elevating platform, the aerial device and apparatus shall meet the requirements of Sections 20.14 through 20.19 and Sections 20.24 through 20.32.

20.1.3 If the apparatus is equipped with a water tower, the aerial device and apparatus shall meet the requirements of Sections 20.20 through 20.32.

20.2 Aerial Ladder Requirements.

20.2.1 The aerial ladder shall consist of two or more ladder sections that, together with the steps and platforms on the apparatus body, provide continuous egress for firefighters and civilians from an elevated position to the ground.

20.2.2 Device Ratings and Performance.

20.2.2.1 The rated vertical height of an aerial ladder shall be both of the following:

- (1) At least 50 ft (15 m)
- (2) Measured vertically with the ladder at maximum elevation and extension from the outermost rung of the outermost fly section to the ground

20.2.2.2* The rated horizontal reach of an aerial ladder shall be measured in a horizontal plane from the centerline of the turntable rotation to the outermost rung on the outermost fly section with the aerial ladder extended to its maximum horizontal reach.

20.2.2.3 Height and reach dimensions shall be taken with the aerial ladder mounted on a chassis meeting the aerial manufacturer's minimum recommended fire apparatus specifications, with the fire apparatus on level ground, and with the stabilizers fully deployed.

20.2.2.4 With the stabilizers set, the aerial ladder shall be capable of being raised using any combination of control functions from the bedded position to maximum elevation and extension and rotated 90 degrees within either of the following time limits:

- (1) 120 seconds if the aerial ladder has a rated vertical height of 110 ft (34 m) or less
- (2) 180 seconds if the aerial ladder has a rated vertical height over 110 ft (34 m)

20.3 Rungs.

20.3.1 Ladder rungs shall be equally spaced on a maximum 14 in. (350 mm) centers and minimum 11¼ in. (300 mm) centers.

20.3.2 Ladder rungs shall have a skid-resistant surface or covering.

20.3.3 Where covering is provided, it shall comply with both of the following:

- (1) The covering shall not twist.
- (2) The covering shall cover at least 60 percent of the length of each rung.

20.3.4 Where round rungs are furnished, the rungs shall have a minimum outside diameter of 1¼ in. (32 mm), including the skid-resistant surface or covering.

20.3.5 Where rungs other than round are furnished, they shall have a cross-sectional area not less than 1.2 in.² (775 mm²); a maximum outside dimension of the cross-sectional area (height or width) of 3.2 in. (81 mm), including the skid-resistant surface or covering; and a minimum outside dimension of ¾ in. (19 mm), including the skid-resistant surface or covering.

20.3.6 The minimum design load for each rung shall be 500 lb (227 kg) distributed over a 3½ in. (89 mm) wide area at the center of the length of the rung with the rung oriented in its weakest position.

20.4 Ladder Handrails.

20.4.1 Top handrails shall be provided on the ladder having a minimum width of 1 in. (25 mm).

20.4.2 Top handrails shall be at a minimum height of 12 in. (300 mm) above the centerline of the rungs, excluding the outermost two rungs of the outermost fly section.

20.4.3 There shall be a minimum of 18 in. (460 mm) in width inside the aerial ladder between the rails measured at the narrowest point, excluding any mounted equipment.

20.5 Secondary Operator Steps.

20.5.1 Two folding steps with surfaces that meet the slip-resistant requirements of 12.6.4 shall be provided on the ladder for use by the ladder-pipe-monitor operator.

20.5.2 Each folding step shall comply with both of the following:

- (1) Have a minimum design load of 500 lb (227 kg)
- (2) Be a minimum of 35 in.² (22,500 mm²) in area

20.5.3 A single step that has a minimum design load of 500 lb (227 kg) and a minimum area of 100 in.² (65,000 mm²) shall be permitted to be used in place of the two steps.

20.6 Fall Protection Anchors.

20.6.1 Provisions shall be made so that personnel working on the ladder can attach fall protection harnesses.

20.6.2 Provisions shall include structural components of the ladder such as rungs or lacing.

20.7 Obstructions Below the Ladder.

20.7.1 Where a solid obstruction below the ladder is wider than 12 in. (300 mm), a minimum clearance of 7 in. (180 mm) between the centerline of the rung and the obstruction shall be provided.

20.7.2 Where the solid obstruction below the centerline of the ladder is 12 in. (300 mm) or less in width, the standoff between the centerline of the rung and the obstruction shall be permitted to be less than 7 in. (180 mm), provided there is at least 6 in. (150 mm) of rung width and 7 in. (180 mm) of depth below the centerline of the rung on each side of the obstruction.

20.8 Access Provisions.

20.8.1 The apparatus shall be equipped with steps that meet the skid resistance requirements of 12.6.4 or with rungs that provide a path at any degree of elevation from the bottom rung of the aerial ladder to the ground.

20.8.1.1 Steps, with the exception of the ground to the first step, shall be spaced on no more than 18 in. (460 mm) centers.

20.8.1.2 Handrails shall be provided within reach at each step location.

20.9 Breathing Air System.

20.9.1 If a secondary operator's position is provided, the breathing air system shall provide air for a minimum of one person at the secondary operator's position.

20.9.2 If a secondary operator's position is provided, the purchaser shall specify where on the aerial device the air supply outlet is to be located.

20.9.3 The breathing air system shall include storage for at least 200 ft³ (5660 L) of breathing air.

20.9.4 The breathing air system shall meet the requirements of Sections 20.10 and 23.5.

20.10 Aerial Device General Breathing Air System Requirements.

20.10.1 Holders shall be provided for the storage of the breathing air equipment when it is not in use.

20.10.2 A low-air warning system shall be provided that will monitor the air volume and provide an audible and visual warning at both the upper and lower control stations when the air volume is at or below 20 percent.

20.10.3 The quality of the breathing air shall meet the requirements of NFPA 1989.

20.10.4 All components of the system that the breathing air will be in contact with shall be cleaned of oil, grease, contaminants, and foreign material.

20.10.5 All components of the piping system shall be designed for a pressure rating of three times the working pressure that they are expected to carry.

20.10.6 The piping system shall be arranged with a high-pressure regulator at the air supply that limits the air pressure in the piping up to the aerial device to the pressure required to supply 125 psi (862 kPa) at the outlet point.

20.10.7 All piping, valves, and components shall be both of the following:

- (1) Fabricated of corrosion-resistant materials
- (2) Sized for the number of outlets provided at the secondary aerial ladder operator's position

20.10.8 A pressure relief valve set to relieve the pressure at 1 ½ times the working pressure of the piping system in the event of regulator failure shall be provided on the downstream side of the high-pressure regulator.

20.10.9 All valves, pressure regulators, and gauges shall be protected from accidental damage.

20.10.10 The piping or hose system between the air cylinder(s) and the secondary aerial ladder operator's position shall be installed so as to prevent damage due to abrasion, bending, pinching, or exposure to excessive heat.

20.11 Aerial Ladder Operating Position.

20.11.1 Indicating devices that are lighted and marked with a label shall be visible from the operator's position and shall indicate the following:

- (1) That the rungs are aligned for climbing
- (2) That the aerial ladder is aligned with the travel bed

20.11.2 A system that is lighted and marked with labels shall be visible from the operator's position to indicate the elevation, extension, and rated capacities.

20.11.3 Voice Communication System.

20.11.3.1* A weather-resistant two-way voice communication system shall be provided between the aerial ladder operator's position and the tip of the ladder.

20.11.3.2 The speaker/microphone at the tip shall allow for hands-free operation.

20.12 Aerial Ladder Operating Mechanisms.

20.12.1 Elevation. A power-operated system for elevating and lowering the aerial ladder under all the rated conditions of loading shall be provided.

20.12.1.1 Where hydraulic components are utilized, they shall meet the requirements of Section 20.26 and shall be designed to prevent damage at the top and bottom limits.

20.12.1.2 An automatic locking device(s) shall be provided so that the desired elevated position can be maintained.

20.12.1.3 A locking device shall be provided that will retain the aerial ladder in the bed when the fire apparatus is in motion.

20.12.2 Rotation. A power-operated turntable shall be provided that will allow continuous rotation in either direction under all the rated conditions of loading.

20.12.2.1* The turntable rotation bearing shall be accessible for lubrication and torque verification of bolts.

20.12.2.2 The turntable rotation mechanism shall be equipped with an automatically applied brake or self-locking drive that provides sufficient braking capacity when all power systems are nonfunctioning, to prevent turntable rotation under all rated conditions of loading.

20.12.3 Extension. A power-operated system for extending and retracting the fly section(s) under all rated conditions of loading shall be provided.

20.12.3.1 Where hydraulic components are utilized, they shall meet the requirements of Section 20.26.

20.12.3.2 An automatic locking device shall be provided so that the desired position of extension can be maintained.

20.12.3.3 Rollers, pulleys, and roller guides shall be equipped with self-lubricating bearings or readily accessible grease fittings.

20.12.3.4 Slide pads, rollers, and bearings, when used, shall be readily accessible for replacement.

20.12.3.5 When wire ropes or chains are used to extend the ladder sections, the system shall be redundant with a minimum of two wire ropes or chains used per ladder section.

20.12.3.6 A means shall be provided to prevent damage to the extension system at full retraction or full extension.

20.12.4* Secondary Operator's Position. If a secondary aerial ladder operator's position is located at the tip of the outermost fly section, the following shall apply:

- (1) The lower control shall override the aerial tip control station.
- (2) The lower control station shall have a momentary switch that enables the tip controls when closed and disables the tip controls when opened or released.
- (3) The maximum speed of the ladder functions measured at the tip shall be as follows when operated from the tip control station:
 - (a) Rotation at 2 ft/sec (0.6 m/sec), when fully extended at 0 degrees elevation
 - (b) Elevation and lowering at 1 ft/sec (0.3 m/sec)
 - (c) Extension and retraction at 0.5 ft/sec (0.15 m/sec)
- (4) The step(s) for the tip operator shall be designed to keep the operator's feet from protruding through the outermost fly section.

20.13* Aerial Ladder Water Delivery System. Where a pre-piped waterway is provided, 20.13.1 through 20.13.10 shall apply.

20.13.1 The waterway system shall be capable of flowing 1000 gpm (4000 L/min) at 100 psi (700 kPa) nozzle pressure at full elevation and extension.

20.13.2 For ladders with a rated vertical height of 110 ft (34 m) or less, the friction loss (total system loss less head loss) between the monitor outlet and a point below the waterway swivel shall not exceed 100 psi (700 kPa) at 1000 gpm (4000 L/min) flow with the ladder at full horizontal extension.

20.13.3 A preset relief valve that is capable of protecting the waterway system by relieving pressure through the dumping of water to the environment shall be provided.

20.13.3.1 Such dumping shall be through a system of piping terminating in an area away from the operator's position.

20.13.3.2 The discharge end of the piping shall not have a threaded connection.

20.13.4 A permanently attached monitor shall be provided.

20.13.4.1 The monitor shall be capable of swiveling at least 135 degrees from a line parallel to the ladder and down.

20.13.4.2 The monitor shall be capable of horizontal traverse at least 45 degrees from each side of center.

20.13.4.3 Positive stops shall be provided to prevent the swivel or traverse of the monitor from exceeding the aerial ladder manufacturer's recommendation.

20.13.4.4 If a power-operated monitor is provided, the primary controls shall be at the aerial operator's position, and those controls shall be capable of overriding all other monitor controls.

20.13.4.5* A permanently installed monitor/nozzle shall not obstruct access to or from the tip of the ladder.

20.13.4.6 For ladders that have a waterway design that allows the monitor to be connected to different ladder sections, a secondary means, not requiring operator intervention, shall be provided to prevent the monitor from being ejected from the ladder.

20.13.5 A 1000 gpm (4000 L/min) nozzle shall be furnished.

20.13.6* The water system shall be arranged so it can be supplied at ground level through an external inlet that is a minimum of 4 in. (100 mm) in size.

20.13.7 If the apparatus is equipped with a fire pump capable of supplying the required flow and pressure, a permanent valved connection shall be provided between the pump and the waterway system.

20.13.8 A flowmeter shall be installed in the waterway, with a display on either the pump operator's panel or the aerial ladder operator's control panel.

20.13.9* A 1½ in. (38 mm) minimum drain valve shall be provided at the low point of the waterway inlet system.

20.13.10 If the apparatus has a fire pump and normal operations are to supply the waterway through the pump, a cap meeting the requirements of 13.7.4 shall be provided on the external inlet.

20.14 Elevating Platform Requirements.

20.14.1 The elevating platform shall consist of an elevated tower of two or more booms or sections equipped with a passenger-carrying platform(s) assembly.

20.14.2 Device Ratings and Performance.

20.14.2.1 The rated vertical height of the elevating platform shall be measured vertically from the top surface of the platform handrail to the ground, with the platform raised to its position of maximum elevation.

20.14.2.2* The rated horizontal reach of the elevating platform shall be measured in a horizontal plane from the centerline of the turntable rotation to the outer edge of the platform handrail, with the elevating platform extended to its maximum horizontal reach.

20.14.2.3 Height and reach dimensions shall be measured with the elevating platforms mounted on a chassis meeting the elevating platform manufacturer's minimum recommended fire apparatus specifications, with the fire apparatus on level ground, and with the stabilizers fully deployed.

20.14.2.4 Where the rated vertical height of the elevated platform is 110 ft (34 m) or less, the elevating platform, with stabilizers set, shall be capable of being raised from the bedded position to maximum elevation and extension and rotated 90 degrees within 150 seconds.

20.14.2.5 Two or more of these functions shall be permitted to be performed simultaneously.

20.14.3 Platform Construction.

20.14.3.1 The platform shall have a minimum floor area of 14 ft² (1.3 m²).

20.14.3.2 A continuous guard railing, a minimum of 42 in. (1070 mm) high, shall be provided on all sides.

20.14.3.2.1 The continuous guard railing shall be capable of withstanding a force of 225 lbf (1000 N) applied at any point from any direction without permanent deformation.

20.14.3.2.2 The railing shall be constructed so there are no horizontal or vertical openings below it greater than 24 in. (610 mm) in either dimension.

20.14.3.2.3 There shall be a minimum of two gates providing access to the platform.

20.14.3.2.4 Each gate shall be provided with a self-engaging latch.

20.14.3.2.5 The use of a vertical opening or inward opening, self-closing gate or door for access to and from the platform shall be permitted to meet the continuous railing requirement.

20.14.3.2.6 Each gate shall be capable of withstanding a 1000 lb force (4000 N) applied at the least favorable position in the least favorable direction, without opening outward.

20.14.3.3 A kick plate of not less than 4 in. (100 mm) high shall be both of the following:

- (1) Provided around the floor
- (2) Permitted to swing with the gate

20.14.3.4 The steps and the floor of the platform shall be provided with skid-resistant surfaces that meet the requirements of 12.6.4.

20.14.3.5 Drain openings shall be provided to prevent water accumulation on the platform floor.

20.14.4* Fall Protection Anchors.

20.14.4.1 Provisions shall be made so that personnel working on the platform can attach fall protection harnesses.

20.14.4.2 At least one attachment point shall be provided for each 250 lb. (114 kg) load rating of the platform.

20.14.4.3 Anchorage points provided for fall protection harnesses shall be clearly labeled and rated for a minimum of 450 lb (205 kg).

20.14.4.4 Anchorage points shall withstand 450 lb (205 kg) of force perpendicular to the mounting surface without noticeable permanent deformation.

20.14.4.5* Anchorage points shall remain attached to the aerial structure after applying a force of 1800 lb (816 kg) perpendicular to the mounting surface.

20.14.4.6 Safety sign FAMA40 shall be located near each anchor point.

20.14.5 Heat Shield.

20.14.5.1 A heat-reflective shield shall be provided on the front, sides, and bottom of the platform.

20.14.5.2 If necessary, openings for the movement and operation of the water monitor shall be permitted in the front heat shield.

20.14.6 Water Curtain System.

20.14.6.1 A water curtain system capable of providing a cooling spray under the entire floor of the platform and flowing a minimum of 75 gpm (284 L/min) shall be provided.

20.14.6.2 The system shall be controlled by a single, quick-acting valve with an actuator accessible from the platform.

20.14.7 Breathing Air System.

20.14.7.1 Where a breathing air system is provided, it shall supply breathing air for a minimum of two persons on the platform.

20.14.7.2 The system shall comply with both of the following:

- (1) Include storage for at least 400 ft³ (11,320 L) of breathing air
- (2) Meet the requirements of Section 23.5

20.14.7.3 The breathing air system shall meet the requirements of Sections 20.10 and 23.5.

20.15 Elevating Platform Rated Capacity.

20.15.1 The rated capacity of the elevating platform shall be a minimum of 750 lb (340 kg), with no water in the water delivery system, with the elevating platform placed in the horizontal position at maximum horizontal extension, and with the stabilizers fully deployed.

20.15.2 The rated capacity of the elevating platform shall be a minimum of 500 lb (227 kg) with the water delivery system full of water but not discharging, with the elevating platform placed in the horizontal position at maximum horizontal extension, and with the stabilizers fully deployed.

20.15.3 The elevating platform shall be capable of operating in any position while carrying its rated capacity.

20.15.4 The elevating platform shall be capable of delivering a minimum of 1000 gpm (4000 L/min) from the platform with the booms or sections and the monitors and nozzles positioned in any configuration allowed by the manufacturer while carrying a minimum load of 500 lb (227 kg) on the platform.

20.15.5 All rated capacities shall be stated in increments of 250 lb (114 kg) and shall be in addition to any firefighting equipment installed on the elevating platform by the manufacturer.

20.15.6* If the elevating platform is rated in multiple configurations, the manufacturer shall describe these configurations, including the rated capacity at each operating position. This information shall be provided in the operations manual and on a capacity label or on an electronic display at the turntable and platform operator's control stations.

20.16 Elevating Platform Operating Positions.

20.16.1 There shall be two control stations, one to be known as the platform control station and the other as the lower control station.

20.16.1.1 All operational controls shall be operable from both of these positions.

20.16.1.2 The lower control station shall be located so as to facilitate the operator's observation of the platform while at the controls.

20.16.1.3 The lower station controls shall be capable of overriding the platform station controls.

20.16.2 Voice Communication System.

20.16.2.1* A weather-resistant two-way voice communication system shall be provided between the platform control station and the lower control station.

20.16.2.2 The speaker/microphone at the platform control station shall allow for hands-free operation.

20.17 Elevating Platform Operating Mechanisms.

20.17.1* Power-operated elevating and extending devices designed and powered to allow multiple movements of the elevating platform booms or sections simultaneously under all rated conditions of loading shall be provided.

20.17.1.1 Where hydraulic components are utilized, they shall meet the requirements of Section 20.26.

20.17.1.2 An automatic locking device(s) shall be provided so that the desired elevated position can be maintained.

20.17.1.3 Provisions shall be made to prevent damage at the top and bottom limits of elevation and extension.

20.17.2 An automatic platform-leveling system shall be provided so that the platform, together with its rated load, is supported and maintained level in relation to the turntable or horizontal regardless of the positions of the booms or sections.

20.17.3 A power-operated turntable shall be provided that allows continuous rotation in either direction under all the rated conditions of loading.

20.17.3.1* The turntable rotation bearing shall be accessible for lubrication and torque verification of bolts.

20.17.3.2 The turntable rotation mechanism shall be equipped with an automatically applied brake or self-locking drive that provides sufficient braking capacity when all power systems are nonfunctioning, to prevent turntable rotation under all rated conditions of loading.

20.17.4 A locking device shall be provided that will retain the elevating platform booms or sections in the bed when the fire apparatus is in motion.

20.18 Ladders on the Elevating Platform.

20.18.1 If the raising and extending booms or sections incorporate a ladder or ladder sections, the ladder shall meet the requirements of 20.2.1, Section 20.3, Section 20.4, Sections 20.6 through 20.8 and Section 20.12.

20.18.2 The transition step between the top rung of the ladder and the platform shall not be greater than 18 in. (457 mm).

20.19 Elevating Platform Water Delivery System. On elevating platforms of 110 ft (34 m) or less rated vertical height, a permanent water delivery system shall be installed.

20.19.1 The water delivery system shall be capable of delivering 1000 gpm (4000 L/min) at 100 psi (700 kPa) nozzle pressure with the elevating platform at its rated vertical height.

20.19.2 Friction loss (total system loss less head loss) between the monitor outlet and a point below the waterway swivel shall not exceed 100 psi (700 kPa) at a flow of 1000 gpm (4000 L/min).

20.19.3 One or more permanently installed monitors with nozzles capable of discharging 1000 gpm (4000 L/min) shall be provided on the platform.

20.19.3.1 The monitor(s) shall be supplied by the permanent water system.

20.19.3.2 The monitor(s) shall allow the operator to control the aimed direction of the nozzle through a rotation of at least 45 degrees on either side of center and at least 45 degrees above and below horizontal.

20.19.3.3 The horizontal and vertical traverse of the monitors shall not exceed the elevating platform manufacturer's recommendation.

20.19.3.4* A slow-operating valve shall be provided at the base of any monitor.

20.19.4 If a hose connection is provided, it shall be a minimum 2½ in. (65 mm) nominal diameter valved connection.

20.19.5* The water system shall be arranged so it can be supplied at ground level through an external inlet that is a minimum of 4 in. (100 mm) in size.

20.19.6 If the apparatus is equipped with a fire pump capable of supplying the required flow and pressure, a permanent valved connection shall be provided between the pump and the waterway system.

20.19.7 A flowmeter shall be installed in the waterway with at least one display on the pump operator's panel or at the elevating platform operator's position.

20.19.8 A preset relief valve capable of protecting the waterway system by relieving pressure through the dumping of water to the environment shall be provided.

20.19.8.1 Such dumping shall be through a system of piping terminating in an area away from the operator's position.

20.19.8.2 The discharge end of the piping shall not have a threaded connection.

20.19.9 Waterway Drains.

20.19.9.1* A 1½ in. (38 mm) minimum drain valve shall be provided at the low point of the waterway system.

20.19.9.2 Additional drains shall be provided to drain any portions of the waterway that do not drain to the low point of the system.

20.19.10 If the apparatus has a pump and normal operations are to supply the waterway through the pump, a cap meeting the requirements of 13.7.4 shall be provided on the external inlet.

20.20 Water Tower Requirements.

20.20.1 The water tower shall consist of two or more booms designed to telescope, articulate, or both and a waterway designed to supply a large capacity elevated water stream.

20.20.2 The rated vertical height of the water tower shall be measured vertically from the discharge end of the nozzle to the ground, with the nozzle raised to its position of maximum elevation.

20.20.3* The rated horizontal reach of the water tower shall be measured in a horizontal plane from the centerline of the turntable rotation to the end of the nozzle, with the water tower extended to its maximum horizontal reach.

20.20.4 Height and reach dimensions shall be taken with the water tower mounted on a chassis meeting the water tower manufacturer's minimum recommended fire apparatus specifications, the fire apparatus on level ground, and stabilizers deployed in accordance with the manufacturer's instructions.

20.20.5 The water tower, with stabilizers set if required, shall be capable of being raised from the bedded position to maximum elevation and extension and rotated 90 degrees within 105 seconds. Two or more of these functions shall be permitted to be performed simultaneously.

20.21 Water Tower Rated Capacity.

20.21.1 The water tower shall be capable of delivering a minimum water stream of 1000 gpm (4000 L/min) at 100 psi (700 kPa) from the water tower nozzle with the booms or sections and nozzle positioned in any configuration permitted by the manufacturer.

20.21.2 The rated capacity shall include the weight of the charged waterway and the maximum nozzle reaction force.

20.21.3 If the water tower is rated in multiple configurations, the manufacturer shall describe these configurations, including the rated capacity of each, in the operations manual and on the label at the operator's control station.

20.22 Water Tower Operating Mechanisms.

20.22.1 Power-operated elevating and extending devices shall be provided.

20.22.1.1 They shall be so designed and powered to allow multiple movements of the water tower booms or sections simultaneously under all rated conditions of loading.

20.22.1.2 Where hydraulic components are utilized, they shall meet the requirements of Section 20.26.

20.22.1.3 An automatic locking device(s) shall be provided so that the desired elevated position can be maintained.

20.22.1.4 Provisions shall be made to prevent damage at the top and bottom limits of elevation and extension.

20.22.2 A lock shall be provided that will retain the water tower booms or sections in the bed when the fire apparatus is in motion.

20.22.3 If the water tower has a rated water delivery capacity of 3500 gpm (14,000 L/min) or less, a power-operated turntable shall be provided that will allow continuous rotation in either direction under all rated conditions of loading.

20.22.3.1* The turntable rotation bearing shall be accessible for lubrication and torque verification of bolts.

20.22.3.2 The turntable rotation mechanism shall be provided with an automatically applied brake or self-locking drive that is capable of preventing turntable rotation under all rated conditions of loading when all power systems are nonfunctioning.

20.23 Water Tower Water Delivery System.

20.23.1 A permanent water system shall be installed capable of delivering 1000 gpm (4000 L/min) at 100 psi (700 kPa) nozzle pressure with the water tower and nozzle positioned in any configuration permitted by the manufacturer.

20.23.2 For water towers with a rated vertical height of 110 ft (34 m) or less, the friction loss (total system loss less head loss) between the monitor outlet and a point below the waterway swivel shall not exceed 100 psi (700 kPa) at a flow of 1000 gpm (4000 L/min).

20.23.3 A permanently installed monitor with a nozzle(s) capable of a discharge rate of at least 1000 gpm (4000 L/min) shall be provided at the top of the water tower and supplied by the permanent water system.

20.23.3.1 The monitor shall be powered so as to allow the operator(s) to control its aimed direction.

20.23.3.2 If the water tower has a rated water delivery capacity of 3500 gpm (14,000 L/min) or less, the monitor, as distinct from the supporting boom, shall allow the operator to control the aimed direction of the nozzle through a rotation of at least 45 degrees either side of center and at least 30 degrees above and 135 degrees below the centerline of the boom.

20.23.3.3 The horizontal and vertical traverse of the monitor shall not exceed the water tower manufacturer's recommendation.

20.23.4 If a variable pattern spray nozzle is provided, a control shall be provided at the operator's position to select the desired stream pattern.

20.23.5* The water system shall be arranged so it can be supplied at ground level through an external inlet that is a minimum of 4 in. (100 mm) in size.

20.23.6 If the apparatus is equipped with a fire pump capable of supplying the required flow and pressure, a permanent valved connection shall be provided between the pump and the waterway system.

20.23.7 A flowmeter shall be installed in the water delivery system with the display on either the pump operator's panel or the water tower operator's control panel.

20.23.8 A preset relief valve capable of protecting the waterway system by relieving pressure through the dumping of water to the environment shall be provided.

20.23.8.1 Such dumping shall be through a system of piping terminating in an area away from the operator's position.

20.23.8.2 The discharge end of the piping shall not have a threaded connection.

20.23.9* A 1½ in. (38 mm) minimum drain valve shall be provided at the low point of the waterway system.

20.23.10 If the apparatus has a pump and normal operations are to supply the waterway through the pump, a cap meeting the requirements of 13.7.4 shall be provided on the external inlet.

20.24 Control Devices.

20.24.1 Controls shall be provided at the driver's position to transfer power to the aerial device.

20.24.2 A visual signal shall be provided at the driver's position to indicate when the operating mechanisms are engaged.

20.24.3 An interlock shall be provided that prevents operation of the aerial device until the parking brakes have been set and the transmission has been placed in neutral or the transmission is in the drive position with the driveline to the rear axle disengaged.

20.24.4 A power-operated governed engine speed control shall be provided to limit the operating speed of the aerial device apparatus engine to within the operating parameters as determined by the manufacturer and this standard.

20.24.4.1 An interlock shall be provided that allows operation of the engine speed control only after the parking brakes have been set and the transmission is in neutral.

20.24.4.2 Where the apparatus is equipped with a fire pump, any high idle speed control shall be automatically disengaged when the fire pump is operating.

20.24.5 An interlock system shall be provided to prevent the following:

- (1) Rotation of the aerial device before the stabilizer(s) is in a configuration to meet the stability requirements of Section 20.28
- (2) Movement of the stabilizers unless the aerial device is in the travel position
- (3) Operation of the aerial device into an unstable position when the aerial device can be operated with the stabilizers not fully deployed on at least one side of the vehicle

20.24.6 Controls at the operator's position shall be lighted, marked with a label, and conveniently arranged.

20.24.6.1 These controls shall allow the operator to perform the following:

- (1) Elevate and lower the aerial device
- (2) Extend and retract the aerial device, if applicable
- (3) Rotate the aerial device in either direction, if applicable
- (4) Operate the intercom, if applicable

20.24.6.2 A method shall be provided to prevent unintentional movement of the aerial device.

20.24.6.3 Each control shall allow the operator to regulate the speed of elevation, extension, and rotation of the aerial device within the limits determined by the manufacturer and this standard.

20.24.6.4 Each control shall be arranged so it can be operated by an operator with a gloved hand without disturbing any other control(s).

20.24.6.5 For aerial devices that can be operated over the side with the stabilizers not fully deployed, an indicator shall be located at the operator's position to allow the operator to determine the maximum extension in relation to the angle of elevation and the extended length of the stabilizers.

20.24.7 Where a three-lever system is used to control the basic functions of the aerial device, the levers shall be different from the other controls on the panel and arranged adjacent to each other, with the extension control being the left lever, the rotation control being the center lever, and the elevation control being the right lever, as shown in Figure 20.24.7.

20.24.7.1 The aerial device shall extend when the extension control is pushed up or forward (i.e., away from the operator).

20.24.7.2 If the rotation control has a forward/backward orientation or an up/down orientation, the turntable shall rotate clockwise when the rotation control is pushed up or forward (i.e., away from the operator), as shown in Figure 20.24.7.2.

20.24.7.3 For rotational control orientation other than that specified in 20.24.7.2, the rotational control handle shall move in the direction of rotation.

20.24.7.4 The aerial device shall lower when the elevation control is pushed up or forward (i.e., away from the operator).

20.24.8 Where a multifunction control lever is furnished, it shall move in the direction of the function it controls, where possible.

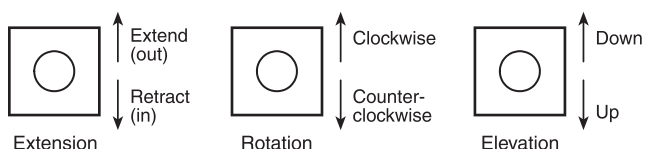


FIGURE 20.24.7 Control Lever Arrangement.

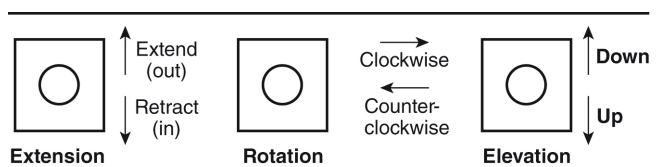


FIGURE 20.24.7.2 Control Lever Arrangement.

20.24.9 Where a two-lever system is used, the extension control shall be to the left, and a combination lever for rotation and elevation shall be to the right.

20.24.10 All controls regulating the movement of the aerial device shall automatically return to the neutral position upon release by the operator.

20.24.11 When electric over hydraulic aerial device controls are incorporated, a readily accessible, manual means of overriding the electric controls shall be provided.

20.25 Safety.

20.25.1* If the primary operator's position is on the turntable, the turntable platform shall be provided with a railing at least 42 in. (1070 mm) high.

20.25.1.1 The railing design shall be capable of withstanding a force of 225 lbf (1000 N) applied at any point from any direction without permanent deformation.

20.25.1.2 Where the primary operator's position is equipped with an operator's seat, the seat shall be provided with a railing or an armrest capable of withstanding a force of 225 lbf (1000 N) applied at any point from the inside of the seat.

20.25.2* Any aerial device operator's position or pump operator's position at ground level shall be arranged so that the operator is not in contact with the ground.

20.25.3 Safety sign FAMA35, which warns of electrocution hazards, shall be placed at any ground level operator's position.

20.25.4 Where the aerial device includes moving cylinders or other moving parts, one of the following shall apply:

- (1) Moving cylinders or other moving parts shall be arranged so as to provide hand clearance
- (2) Hand guards shall be provided to prevent injury to the operator

20.25.5 Lighting shall be both of the following:

- (1) Provided at the base of the aerial device
- (2) Arranged to illuminate the aerial device in any position of operation

20.25.6 A spotlight of not less than 75,000 beam cp (75,000 lumens per steradian) or a floodlight with a total luminous flux of not less than 4,000 lumens shall be provided on the apparatus by which the operator is able to observe the effect of the stream from the ladder pipe or monitor nozzle.

20.25.6.1* Light output of the complete fixture, including the light source, shall be measured with the light source and fixture at photometric stability, per SAE J1889, *L.E.D. Signal and Marking Devices*.

20.25.6.2 Measurements for a floodlight shall be made with a goniophotometer or other instrument that measures actual light output from the fixture in relation to positions around the fixture.

20.25.6.3 Optical Test Data.

20.25.6.3.1 Optical test data shall be certified by the optical device manufacturer.

20.25.6.3.2 The test data shall be published on the website of the optical device manufacturer.

20.25.7 Provisions shall be made so that in the event of failure of the primary operating power source, an auxiliary source of power be available that is capable of returning the aerial device to the road travel position.

20.25.8 Where the operation of the aerial device is accomplished by hydraulic means, the system shall prevent motion of the aerial device in the event of any hydraulic hose failure.

20.25.9 Where the operation of the aerial device is accomplished by means other than hydraulic, the system shall be designed to prevent motion of the aerial device in the event of a power failure.

20.25.10 All components used to stabilize the apparatus on which the aerial device is mounted shall be designed to prevent instability in the event of a hydraulic hose failure or a power failure.

20.25.11 Where the design of the aerial device incorporates a knuckle, the knuckle shall be as follows:

- (1) Equipped with position lights or continuously illuminated by boom lights
- (2) Painted with reflective paint or provided with retroreflective striping

20.26 Hydraulic System.

20.26.1* All load-bearing hydraulic components whose failure results in motion of the aerial device shall have a minimum bursting strength of four times the operating pressure for which the system is designed.

20.26.2* All other hydraulic system components normally rated according to bursting strength shall have a minimum bursting strength of at least three times the pressure they will be subjected to in normal operation.

20.26.3* All other hydraulic components normally rated according to performance criteria shall have a minimum bursting strength of at least two times the pressure they will be subjected to in normal operations.

20.26.4 The hydraulic system shall be provided with an oil pressure gauge at the lower operating position.

20.26.5 Hydraulic Reservoir.

20.26.5.1 A means for checking and filling the hydraulic reservoir shall be readily accessible.

20.26.5.2 The fill location shall be conspicuously marked with a label that reads "Hydraulic Oil Only."

20.26.5.3 The manufacturer shall provide instructions for checking and filling the hydraulic reservoir.

20.26.6 The hydraulic system components shall be capable of maintaining, under all operating conditions, oil cleanliness and temperature that comply with the component manufacturer's recommendations.

20.26.7* The hydraulic system shall have adequate cooling for continuous operation of not less than 2½ hours.

20.26.8 An hour meter shall be provided that records any time the aerial device hydraulic system is engaged.

20.27 Structure.

20.27.1* All structural-load-supporting elements of the aerial device that are made of a ductile material shall have a design stress of not more than 50 percent of the minimum yield strength of the material based on the combination of the rated capacity and the dead load, which is equivalent to a 2:1 safety factor.

20.27.2 All structural-load-supporting elements of the aerial device that are made of a nonductile material shall have a design stress of not more than 20 percent of the minimum ultimate strength of the material, based on the combination of the rated capacity and the dead load, which is equivalent to a 5:1 safety factor.

20.27.3 Wire ropes, chains, and attaching systems used to extend and retract the fly sections or booms shall have a 5:1 safety factor based on ultimate strength under all operating conditions allowed by the manufacturer.

20.27.3.1 The factor of safety for the wire rope shall remain above 2:1 during any extension or retraction system stall.

20.27.3.2 The minimum ratio of the diameter of wire rope used to the diameter of the sheave used shall be 1:12.

20.27.4 The structural safety factors of Section 20.19 shall be met for the rated capacity of the aerial device in all operating positions that the control system will allow it to be placed.

20.28 Stabilization.

20.28.1* The stability requirements of Section 20.20 shall be met for the rated capacity of the aerial device in all operating positions that the control system will allow it to be placed in when the apparatus is in a service-ready condition but with all normally removable items, such as water, hose, ground ladders, and loose equipment removed.

20.28.1.1 Items mounted on the aerial device by the manufacturer shall remain mounted.

20.28.1.2 Stabilizers shall be provided, if required, to meet the stability requirements Section 20.20.

20.28.2 Stability on a Level Surface.

20.28.2.1 The aerial device shall be capable of sustaining a static load $1\frac{1}{2}$ times its rated capacity in every position in which the aerial device can be placed when the apparatus is on a firm and level surface.

20.28.2.2 The worst case for stability test shall be the greater of the following:

- (1) 1.5 times the rated capacity with no water in the waterway system
- (2) 1.33 times the rated capacity, plus the equivalent weight of the water in the aerial waterway and the downward load caused by nozzle reaction force applied at the aerial tip

20.28.3 Stability on a Sloping Surface.

20.28.3.1 The aerial device shall be capable of sustaining a static load $1\frac{1}{3}$ times its rated capacity in every position in which the aerial device can be placed when the apparatus is on a slope of 5 degrees (8.7 percent) downward in the direction most likely to cause overturning.

20.28.3.2 If other capabilities, such as a means of turntable leveling, are provided to minimize the effect of the sloping surface, those capabilities shall be permitted to be utilized for determining whether the apparatus meets this stability requirement.

20.28.4 Stabilizer System. If a stabilizer system is provided, it shall meet the requirements of 20.28.4.1 through 20.28.4.3.

20.28.4.1 If the stabilizer system is power operated, the controls shall be arranged so that the operator can view the stabilizers in motion.

20.28.4.1.1 An audible alarm, of not less than 87 dBA measured at any position the stabilizer can be in, shall sound when a stabilizer is moving.

20.28.4.1.2 An indicator(s) shall be provided to denote when the apparatus is operable within the manufacturer's range of level conditions.

20.28.4.1.3 Where the rated vertical height of the aerial device is 110 ft (34 m) or less, all stabilizers shall be deployed from the stored position to the operating position within 90 seconds.

20.28.4.2 All stabilizers that protrude beyond the body of the apparatus shall be striped or painted with retroreflective material so as to indicate a hazard or obstruction.

20.28.4.3 All stabilizers that protrude beyond the body of the apparatus shall be provided with one or more red warning lights located either on the stabilizer or in the body panel above the stabilizer visible on the side of the apparatus where the stabilizer is located.

20.28.5 Stabilizer Shoes and Pads.

20.28.5.1 At a minimum, the stabilizer shoe shall be capable of swiveling on an axis parallel to the longitudinal axis of the apparatus.

20.28.5.2 The ground contact area for each stabilizer shall be such that a unit pressure of not greater than 100 psi (675 kPa) will be exerted over the ground contact area when the apparatus is loaded to its maximum in-service weight and the aerial device is carrying its rated capacity in every position permitted by the manufacturer.

20.28.5.3 Auxiliary stabilizer pads shall be permitted beneath the stabilizer shoes to meet the loading requirement.

20.28.5.4* The maximum force on any stabilizer shall not exceed 65,000 lb (29,484 kg) when the apparatus is loaded to its maximum in-service weight and the aerial device is carrying its rated capacity in every position permitted by the manufacturer.

20.29 Quality Control.

20.29.1 The manufacturer and installer shall have in effect a complete and documented quality control program that will ensure complete compliance with the requirements of this standard.

20.29.2 The quality control program shall include 100 percent nondestructive testing (NDT) of all critical structural components of the aerial device.

20.29.2.1 The manufacturer shall determine the types of NDT to be conducted.

20.29.2.2 The procedures used for NDT shall comply with the applicable standards defined in 20.29.5.

20.29.2.3 All NDT procedures shall be fully documented with respect to the extent of the examination, the method of testing, and the inspection techniques.

20.29.2.4 All testing shall be performed by Level II or Level III NDT technicians or by Level I NDT technicians or trainees under the direct supervision of an onsite Level II or Level III NDT technician, all of whom have been certified in the test methods used in accordance with ANSI/ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel*.

20.29.2.5 Personnel certified under ANSI/ASNT CP-189 shall be permitted to conduct NDT with limited certifications, so long as the certifications meet the training and experience requirements listed in Table 20.29.2.5 and any applicable requirements in Appendix B of ANSI/ASNT CP-189. The personnel shall be certified as Limited Level II, and the certification card shall indicate that a limited certification has been issued in the given technique.

20.29.3 Welder Certification.

20.29.3.1 Welds for all structural load-supporting elements shall be performed by certified welders under the guidelines of AWS D1.1/D1.1M, *Structural Welding Code — Steel*; AWS D1.2/D1.2M, *Structural Welding Code — Aluminum*; and AWS D1.3/D1.3M, *Structural Welding Code — Sheet Steel*.

20.29.3.2 Welding performed by fabricators and welders approved by the Canadian Welding Bureau to Canadian Standards Association (CSA) W47.1, *Certification of Companies for Fusion Welding of Steel*, or CSA W47.2, *Certification of Companies for Fusion Welding of Aluminum*, shall be considered equivalent to welding performed according to 20.29.3.1.

20.29.3.3 Welding performed by machines shall be considered equivalent to welding performed by certified welders.

20.29.4 The manufacturer and the installer shall establish applicable welding quality assurance procedures for all weldments.

Table 20.29.2.5 Training and Experience Hours for Conducting Limited Level II Inspections

Evaluation Technique	Required Training (hr)	Minimum Required Experience in Method (hr)
Magnetic particle — ac yoke, visible dry powder	8	120
Liquid penetrant — water washable or solvent removable, visible dye, penetrant	8	100
Visual inspection — eye, aided by magnifiers and measuring tools	8	100
Ultrasonic straight beam (A-scan) flaw detection	40	60

20.29.4.1 Methods of NDT shall be described in the manufacturer's quality assurance procedures and shall be as recommended by AWS B1.10M/B1.10, *Guide for the Nondestructive Examination of Welds*.

20.29.4.2 The manufacturer shall designate the welds to be examined, the extent of examination, and the type of testing.

20.29.5 Nondestructive Testing Procedure.

20.29.5.1 All ultrasonic inspections shall be conducted in accordance with the following ASTM standards:

- (1) ASTM E114, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method*
- (2) ASTM E797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*

20.29.5.2 All magnetic particle inspections shall be conducted in accordance with ASTM E709, *Standard Guide for Magnetic Particle Testing*.

20.29.5.3 All liquid penetrant inspections shall be conducted in accordance with ASTM E165, *Standard Test Method for Liquid Penetrant Examinations*.

20.29.5.4 All electrical conductivity measurements shall be conducted in accordance with ASTM E1004, *Standard Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method*.

20.29.5.5 All hardness readings shall be conducted in accordance with the following ASTM standards:

- (1) ASTM E6, *Standard Terminology Relating to Methods of Mechanical Testing*
- (2) ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*
- (3) ASTM E18, *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*
- (4) ASTM E384, *Standard Test Method for Microindentation Hardness of Materials*
- (5) ASTM B647, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage*
- (6) ASTM B648, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor*

20.29.5.6 All acoustic emission inspections shall be conducted in accordance with the following ASTM standards:

- (1) ASTM E569, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation*
- (2) ASTM E650, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*

20.30 Instruction Plates and Signs.

20.30.1 Instruction plates and signs that provide operational directions, warnings, and cautions shall be installed in positions visible to the operator(s).

20.30.1.1 Instruction plates shall describe the function and operation of each control.

20.30.1.2 The following safety signs shall be provided where applicable:

- (1) FAMA25 (Training Required): One sign visible to the operator at the main aerial controls
- (2) FAMA30 (Stabilizer Crush): One sign visible to personnel near each stabilizer and one sign at the stabilizer deployment control(s)

- (3) FAMA31 (Stabilizers with Pins) or FAMA32 (Stabilizers without Pins): One sign in a location visible to personnel at the stabilizer deployment control(s)
- (4) FAMA34 (Fall Restraint Required): One sign in a location visible to personnel at the base of any aerial device with a ladder capable of being climbed and one sign visible to personnel in any aerial platform
- (5) FAMA35 (Electrocution): One sign in a location visible to the aerial operator and one sign in a location visible to the pump operator
- (6) FAMA36 (Electrocution): One sign on each side of the vehicle and one sign on the back
- (7) FAMA37 (Aerial Device Load Capacity): One sign visible to operators at any location where the aerial can be controlled
- (8) FAMA38 (Aerial Ladder Rung Pinch): One sign visible to operators at any location where the aerial can be controlled
- (9) FAMA39 (Aerial Inspection and Maintenance): One sign visible to the operator at the main aerial controls
- (10) FAMA46 (Aerial Device Pinch): One sign on aerial device visible to personnel on the turntable at the foot of the device
- (11) FAMA47 (Aerial Operator Attention Required): Visible to aerial operator at turntable, in the platform, and at tip controls

20.30.2 Labels shall disclose the following information relative to the aerial device:

- (1) Make
- (2) Model
- (3) Insulated or noninsulated
- (4) Serial number
- (5) Date of manufacture
- (6) Maximum hydraulic system pressure, if applicable
- (7) Hydraulic oil requirements (i.e., change quantity and type), if applicable

20.30.3 Load Chart.

20.30.3.1 A load chart shall be visible to the primary operator and to the platform operator.

20.30.3.2 A load chart shall be visible to the primary operator and to the platform operator.

- (1) Rated capacity through the range of motion of the device
- (2) Rated vertical height
- (3) Rated horizontal reach
- (4) Rated water Flow (if applicable)
- (5)* Rated wind speed

20.31 Certification Tests. The completed apparatus with the aerial device shall be tested to the criteria defined in this section and the test results certified by an independent third-party certification organization. The certified test results shall be delivered with the fire apparatus.

20.31.1 The aerial device shall be inspected and tested in accordance with the requirements of Chapter 23 of NFPA 1910, including all NDT, prior to being subjected to the tests defined in 20.31.2 through 20.31.4.

20.31.2 Stability Test.

20.31.2.1 The apparatus on which the aerial device is mounted shall be in a service-ready condition and shall be placed on a firm, level surface.

20.31.2.2 All normally removable items, such as water, hose, ground ladders, and loose equipment, shall be removed, but items mounted on the aerial device by the manufacturer shall remain mounted.

20.31.2.3 If having the stabilizers extended is part of the configuration, the stabilizers shall be deployed to the point where the interlock system allows operation of the aerial device.

20.31.2.4 Systems that allow the aerial device to be operated with the stabilizers not fully deployed shall be tested in three positions:

- (1) Stabilizers at the minimum extension as defined by the manufacturer
- (2) Stabilizers extended to midpoint of the minimum extension and full extension
- (3) Stabilizers fully deployed

20.31.2.5 A load of 1½ times the rated capacity as specified by the manufacturer shall be suspended from the tip of the aerial ladder or from the platform of the elevating platform when it is in the position of least stability.

20.31.2.5.1 For aerial devices that have computer controlled or electronically controlled limitations to the range of aerial movement, a test as defined by the manufacturer shall be performed to validate the proper operation of the control system.

20.31.2.6 If the manufacturer specifies a rated capacity while water is flowing, then one times the water load and the worst-case nozzle reaction shall be added to the stability test weights.

20.31.2.7 For a water tower, the stability test shall include the weight of the water in the system and 1½ times the maximum nozzle reaction force when the aerial device is in the position of least stability.

20.31.2.8* The apparatus shall show no signs of instability, and the test shall not cause permanent deformation of any components.

20.31.2.9 The stability shall be further tested as defined in 20.31.2.9.1 through 20.31.2.9.6.

20.31.2.9.1 The apparatus that the aerial device is mounted on shall be placed on a firm surface sloping downward at 5 degrees (8.7 percent grade) in the direction most likely to cause overturning and shall be configured as defined in 20.31.2.2.

20.31.2.9.2 If having the stabilizers extended is part of the configuration, the stabilizers shall be deployed in accordance with the manufacturer's recommendations.

20.31.2.9.3 Systems that allow the aerial device to be operated with the stabilizers not fully deployed shall be tested in three positions:

- (1) Stabilizers at the minimum extension as defined by the manufacturer
- (2) Stabilizers extended to midpoint of the minimum extension and full extension
- (3) Stabilizers fully deployed

20.31.2.9.4 A load of $1\frac{1}{3}$ times the rated capacity shall be suspended from the tip of the aerial ladder or the platform of the elevating platform when it is in the position of least stability.

20.31.2.9.5 For a water tower, the stability test shall include the weight of the water in the system and $1\frac{1}{3}$ times the maximum nozzle reaction when it is in the position of least stability.

20.31.2.9.6 The apparatus shall show no signs of instability, and the test shall not cause permanent deformation of any components.

20.31.3 Horizontal Rotation Load Test.

20.31.3.1 With the aerial device out of the cradle in the fully extended position at zero degrees elevation, a test load shall be applied in a horizontal direction normal to the centerline of the ladder or boom.

20.31.3.1.1 For aerial devices with a prepiped waterway, a 350 lb (160 kg) test load shall be applied at the tip of the ladder or boom.

20.31.3.1.2 For aerial ladders without a prepiped waterway, a 220 lb (100 kg) test load shall be applied at the tip of the ladder or boom.

20.31.3.2 The turntable shall not rotate, and the ladder or boom shall not deflect beyond what the manufacturer's specification allows.

20.31.4 Aerial Device Water System Test.

20.31.4.1 If the aerial device is equipped with a permanent water system and has a rated vertical height of 110 ft (34 m) or less, standard model flow test data shall be delivered with the fire apparatus.

20.31.4.2 If the water system has been modified from the standard model configuration, a new flow test shall be conducted to determine that the friction loss in the water system between the base of the swivel and the monitor outlet does not exceed 100 psi (700 kPa) with 1000 gpm (4000 L/min) flowing and with the water system at full extension.

20.31.4.3 A flow test shall be conducted on each vehicle to determine that the water system is capable of flowing 1000 gpm (4000 L/min) at 100 psi (700 kPa) nozzle pressure with the aerial device at full elevation and extension.

20.31.4.3.1 Where the apparatus is equipped with a fire pump designed to supply the water system, the test shall be conducted using the onboard fire pump.

20.31.4.3.2 The intake pressure to the fire pump shall not exceed 20 psi (138 kPa).

20.32* Manufacturer's Predelivery Test. If the aerial device is equipped with a permanent water delivery system, the manufacturer shall, prior to delivery of the apparatus, hydrostatically test the piping for the waterway system, including the monitor, at the maximum operating pressure required to flow 1000 gpm (4000 L/min) at 100 psi (700 kPa) nozzle pressure at maximum elevation and extension.

Chapter 21 Fire Apparatus — Line Voltage Electrical Systems (NFPA 1901)

21.1* Application. Where any part of a line voltage electrical system is provided as a fixed installation, the applicable requirements of this chapter shall apply.

21.2 General Requirements.

21.2.1 Stability.

21.2.1.1 Any fixed line voltage power source producing alternating current (ac) shall produce electric power at its rated frequency ± 5 percent when producing power at all levels between no load and full rated power.

21.2.1.2 Any fixed line voltage power source shall produce electric power at the rated voltage ± 10 percent when producing power at all levels between no load and full rated power.

21.2.2 The maximum voltage supplied to portable equipment shall not exceed 275 volts to ground. Higher voltage shall be permitted only when used to operate fixed wired, permanently mounted equipment on the apparatus.

21.2.3 Conformance with *National Electrical Code*.

21.2.3.1 All components, equipment, and installation procedures shall conform to *NFPA 70*, except where superseded by the requirements of this chapter.

21.2.3.2 Where the requirements of this chapter differ from those in *NFPA 70*, the requirements in this chapter shall apply.

21.2.4* Where available, line voltage electrical system equipment and materials included on the apparatus shall be listed and used only in the manner for which they have been listed.

21.2.5 All equipment and materials shall be installed in accordance with the manufacturer's instructions.

21.2.6 Location Ratings.

21.2.6.1 Any equipment used in a dry location shall be listed for dry locations.

21.2.6.2 Any equipment used in a wet location shall be listed for wet locations.

21.2.6.3 Any equipment, except a PTO-driven generator, used in an underbody or underchassis location that is subject to road spray shall be either listed as Type 4 or mounted in an enclosure that is listed as Type 4.

21.2.6.4* If a PTO-driven generator is located in an underbody or underchassis location, the installation shall include a shield to prevent road spray from splashing directly on the generator.

21.2.7* Power Factor Correction. Any permanently mounted line voltage device shall be equipped with circuitry such that the power factor of the device is 0.9 or greater.

21.3 Grounding and Bonding.

21.3.1* Grounding. Grounding shall be in accordance with 250.34(A) and 250.34(B) of *NFPA 70*.

21.3.1.1* Ungrounded systems shall not be used.

21.3.1.2 Only stranded or braided copper conductors shall be used for grounding and bonding.

21.3.1.3 The grounded current-carrying conductor (neutral) shall be insulated from the equipment-grounding conductors and from the equipment enclosures and other grounded parts.

21.3.1.4 The neutral conductor shall be colored white or gray in accordance with 200.6, "Means of Identifying Grounded Conductors," of *NFPA 70*.

21.3.1.5 Any bonding screws, straps, or buses in the distribution panelboard or in other system components between the neutral and equipment-grounding conductor shall be removed and discarded.

21.3.2 Bonding.

21.3.2.1 The neutral conductor of the power source shall be bonded to the vehicle frame.

21.3.2.2 The neutral bonding connection shall occur only at the power source.

21.3.2.3 In addition to the bonding required for the low voltage return current, each body and each driving or crew compartment enclosure shall be bonded to the vehicle frame by a copper conductor.

21.3.2.3.1 The conductor shall have a minimum amperage rating, as defined in 310.15 of *NFPA 70*, of 115 percent of the rated amperage on the power source specification label.

21.3.2.3.2 A single conductor that is sized to meet the low voltage and line voltage requirements shall be permitted to be used.

21.3.3* Ground Fault Circuit Interrupters.

21.3.3.1 In special service vehicles incorporating a lavatory, sink, toilet, shower, or tub, 120 V, 15 or 20 A receptacles within 6 ft (1.8 m) of these fixtures shall have ground fault circuit interrupter (GFCI) protection.

21.3.3.2 GFCIs integrated into outlets or circuit breakers or as stand-alone devices shall be permitted to be used in situations other than those described in 21.3.3.1.

21.4 Power Source General Requirements. The requirements in 21.4.1 through 21.4.10 shall apply to all line voltage power sources.

21.4.1 All power source system mechanical and electrical components shall be sized to support the continuous duty nameplate rating of the power source.

21.4.2 The power source shall be shielded from contamination that would prevent the power source from operating within its design specifications.

21.4.3 Power Source Rating.

21.4.3.1* For power sources of 8 kW or larger, the power source manufacturer shall declare the continuous duty rating that the power source can provide when installed on fire apparatus according to the manufacturer's instructions and run at 120°F (49°C) air intake temperature at 2000 ft (600 m) above sea level.

21.4.3.2 The rating on the power source specification label shall not exceed the declared rating from the power source manufacturer.

21.4.4 Access shall be provided to permit both routine maintenance and removal of the power source for major servicing.

21.4.5 The power source shall be located such that neither it nor its mounting brackets interfere with the routine maintenance of the fire apparatus.

21.4.6 Instrumentation.

21.4.6.1 If the power source is rated at less than 3 kW, a "Power On" indicator shall be provided.

21.4.6.2 If the power source is rated at 3 kW or more but less than 8 kW, a voltmeter shall be provided.

21.4.6.3* If the power source is rated at 8 kW or more, the following instrumentation shall be provided at an operator's panel:

- (1) Voltmeter
- (2) Current meters for each ungrounded leg
- (3) Frequency (Hz) meter
- (4) Power source hour meter

21.4.6.4 The instrumentation shall be permanently mounted at an operator's panel.

21.4.6.4.1 The instruments shall be located in a plane facing the operator.

21.4.6.4.2 Gauges, switches, or other instruments on this panel shall each have a label to indicate their function.

21.4.6.4.3 The instruments and other line voltage equipment and controls shall be protected from mechanical damage and not obstructed by tool mounting or equipment storage.

21.4.7 An instruction plate(s) that provides the operator with the essential power source operating instructions, including the power-up and power-down sequence, shall be permanently attached to the apparatus at any point where such operations can take place.

21.4.8* Operation.

21.4.8.1 Provisions shall be made for placing the generator drive system in operation using controls and switches that are identified and within convenient reach of the operator.

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

21.4.9 If there is permanent wiring on the apparatus that is designed to be connected to the power source, a power source specification label that is permanently attached to the apparatus at the operator's control station shall provide the operator with the information detailed in Figure 21.4.9.

21.4.10 The power source, at any load, shall not produce a noise level that exceeds 90 dBA in any driving compartment, crew compartment, or onboard command area with windows and doors closed or at any operator's station on the apparatus.

21.5 Power Source Type Specific Requirements.

21.5.1* Direct Drive (PTO) Generators. If the generator is driven by any type of PTO, it shall meet the requirements of 21.5.1.1 through 21.5.1.3.

21.5.1.1 The PTO port, PTO, and all associated PTO and drive shaft components shall be rated to support the continuous-duty torque requirements of the generator's

Power Source Specifications	
Operational Category	Continuous Duty Rating
Rated voltage(s) and type (ac or dc)	
Phase	
Rated frequency	
Rated amperage	
Continuous rated watts	
Power source engine speed	

FIGURE 21.4.9 Power Source Specifications Label.

continuous-duty rating as stated on the power source nameplate.

21.5.1.2 The direct drive generator shall be mounted so that it does not change the ramp breakover angle, angle of departure, or angle of approach as defined by other components, and it shall not extend into the ground clearance area.

21.5.1.3 The direct drive generator shall be mounted away from exhaust and muffler areas or provided with a heat shield to reduce operating temperatures in the generator area.

21.5.2* Hydraulically Driven Generators. If the generator is driven using hydraulic components, it shall meet the requirements of 21.5.2.1 through 21.5.2.5.

21.5.2.1* A means shall be provided to activate the hydraulic generator system.

21.5.2.2 If the hydraulic generator system is not capable of output as stated on the power source specification label at all engine speeds, an automatic engine speed control system shall be provided.

21.5.2.3 If the apparatus is equipped with a fire pump driven by the chassis engine, the generator shall be capable of output as stated on the power source specification label with the engine at idle.

21.5.2.4 Hydraulic Components.

21.5.2.4.1 A hydraulic system filter and strainer shall be provided and shall be located in a readily accessible area.

21.5.2.4.2 Hydraulic hose shall meet the hydraulic pump manufacturer's recommendations for pressure, size, vacuum, and abrasion resistance.

21.5.2.4.3* Hydraulic fittings shall meet the hydraulic pump manufacturer's recommendations for pressure, size, and the type of hose used.

21.5.2.5* Where the hydraulic hose comes into contact with other surfaces, the hose shall be protected from chafing.

21.5.3* Fixed Auxiliary Engine-Driven Generators. If the generator is driven by a fixed auxiliary engine, it shall meet the requirements of 21.5.3.1 through 21.5.3.9.4.

21.5.3.1 The generator shall be installed so that fumes, vapors, heat, and vibrations do not enter the driving or crew compartment.

21.5.3.2* Generators rated at 8 kW or more shall be equipped with a high temperature automatic shutdown system and a low oil (pressure or level) automatic shutdown system.

21.5.3.3 The generator shall be installed in accordance with the generator manufacturer's requirements for ventilation and service accessibility.

21.5.3.4 If the generator is installed in a compartment and the compartment doors must be open during its operation, the generator shall be equipped with an interlock system to prevent its operation if the doors are not open, or the compartment shall be equipped with a high temperature alarm.

21.5.3.5 If the generator is installed in a compartment on a slide tray and the slide tray must be in the extended or out position during operation, an interlock shall be provided to prevent operation unless the tray is in the correct position, or the compartment shall be equipped with a high temperature alarm.

21.5.3.6 Permanently installed generators shall have readily accessible engine oil drain provisions or piping to a remote location for oil changing.

21.5.3.7* If the generator is located in a position on the apparatus where the operator cannot see the instrumentation and operate the controls while standing at ground level or positioned at a specifically designated operator station, an operating panel with the required instrumentation, start and stop controls, and other controls necessary for safe operation shall be provided at a remote operator's panel.

21.5.3.8 Fuel System.

21.5.3.8.1 Fuel lines shall be protected from chafing at all wear points.

21.5.3.8.2 If the fuel source is shared with the apparatus engine, a separate fuel pickup system shall be provided that is arranged to ensure that the generator cannot utilize more than 75 percent of the fuel tank's capacity.

21.5.3.9 Exhaust System.

21.5.3.9.1* The exhaust piping and discharge shall be located or shielded to prevent thermal damage to the apparatus or equipment.

21.5.3.9.2 The exhaust shall be piped to the exterior of the vehicle and discharged at a location away from any operator's position.

21.5.3.9.3 Where parts of the exhaust system are exposed so that they can cause injury to operating personnel, protective guards shall be provided.

21.5.3.9.4 Silencing devices shall be provided and shall not create exhaust backpressure that exceeds the limits specified by the engine manufacturer.

21.5.4* Belt-Driven Power Sources. If the power source is belt driven, it shall meet the requirements of 21.5.4.1 through 21.5.4.3.

21.5.4.1 A means shall be provided to mechanically engage and disengage the generator or alternator rotation or to electronically stop the production of electricity from the generator or alternator.

21.5.4.2 A voltmeter shall be provided at an operator's panel for any system of this type.

21.5.4.3 The belt drive system shall be rated to drive the generator or alternator at the nameplate rating.

21.5.5* Line Voltage Power Derived from the Apparatus Low Voltage Power Supply Systems. If the power source derives its input energy from the apparatus low voltage electrical system, it shall meet the requirements of 21.5.5.1 and 21.5.5.2.

21.5.5.1 The low voltage power supply system shall be installed in compliance with the requirements of Chapter 10.

21.5.5.2* The alternator and/or battery system shall be adequate to provide power for continuous operation for a minimum of 2 hours at full output.

21.5.6 Power Sources Requiring Elevated Engine Speed. If the power source requires the chassis engine to be operating at a specific fixed speed or a specific speed range, it shall meet the requirements of 21.5.6.1 through 21.5.6.3.

21.5.6.1 The main propulsion engine shall have a governor capable of maintaining the engine speed within the limits required by the power source to meet the frequency control, voltage control, and power output specifications.

21.5.6.2 An interlock shall prevent engagement of the generator unless the parking brake is engaged and the transmission is in neutral or not connected to the drive wheels.

21.5.6.3* Where the chassis engine drives the generator and electronic engine throttle controls are provided, an interlock shall prevent engine speed control from any other source that would interfere with the generator while the generator is operating.

21.5.7 Power Sources Requiring the Chassis Transmission to Be in a Specific Gear. If the power source requires the chassis transmission be in a specific gear when producing line voltage power, it shall meet the requirements of 21.5.7.1 and 21.5.7.2.

21.5.7.1 A label indicating the chassis transmission shift selector position to be used for generator operation shall be provided in the driving compartment and located so that it can be read from the driver's position.

21.5.7.2 Interlocks shall be provided that prevent advancement of the engine throttle for generator operation unless the transmission is in the correct gear.

21.5.8 Generators. If the power source is mechanically driven, it shall comply with Article 445, "Generators," of *NFPA 70*.

21.5.9 Chassis Engine-Driven Generators. Where the generator is driven by the chassis engine, the requirements in 21.5.9.1 through 21.5.9.3 shall apply.

21.5.9.1* Unless the generator is always engaged, a "Generator Engaged" indicator shall be provided in the driving compartment to indicate that the generator shift has been successfully completed.

21.5.9.2 Unless the generator is always engaged and operating, an "OK to Operate Generator" indicator shall be provided in the driving compartment to indicate that the generator is engaged (if not always engaged), the transmission is in the proper gear (if required, automatic transmissions only), and the parking brake is engaged (if applicable).

21.5.9.3 An interlock system shall be provided to prevent advancement of the engine speed in the driving compartment or at any operator's panel unless the parking brake is engaged, and the transmission is in neutral or the output of the transmission is correctly connected to a pump or generator instead of the drive wheels.

21.5.10* Waveform Created Electronically. If the power output waveform is electronically created, the purchaser shall specify whether modified sine wave or pure sine wave output is required.

21.6* Portable Generator Installations. The generator shall comply with Article 445, "Generators," of *NFPA 70*.

21.6.1 Any portable generator that can be operated while mounted on the apparatus shall be as follows:

- (1) Installed so that fumes, vapors, heat, excessive noise, and vibrations do not enter interior driving or crew compartments or damage the generator during operation
- (2) Have the exhaust outlet located so that exhaust is directed away from any operator station located on the apparatus and guarded to protect the operator

21.6.2 If the portable generator is remotely mounted, it shall have a remote operator's control station that shall provide a means for starting and stopping the generator and monitoring the same instrumentation as is required for fixed power sources.

21.6.3 Wiring for Portable Generator Installations. Wiring installed for the purpose of facilitating the distribution of power from a portable generator installation to fixed wiring on the apparatus shall conform to the additional requirements of 21.6.3.1 through 21.6.3.5.

21.6.3.1 Circuit conductors shall be sized in relation to the power source specification label rating and shall be protected by an overcurrent device commensurate with their amperage capacities.

21.6.3.2 There shall be a single output connector cord with all of the conductors in the cord sized to carry a minimum of 115 percent of the nameplate amperage.

21.6.3.3 If there is not an overcurrent protection device at the power source, the output connector cord shall not exceed 72 in. (1830 mm) in length and shall be connected to an overcurrent protection device.

21.6.3.4 The rating of an external main overcurrent protection device shall equal the rated amperage on the power source specification label or the next larger available size overcurrent protection device where so recommended by the power source manufacturer.

21.6.3.5 If a connecting plug is required, it shall be sized in relation to the system and conform to NEMA configurations for plugs.

21.7 Line Voltage Supplied from an External Source.

21.7.1* If the apparatus is equipped with a fixed power inlet (shoreline inlet), it shall be a permanently mounted inlet (male-recessed type with cover), sized in accordance with the anticipated load, and wired directly to the system or device to be powered or wired to a transfer switch where required by 21.7.2.

21.7.1.1 The protective ground from the shoreline inlet shall be bonded to the vehicle frame.

21.7.2 Transfer Switch Applications.

21.7.2.1 A transfer switch shall be required to isolate one power source from the other where a circuit(s) is intended to be supplied from more than one power source.

21.7.2.2 Transfer equipment, including transfer switches, shall operate such that all ungrounded conductors of one power source are disconnected before any ungrounded conductors of the second power source are connected.

21.7.2.3 The neutral conductor shall be switched through the transfer switch.

21.7.3 The apparatus shall have a label permanently affixed at the power inlet that indicates the information shown in Figure 21.7.3.

21.8 Power Supply Assembly.

21.8.1 The conductors used in the power supply assembly between the output terminals of the power source and the main overcurrent protection device shall not exceed 12 ft (4 m) in length.

21.8.2 All power supply assembly conductors, including neutral and grounding conductors, shall have an equivalent ampere rating and shall be sized to carry not less than 115 percent of the ampere rating of the nameplate current rating of the power source.

21.8.3* If the power supply assembly connects to the vibrating part of a generator (not a connection on the base), the conductors shall be flexible cord or other fine-stranded conductors enclosed in metallic or nonmetallic liquidtight flexible conduit rated for wet locations and temperatures not less than 194°F (90°C).

21.9 Overcurrent Protection. Manually resettable overcurrent devices shall be installed to protect the line voltage electrical system components.

21.9.1 Power Source Protection. A main overcurrent protection device shall be provided that is either incorporated in the power source or connected to the power source by a power supply assembly.

21.9.1.1 The size of the main overcurrent protection device shall not exceed 100 percent of the rated ampere rating stated on the power source specification label or the rating of the next larger available size overcurrent protection device, where so recommended by the power source manufacturer.

21.9.1.2 If the main overcurrent protection device is subject to road spray, the unit shall be housed in a Type 4-rated enclosure.

Shorepower Inlet	
Line voltage	_____ volts
Current rating	_____ amps

FIGURE 21.7.3 Shorepower Inlet Label.

21.9.2 Branch Circuit Overcurrent Protection. Overcurrent protection devices shall be provided for each individual circuit and shall be sized at not less than 15 amps in accordance with 240.4, "Protection of Conductors," of *NFPA 70*.

21.9.2.1 Any panelboard shall have a main breaker where the panel has six or more individual branch circuits or the power source is rated 8 kW or larger.

21.9.2.2 Each overcurrent protection device shall be marked with a label to identify the function of the circuit it protects.

21.9.2.3 Dedicated circuits shall be provided for any large appliance or device (air conditioning units, large motors, etc.) that requires 60 percent or more of the rated capacity of the circuit to which it is connected, and that circuit shall serve no other purpose.

21.9.3 Panelboards. All fixed power sources shall be hardwired to a permanently mounted panelboard unless one of the following conditions exists:

- (1) All line voltage power connections are made through receptacles on the power source and the receptacles are protected by integrated overcurrent devices.
- (2) Only one circuit is hardwired to the power source, which is protected by an integrated overcurrent device.

21.9.3.1 The panel shall be visible and located so that there is unimpeded access to the panelboard controls.

21.9.3.2 All panelboards shall be designed for use in their intended location.

21.9.3.3 The panel(s) shall be protected from mechanical damage, tool mounting, and equipment storage.

21.9.3.4* Where the power source is 120/240 V and 120 V loads are connected, the apparatus manufacturer or line voltage system installer shall consider load balancing to the extent that it is possible.

21.10* Wiring Methods. Fixed wiring systems shall be limited to the following:

- (1) Metallic or nonmetallic liquidtight flexible conduit rated at temperatures not less than 194°F (90°C) with stranded copper wire rated for wet locations and temperatures not less than 194°F (90°C)
- (2) Type SOW, SOOW, SEOW, or SEOOW flexible cord rated at 600 V and at temperatures not less than 194°F (90°C)

21.10.1 Electrical cord or conduit shall not be attached to chassis suspension components, water or fuel lines, air or air brake lines, fire pump piping, hydraulic lines, exhaust system components, or low voltage wiring and shall be arranged as follows:

- (1) Separated by a minimum distance of 12 in. (300 mm) from exhaust piping or shielded from such piping
- (2) Separated from fuel lines by a minimum distance of 6 in. (150 mm)

21.10.2 A means shall be provided to allow "flexing" between the driving and crew compartment, the body, and other areas or equipment whose movement would stress the wiring.

21.10.3 Electrical cord or conduit shall be supported within 6 in. (150 mm) of any junction box and at a minimum of every 24 in. (600 mm) of run.

21.10.3.1 Supports shall be made of nonmetallic materials or of corrosion-resistant or corrosion-protected metal.

21.10.3.2 All supports shall be of a design that does not cut or abrade the conduit or cord and shall be mechanically fastened to the apparatus.

21.10.4 Only fittings and components listed for the type of cord or conduit being installed shall be used.

21.10.5* Splices shall be made in a listed junction box or in accordance with Section 110.14(B) of *NFPA 70*, and they shall be in an accessible location that can be exposed without damaging the structure or finish of the vehicle.

21.10.6 Additional Requirements for Flexible Cord Installations.

21.10.6.1* Where flexible cord is used in any location where it could be damaged, it shall be protected by installation in conduit, enclosures, or guards.

21.10.6.2 Where flexible cord penetrates a metal surface, rubber or plastic grommets or bushings shall be installed.

21.10.7 Wiring Identification.

21.10.7.1 Each line voltage circuit originating from the main panelboard shall be identified.

21.10.7.2 The wire or circuit identification either shall reference a wiring diagram or wire list or shall indicate the final termination point of the circuit.

21.10.7.3 Where prewiring for future power sources or devices exists, the unterminated ends shall be marked with a label showing their wire size and intended function.

21.11 Wiring System Components.

21.11.1 Only stranded copper conductors with an insulation rated for temperatures of at least 194°F (90°C) and wet locations shall be used.

21.11.1.1 Conductors in flexible cord shall be sized in accordance with Table 400.5(A)(1) of *NFPA 70*.

21.11.1.2 Conductors used in conduit shall be sized in accordance with 310.15 of *NFPA 70*.

21.11.1.3 Aluminum or copper-clad aluminum conductors shall not be used.

21.11.2 All boxes shall conform to and be mounted in accordance with Article 314 of *NFPA 70*.

21.11.2.1 All boxes shall be accessible using ordinary hand tools.

21.11.2.2 Boxes shall not be permitted behind welded or pop-riveted panels.

21.11.2.3 The maximum number of conductors permitted in any box shall be in accordance with 314.16, "Number of Conductors in Outlet, Device, and Junction Boxes, and Conduit Bodies," of *NFPA 70*.

21.11.3* All wiring connections and terminations shall provide a positive mechanical and electrical connection.

21.11.3.1 Connectors shall be installed in accordance with the manufacturer's instructions.

21.11.3.2 Wire nuts or insulation displacement and insulation-piercing connectors shall not be used.

21.11.4* Each switch shall indicate the position of its contact points (i.e., open or closed) and shall be rated for the continuous operation of the load being controlled.

21.11.4.1 All switches shall be marked with a label indicating the function of the switch.

21.11.4.2* Circuit breakers used as switches shall be "switch rated" (SWD) or better.

21.11.4.3 Switches shall simultaneously open all associated line voltage conductors.

21.11.4.4 Switching of the neutral conductor alone shall not be permitted.

21.11.4.5 Line voltage circuits controlled by low voltage circuits shall be wired through properly rated relays in listed enclosures that control all nongrounded current-carrying conductors.

21.11.5* Receptacles and Inlet Devices.

21.11.5.1 Wet and Dry Locations.

21.11.5.1.1 All wet-location receptacle outlets and inlet devices, including those on hardwired, remote power distribution boxes, shall be of the grounding type, provided with a wet location cover, and installed in accordance with 406.9 of *NFPA 70*.

21.11.5.1.2 All receptacles located in a wet location shall be not less than 24 in. (600 mm) from the ground.

21.11.5.1.3* Receptacles on off road fire apparatus shall be a minimum of 30 in. (750 mm) from the ground.

21.11.5.2 All receptacles located in a dry location shall be both of the following:

- (1) Of the grounding type
- (2) At least 3 in. (75 mm) above the interior floor height

21.11.5.3 No receptacle shall be installed in a face-up position.

21.11.5.4 The face of any wet location receptacle shall be installed in a plane from vertical to not more than 45 degrees off vertical.

21.11.5.5 Receptacle Label.

21.11.5.5.1 Each receptacle shall be marked with a label indicating the nominal line voltage (120 volts or 240 volts) and the current rating in amps of the circuit.

21.11.5.5.2 If the receptacle is dc or other than single phase, that information shall also be marked on the label.

21.11.5.6* All receptacles and electrical inlet devices shall be listed to UL 498, *Attachment Plugs and Receptacles*, or other recognized performance standards.

21.11.5.7 Receptacles used for dc voltages shall be rated for dc service.

21.12 Cord Reels. All permanently mounted cord reels shall be rated for continuous duty and installed to be accessible for removal, cord access, maintenance, and servicing.

21.12.1 The power rewind cord reel spool area shall be visible to the operator during the rewind operation, or the reel spool

shall be encapsulated to prevent cord from spooling off the reel.

21.12.2 Rollers or guides shall be provided, where required, to prevent damage to the cord at reel spools or compartment openings.

21.12.3 Rewind Provision.

21.12.3.1 Manually operated reels shall have a hand crank.

21.12.3.2 Power rewind-type reels shall have the control in a position where the operator can observe the rewinding operation. If a reel is in an enclosure or out of direct view, the cord entry point to the enclosure shall be visible to the operator of the reel control.

21.12.3.3 The rewind control or crank shall not be more than 72 in. (1830 mm) above the operator's standing position.

21.12.3.4 The rewind control shall be marked with a label indicating its function and shall be guarded to prevent accidental operation.

21.12.4* The reel shall be designed to hold 110 percent of the capacity needed for the intended cord length.

21.12.5* The wire size shall be in accordance with Table 400.5(A)(1) of *NFPA 70*, but in no case shall it be smaller than 12 AWG.

21.12.6* Electrical cord shall be Type SEOOW, Type SOOW, or Type STOOW.

21.12.7* A label that indicates the following information shall be provided in a visible location adjacent to any permanently connected reel:

- (1) Current rating
- (2) Current type
- (3) Phase
- (4) Voltage
- (5) Total cord length

21.12.8 Where a power distribution box is hardwired to the end of a cord that is stored on a fixed cord reel or other fixed storage means, the requirements in 21.12.8.1 through 21.12.8.6 shall apply.

21.12.8.1 The remote power distribution box shall be listed for use in a wet location.

21.12.8.2* The distribution box shall be as follows:

- (1) Protected from corrosion
- (2) Capable of being carried with a gloved hand
- (3) Designed to keep the exterior electrical components above 2 in. (51 mm) of standing water

21.12.8.3 Inlets, receptacles, circuit breakers, or GFCI devices shall not be mounted in a face-up position.

21.12.8.4 Branch circuit breakers shall be installed in the remote power distribution box if the overcurrent device protecting the feed cord to the box is too large to protect the wiring supplying the devices plugged onto the distribution box.

21.12.8.5* Remote power distribution boxes shall have a light on the box to indicate the power is on.

21.12.8.5.1* The light shall be visible in a 360 degree plane from a minimum of 200 ft (60 m) in complete darkness.

21.12.8.5.2 The light shall be mechanically protected to prevent damage.

21.12.8.6 The hardwired portable cord connection to the box shall have strain relief and meet the intended usage requirements.

21.13* Scene Lighting Systems. Where fixed line-voltage scene lights are supplied, the requirements in 21.13.1 through 21.13.6 shall apply.

21.13.1 All scene lights shall be both of the following:

- (1) Provided with a lens or a means for preventing damage from water spray
- (2) Listed for wet location usage

21.13.2 Handle on Lights.

21.13.2.1* If the light is adjustable, and the housing temperature can exceed 131°F (55°C) at 110°F (43°C) ambient temperature, a handle shall be provided.

21.13.2.2 The design of the light shall not allow the temperature of the handle to exceed 131°F (55°C) at 110°F (43°C) ambient temperature.

21.13.3 Testing and Listing.

21.13.3.1 The manufacturer of the device shall have the scene light tested by a nationally recognized testing laboratory and listed to UL 153, *Portable Electric Luminaires*, or UL 1598, *Luminaires*.

21.13.3.2 If the light source is LED, the manufacturer of the device shall also have the scene light tested by a recognized testing laboratory and listed to UL 8750, *Light Emitting Diode (LED) Equipment for Use in Lighting Products*.

21.13.3.3 If the scene light is powered by an external Class 2 power supply, the manufacturer of the device shall also have the power supply tested by a recognized testing laboratory and listed to UL 1310, *Standard for Class 2 Power Units*.

21.13.4 If manually operated floodlights are not operable from the ground, access steps that meet the requirements of Section 12.6 and handrails that meet the requirements of Section 12.7 shall be provided to allow the user to reach the floodlights.

21.13.5 Any scene lights shall be mounted in a way that they do not block the DOT clearance, identification, or other required 49 CFR 571.108 lights on the cab or the body.

21.13.6* All devices used for scene lighting shall show no more than 25 percent drop in light output from initial turn-on with the light at room temperature to photometric stability per SAE J1889, *L.E.D. Signal and Marking Lighting Devices*.

21.14 Power-Operated Light Mast.

21.14.1* General.

21.14.1.1 The mast shall be designed to sustain the intended tip load with at least a 125 percent safety factor.

21.14.1.2 The mast shall withstand a minimum of a 50 mph (80 kph) wind in a raised, unguyed position.

21.14.2* Installation and Operational Requirements.

21.14.2.1 The mast shall be capable of being raised within 2 minutes.

21.14.2.2 Where the installation precludes the operator from seeing the light in its nested position, a means shall be provided to allow the operator to align the light for nesting when the operator is at the operator's position.

21.14.2.3* Appropriate warning labels on the hazards of electrocution shall be installed.

21.14.2.4 A means shall be provided to prevent operations that could cause damage to the power supply conductors.

21.14.2.5 In the event of a failure of the light tower's raising system while the tower is deployed or being deployed, a means shall be provided to limit the rate of descent in order to prevent injury to equipment or personnel.

21.14.2.6 A secondary means of control shall be provided to allow for emergency lowering of the mast.

21.14.2.7 Where the tower is powered by the chassis air brake system, the air supply shall be from an auxiliary air circuit that is equipped with a pressure protection valve and an auxiliary air tank(s).

21.14.2.8* An automatic de-energizing means shall be provided so there is no electrical power to the mast or to the light wiring when the mast is in a stowed position.

21.14.2.9 The hazard warning light required in Section 10.10 shall be illuminated whenever the light tower is not in the stowed position.

21.14.2.10 The operational envelope of the mast shall be automatically illuminated whenever the mast assembly is being raised, lowered, or rotated.

21.14.3 Labeling.

21.14.3.1 An instruction plate showing the operation of the mast and operational warning signs shall be provided at the operator's position.

21.14.3.2 A label shall be provided at the operator's position to indicate the following:

- (1) Extended tower height from the ground
- (2) Bulb replacement data

21.15* Electrical System Testing.

21.15.1 The wiring and associated equipment shall be tested by the apparatus manufacturer or the installer of the line voltage system.

21.15.2 Dielectric Voltage Withstand Test.

21.15.2.1 The wiring and permanently connected devices and equipment shall be subjected to a dielectric voltage withstand test of 900 volts for 1 minute.

21.15.2.2 The testing shall be performed after all body work has been completed.

21.15.2.3* The test shall be conducted as follows:

- (1) Isolate the power source from the panel board and disconnect any solid state low voltage components.

- (2) Connect one lead of the dielectric tester to all the hot and neutral buses tied together.
- (3) Connect the other lead to the fire apparatus frame or body.
- (4) Close any switches and circuit breakers in the circuit(s).
- (5) Apply the dielectric voltage for 1 minute in accordance with the testing equipment manufacturer's instructions.

21.15.3* The electrical polarity of all permanently wired equipment, cord reels, and receptacles shall be tested to verify that wiring connections have been properly made.

21.15.4 Electrical continuity shall be verified from the chassis or body to all line voltage electrical enclosures, light housings, motor housings, light poles, switch boxes, and receptacle ground connections that are accessible to firefighters in normal operations.

21.15.5 If the apparatus is equipped with a transfer switch, it shall be tested to verify operation and that all current-carrying conductors are switched.

21.15.6 Electrical light towers, floodlights, motors, fixed appliances, and portable generators shall be operated at their full rating or capacity for 30 minutes to ensure proper operation.

21.15.7* Certification Test of Power Source.

21.15.7.1 The apparatus manufacturer or installer of the power source shall perform a certification test on the power source.

21.15.7.2 The testing of the power source shall be witnessed, and the results of the tests of the power source shall be certified by an independent third-party certification organization.

21.15.7.3 Test Procedure.

21.15.7.3.1 The prime mover shall be started from a cold start condition, and the unloaded voltage and frequency shall be recorded.

21.15.7.3.2 The line voltage electrical system shall be loaded to at least 100 percent of the continuous rated wattage stated on the power source specification label. Testing with a resistive load bank shall be permitted.

21.15.7.3.3 The power source shall be operated in the manner specified by the apparatus manufacturer as documented on instruction plates or in operation manuals.

21.15.7.3.4 The power source shall be operated at a minimum of 100 percent of the continuous rated wattage as stated on the power source specification label for a minimum of 2 hours.

21.15.7.3.4.1 The load shall be adjusted to maintain the output wattage at or above the continuous rated wattage during the entire 2-hour test.

21.15.7.3.4.2 The following conditions shall be recorded at least every ½ hour during the test:

- (1) The power source output voltage, frequency, and amperes
- (2) The prime mover's oil pressure, water temperature, and transmission temperature, if applicable
- (3) The power source hydraulic fluid temperature, if applicable
- (4) The ambient temperature and power source air inlet temperature

21.15.7.3.4.3 The following conditions shall be recorded once during the test for power sources driven by dedicated auxiliary internal combustion engines:

- (1) Altitude
- (2) Barometric pressure
- (3) Relative humidity

21.15.7.3.5 If the generator is driven by the chassis engine and the generator allows for operation at variable speeds, the chassis engine speed shall be reduced to the lowest rpm allowed for generator operation and the voltage and frequency shall be recorded.

21.15.7.3.6 The load shall be removed, and the unloaded voltage and frequency shall be recorded.

21.15.7.3.7 Voltage shall be maintained within ± 10 percent of the voltage stated on the power source specification label during the entire test.

21.15.7.3.8 Frequency shall be maintained within ± 3 Hz of the frequency stated on the power source specification label during the entire test.

21.15.7.3.9 The total continuous electrical loads, excluding those loads associated with the equipment defined in 21.15.7.3.11.2, shall be applied during the testing unless an auxiliary engine drives the power source.

21.15.7.3.10 Concurrent Pumping.

21.15.7.3.10.1* If the apparatus is equipped with a fire pump, the 2-hour certification test of the power source shall be completed with the fire pump pumping at 100 percent capacity at 150 psi (1000 kPa) net pump pressure.

21.15.7.3.10.2 The test shall be permitted to be run concurrently with the pump certification test required in 13.13.1.

21.15.7.3.10.3 Running the pump during testing of portable generators connected to fixed wiring on the apparatus shall not be required unless the generator is mounted in an area subjected to a rise in ambient temperature greater than 30°F (17°C) from the vehicle engine, pump, or other heat source.

21.15.7.3.11 Prime Mover–Driven Accessories.

21.15.7.3.11.1 Accessories driven by the power source prime mover shall not be functionally disconnected or otherwise rendered inoperative during the line voltage electrical tests.

21.15.7.3.11.2 The following devices shall be permitted to be turned off or not operating during the fixed power source test:

- (1) Aerial hydraulic pump
- (2) Foam pump
- (3) Hydraulically driven equipment other than a hydraulically driven line voltage generator
- (4) Winch
- (5) Windshield wipers
- (6) Four-way hazard flashers
- (7) Compressed air foam system (CAFS) compressor

21.15.7.3.12 If the line voltage power is derived from the fire apparatus's low voltage system and is the primary source for line voltage, the power source shall not be shed by a load management system during the 2-hour test.

21.15.8 The results of each test shall be recorded on an appropriate form and provided with the delivery of the fire apparatus.

Chapter 22 Fire Apparatus — Command and Communications (NFPA 1901)

22.1 General. If the fire apparatus is equipped with a separate communications area or if it is used as a totally dedicated command apparatus, it shall meet the requirements of this chapter.

22.2* Location. The command center shall be enclosed within a vehicle crew area or body.

22.3* Climate Control.

22.3.1 The command area shall be provided with a heater capable of maintaining the temperature at a minimum of 60°F (16°C) with the fire apparatus's doors closed.

22.3.2 If an air conditioner is provided, it shall be capable of maintaining a minimum temperature of 20°F (11°C) below ambient down to 72°F (22°C) with the fire apparatus's doors closed.

22.4* Noise Levels. When the fire apparatus is stopped with all components on the apparatus required for continuous operation at an incident in operation, the noise levels in the command area shall not exceed 80 dBA.

22.5 Lighting Levels.

22.5.1 The command area shall have a switch control at the door entry area for general entry lighting or automatic dome lighting.

22.5.2* Lighting levels during command operations shall provide a continuous 25 fc (269 lx) in the command area.

22.6* Command Working Surfaces and Countertop. Horizontal working surfaces shall be smooth and shall have corners and edges that will not cause injury or damage when rubbed up against.

22.7 Seating in Command Center.

22.7.1* If seating is provided in the command center and that same seating is used during mobile operations (moving over the highway), the seat(s) and crew area(s) shall comply with Section 11.1.

22.7.2 Storage shall be provided for all seating that is not permanently mounted in the fire apparatus so that the seating can be stored in such a way as to protect all passengers while the fire apparatus is in motion.

22.7.3 Safety sign FAMA06 shall be visible from each seat that is not equipped with occupant restraint and is therefore not intended to be occupied while the vehicle is in motion.

22.8* Cabinets and Equipment Storage. Cabinets for the storage of equipment shall be designed and engineered to contain the equipment during periods of transit.

22.9 Wall, Ceiling, and Floor Surfaces.

22.9.1* The interior surfaces of command areas shall be free of sharp corners, projections, and edges.

22.9.2 Floor surfaces shall be capable of being routinely cleaned.

22.9.2.1 Floor mats or coverings shall be durable and removable for cleaning.

22.9.2.2 Floor surfaces, walking surfaces, and access steps shall comply with Section 12.6.

22.9.2.3 Access handrails shall comply with Section 12.7.

22.9.3 Dry-type greaseboards, corkboards, chalk-type boards, or similar bulletin- or command-type wall surfaces shall be fastened in place and shall be replaceable.

22.10 Communications and Electrical Consoles.

22.10.1* The communications equipment shall be installed in accordance with the component manufacturer's instructions and manuals.

22.10.2 If a radio or electrical console is provided, it shall be enclosed on all sides to afford protection to equipment mounted in the console.

22.10.2.1 The front surface shall be hinged or bolted in place.

22.10.2.2 Additional hinged or removable panels shall be provided, as required, for access to equipment.

22.11* Computer Equipment and Installation.

22.11.1 All computer equipment shall be installed in a manner to reduce shock, vibration, and mechanical injury.

22.11.2 All equipment not used during transit, such as computer equipment, shall be stored in cabinets or mounted to comply with 11.1.11.

22.11.3 Electrical outlets specifically for computer use, whether low voltage or line voltage, shall be marked with a label for their intended usage and power output.

22.12 Video Equipment and Installation.

22.12.1 The purchaser shall detail the exact video equipment that is to be mounted on and used with the apparatus.

22.12.2 If a video monitor is provided, it shall be mounted so as to prevent it from being damaged during transit.

22.12.3 If the equipment is to be externally mounted, mounting brackets and outlet plugs shall be installed as necessary to accommodate the outside mounting of video equipment.

22.12.4 Roof access ladders, steps, and safety railings shall meet the requirements of and be installed as required by Chapter 12.

22.13 Power Operated Masts. Where power operated masts are supplied, the requirements in 22.13.1 through 22.13.7 shall apply.

22.13.1 The mast shall be designed to sustain the intended tip load with at least a 125 percent safety factor.

22.13.2 The mast shall withstand a minimum of a 50 mph (80 kph) wind in a raised, unguyed position.

22.13.3 In the event of a failure of the tower's raising system while the tower is deployed or being deployed, a means shall be provided to limit the rate of descent in order to prevent injury to equipment or personnel.

22.13.4 A secondary means of control shall be provided to allow for emergency lowering of the mast.

22.13.5 Where the tower is powered by the chassis air brake system, the air supply shall be from an auxiliary air circuit that is equipped with a pressure protection valve and an auxiliary air tank(s).

22.13.6 The hazard warning light required in Section 10.10 shall be illuminated whenever the tower is not in the stowed position.

22.13.7 The operational envelope of the mast shall be automatically illuminated whenever the mast assembly is being raised, lowered, or rotated.

Chapter 23 Fire Apparatus — Air Systems (NFPA 1901)

23.1 Application.

23.1.1 Where a breathing air system or a utility air system is mounted on fire apparatus, the requirements of this chapter shall apply.

23.1.2 This chapter shall not apply to a compressed air foam system (CAFS).

23.2* Provisions Applying to All Air Systems.

23.2.1* Compressor- and booster-supplied systems shall be capable of storage and operation in any ambient temperature between 40°F and 110°F (4°C and 43°C).

23.2.2 Cascade and bulk air systems shall be capable of storage and operation in any ambient temperature between 0°F and 110°F (−18°C and 43°C).

23.2.3 The air system shall be designed so that it can be stored and operated in environments with relative humidity up to and including 100 percent.

23.2.4 All materials used in the air system shall be corrosion resistant or treated to resist corrosion unless the finished product will be in continual contact with a noncorrosive lubricant.

23.2.5 Assembly and Installation Practices.

23.2.5.1 Installation of low voltage electrical components shall meet the requirements of Chapter 16, and installation of line voltage electrical components shall meet the requirements of Chapter 25.

23.2.5.2 Hot Surfaces.

23.2.5.2.1 Surfaces over 142°F (61°C) shall be covered with a thermal insulating material or shall be mechanically guarded to protect the operator.

23.2.5.2.2 If covering or guarding the surface affects the operation of the component, a label shall be provided that states "Caution: Hot Surfaces When Operating."

23.2.5.3 The air system shall be designed and constructed to withstand the stresses, vibrations, and other conditions incident to being mounted on a fire apparatus and being used in mobile service.

23.2.5.4 Locking Devices.

23.2.5.4.1 All screws, pins, bolts, and other fasteners whose failure would create a hazardous condition for personnel or equipment shall be equipped with locking devices.

23.2.5.4.2 Safety wire, self-locking nuts, cotter pins, lock washers, and liquid-locking compounds shall be acceptable.

23.2.6 Breathing Air Systems.

23.2.6.1* Each part utilized in the fabrication of the air system and its components shall be designed for use in compressed-breathing-air service at pressures, temperatures, and flow rates that will be encountered during actual air system operation.

23.2.6.2 Discharge air from a compressor shall pass through a purification system prior to distribution.

23.2.6.3 Prior to the initial air quality test and commissioning, the breathing air system shall be purged with pure air until moisture and other contaminants have been removed.

23.2.7 General Piping and Installation.

23.2.7.1 All pneumatic fittings, tubing, and hose shall be rated for the maximum allowable working pressure that could be encountered, with a test safety factor of not less than 4:1.

23.2.7.2 All pneumatic fittings, tubing, and hose shall be corrosion resistant or treated to resist corrosion.

23.2.7.3 No threaded close nipples shall be used.

23.2.7.4 Plugs shall be bar stock type with Allen head or hex heads.

23.2.7.5 All piping and tubing shall be blown clean with clean, dry air before being installed.

23.2.7.6 When making up threaded piping joints, the sealant shall be applied to the thread in a manner that will prohibit entry of the sealant into the piping system.

23.2.7.7 Pipes or tubes installed but not connected shall have the ends closed with threaded caps or plugs to prevent the entry of foreign material.

23.2.7.8 Air connections on equipment or panels shall be provided with a threaded dust cap on a safety chain or shall be a quick disconnect-type fitting.

23.2.7.9 All exposed piping compressed air lines shall be clamped to a rigid body or chassis component at a minimum of every 24 in. (610 mm) and within 6 in. (150 mm) on each side of a coupling or elbow.

23.2.7.9.1 Piping shall run in an orderly manner in accordance with the air system manufacturer's installation requirements.

23.2.7.9.2 The piping installation shall provide room for maintenance and repairs with access panels provided where applicable.

23.2.7.10 Any rigid piping or flexible lines that run through a compartment shall be protected with removable mechanical protection to prevent wear and damage from equipment stored in the compartment.

23.2.8 Flexible Hose.

23.2.8.1 Flexible hose shall be installed in such a manner as to prevent cuts, abrasions, exposure to damage, excessive temperatures, damage from loose equipment, and excessive bending.

23.2.8.2 The hose shall be installed in a manner that permits removal of the hose without removal of major vehicle components or vehicle-mounted equipment.

23.2.9 Operator's Panel and Controls.

23.2.9.1 The air operator's panel containing gauges, instruments, and valves shall face the operator's position and shall be lighted in compliance with 7.11.1.

23.2.9.2 Any instrument that is to be used as a basis for manual control shall be visible and controlled from the operator's position.

23.2.9.3 Accessory gauges or controls that are not critical to the mission of the air system shall be permitted to be mounted remotely from the operator's panel or at another location where they can be monitored.

23.2.9.4 Pressure gauges or other devices shall not be mounted directly on lines where excessive vibration is likely to occur.

23.2.9.5 With the exception of direct connected process instruments (e.g., pressure gauges), instruments shall not use instrument piping or electrical conduit for support.

23.2.9.6 Any gauge shall be capable of reading at least 110 percent but not greater than 200 percent of maximum working air pressure.

23.2.10 Maintainability.

23.2.10.1 The design of the air system shall provide for maintainability by including, but not necessarily being limited to, the following maintainability objectives and technical and operational constraints:

- (1) The design shall be such that faults can be isolated to allow access to removable assemblies or components.
- (2) Electrical panels, junction boxes, circuit breakers, and fuses shall be readily accessible.
- (3) The physical arrangement of components shall be such that they can be inspected, serviced, calibrated, and, if necessary, adjusted without being removed and with minimum disturbance to other parts.
- (4) The design shall be such that inspection, service, and replacement can be accomplished using a minimum of special tools and support equipment.
- (5) Test points shall be provided to facilitate malfunction isolation and the connection of calibration instrumentation.
- (6) If equipment requires oil or other liquid drainage, it shall be provided with a remote drainage system that is equipped with a control valve, threaded plug or cap, and a label to note usage.

23.2.10.2 If special tools are required to service or maintain the air system, those tools shall be supplied by the manufacturer.

23.2.11 Labels and Plates.

23.2.11.1 All major components and accessories shall be identified with a label.

23.2.11.2 Caution and warning signs shall be affixed where necessary.

23.2.11.3 Instruction plate(s) shall be installed, as applicable, to advise the operator on the proper adjustment or setting of controls for safe operation.

23.2.11.4 Controls, gauges, valves, and other equipment shall be marked with a label indicating their function.

23.2.11.5 All controls and valves shall have a label to indicate movement direction.

23.2.11.6* The major component manufacturers and installers of the air system shall provide electrical diagrams and air piping drawings that document the system and its operation.

23.2.11.6.1 All symbols used shall be described in key charts on the drawings.

23.2.11.6.2 All diagrams and drawings shall be delivered with the fire apparatus.

23.2.11.6.3 The following information shall be shown:

- (1) The general arrangement of the air system, including air storage, air compressor (if provided), air panel, SCBA fill station (if provided), and air inlets and outlets
- (2) The electrical wiring arrangement and controls, denoting shorepower equipment, low voltage equipment, and line voltage equipment
- (3) The air operator's control panel surface showing all controls, gauges, valves, outlets, and other specified equipment, including the labeling on the panel and controls
- (4) The air piping arrangement with airflow direction indicated and showing all valves, gauges, controls, air tanks, and furnished equipment

23.2.12 Documentation.

23.2.12.1 Two complete sets of documentation that cover the operation and maintenance of the system shall be delivered with the fire apparatus.

23.2.12.2 The documentation shall be permitted to be in printed format, electronic format, audiovisual format, or a combination thereof.

23.2.12.3 Nomenclature for switches, controls, and indicators shall be consistent with that used on the diagrams required in 23.2.11.6 and on equipment nameplates.

23.2.12.4 The manuals shall include, but not necessarily be limited to, the following:

- (1) An illustrated parts lists
- (2) A schedule of maintenance and adjustment checks
- (3) A lubrication schedule
- (4) Troubleshooting information to enable a technician to locate trouble and to make repairs or adjustments to the equipment
- (5) Step-by-step procedures for starting, operating, and stopping the equipment

23.2.13 Training and Instruction.

23.2.13.1* If a breathing air system without a compressor/purification system is provided, the final installer of the air system shall supply a qualified person to provide operational

training to the purchaser's designated personnel that includes the following:

- (1) A complete system component familiarization/walk-around
- (2) A complete review of the system and its safety features
- (3) A review of all operation, service, and maintenance documentation
- (4) Hands-on familiarization of the safe operation of the fill station and air management panel, including actual SCBA filling, air reel operations, and other pertinent operations of the system

23.2.13.2* If a breathing air system that includes a compressor/purification system is provided, a person certified by the breathing air compressor manufacturer in the operation of the specified air compressor system shall provide training to the purchaser's designated personnel.

23.2.13.2.1 The training shall include the items listed in 23.2.13.1.

23.2.13.2.2 The training shall also include the following:

- (1) A review of the compressor/purification system operations and maintenance, including the operations and maintenance documentation and the name, address, and phone number of the local distributor
- (2) Procedures to change purification cartridges
- (3) Hands-on familiarization of the safe operation of the compressor and purification system

23.2.13.3 The purchaser shall designate one or two individuals to be the resource persons for all the breathing air system training and equipment indoctrination.

23.2.13.4 The purchaser shall designate where the training is to take place.

23.3* Breathing Air Compressor.

23.3.1 The purchaser shall determine the working pressure and capacity required from the compressor and state those requirements in the purchase specifications.

23.3.2 Compressor Intake.

23.3.2.1* The air intake shall be located where it will not be contaminated by the exhaust of the fire apparatus or the exhaust of the gasoline or diesel engines used to power the compressor or other components on the apparatus.

23.3.2.2 If an extended air intake pipe is used, it shall be installed in accordance with the compressor manufacturer's specifications.

23.3.3 Cooling.

23.3.3.1 The final installer shall assemble and install all components in accordance with the component manufacturers' instructions and shall test the final assembled system in accordance with this standard and the operating parameters of the component manufacturers.

23.3.3.2* Provisions shall be made by the final installer to ensure there is adequate cooling to keep the air compressor within the compressor manufacturer's operating temperature range while the vehicle is operating in an ambient temperature range between 40°F and 110°F (4°C and 43°C).

23.3.3.2.1 The final stage installer of the air compressor shall submit air system arrangement drawings, airflow schematic drawings, body drawings, and other pertinent data to the air compressor assembler for written approval.

23.3.3.2.2 A copy of this approval shall be retained by the final assembler in apparatus documentation.

23.3.3.3 The temperature of the compressed air shall not exceed 20°F (11°C) above ambient when measured at the discharge nozzle of the compressor aftercooler.

23.3.3.4 The air compressor compartment shall be equipped with a temperature sensing device that will actuate an audible and visual alarm at the fill station operator's panel when the compartment temperature exceeds the compressor manufacturer's requirements.

23.3.3.5* The final stage installer shall provide a warning label(s) cautioning: "Do not obstruct airflow path with equipment mounting."

23.3.4 A relief valve shall be provided after each stage of compression.

23.3.5 If interstage condensate traps are provided by the compressor manufacturer, they shall be plumbed with the final separator and to an automatic condensate drain system, which shall be plumbed to a reservoir to collect the discharged liquids.

23.3.6 Compressor Drive System, Controls, and Air Quality Monitoring.

23.3.6.1 All compressors shall have automatic audible and visual alarms and controls at the main operator's panel that shut down the compressor and prevent automatic restart when any of the following conditions occurs:

- (1) Oil level or oil pressure is low.
- (2) Discharge air temperature is higher than recommended by the manufacturer.
- (3) Moisture in the compressed air at the purification system outlet exceeds the allowances established in NFPA 1989.
- (4) Carbon monoxide level within the processed air exceeds the allowances established in NFPA 1989.

23.3.6.2* All compressors shall be equipped with the following:

- (1) An air pressure switch that controls the maximum operating pressure
- (2) Interstage pressure gauges after each compression stage
- (3) Final stage pressure gauge
- (4) Oil pressure gauge on pressure lubricated compressors or an oil level indicator or device on nonpressure lubricated compressors
- (5) Electric, nonresettable hour meter(s)

23.3.6.3* Compressors with electric motors shall be equipped with the following:

- (1) Magnetic motor starter with motor overload protection
- (2) Protective control to prevent automatic restart after power loss has been restored

23.3.6.4 Compressors with gasoline and diesel engines shall be equipped with the following:

- (1) Means to allow the engine to be started, idled, and run with the compressor disengaged or unloaded

- (2) Electric, nonresettable hour meter to record engine operating hours

23.3.7 The compressor and driver assembly shall be mounted in accordance with the compressor manufacturer's requirements.

23.3.7.1 The compressor frame shall have provision for safe handling or lifting.

23.3.7.2 Frames for compressors with V-belt drives shall include a means to adjust the V-belt tension.

23.3.8 The air compressor shall have a label affixed in a conspicuous location showing the name and address of the manufacturer, the serial number and model number, the date of manufacture, and the rated capacity.

23.4 Purification System. If the compressed air system is to supply breathing air, a purification system that meets the requirements of 23.4.1 through 23.4.8 shall be installed.

23.4.1* If the processed air is to be used as breathing air, the purification system shall produce breathing air that meets the requirements of NFPA 1989.

23.4.2 If the processed air is to be used for underwater diving, the purification system shall produce breathing air that meets the requirements of Grade E breathing air as specified by CGA G-7.1, *Commodity Specification for Air*.

23.4.3 The purification system shall be capable of producing the required air quality at full capacity of the compressor for a minimum of 50 hours with inlet air of 80°F (27°C) at saturation.

23.4.3.1 The purification system shall be equipped with purifier cartridges and filter elements.

23.4.3.2* The design of the purification system shall permit replacement of the purifier cartridges without disconnecting piping or other components.

23.4.3.3 The purifier system shall be protected from mechanical damage caused by loose equipment stored on the apparatus.

23.4.4 A relief valve shall be provided in the purification system, set no higher than 10 percent above the maximum allowable working pressure.

23.4.5 A mechanical separator shall be provided and shall be piped to the automatic drain system.

23.4.5.1 A check valve shall be installed between the mechanical separator and the remainder of the purification system.

23.4.5.2 The mechanical separator and the purifier housings shall be designed for a 4:1 safety factor at their maximum allowable working pressure.

23.4.5.3 The mechanical separator and the purifier housings shall be corrosion resistant or treated to resist corrosion.

23.4.6 A pressure gauge shall be installed ahead of the purifier to monitor depressurization before service, maintenance, or repairs of the compressor or purifier.

23.4.7 A pressure regulator valve (back pressure regulator or minimum pressure valve) with a minimum setting of 2000 psi (14,000 kPa) shall be installed in the purification system downstream of the mechanical separator and purifier housings.

23.4.7.1 A piping connection shall be provided downstream of the pressure regulator valve to provide an air sample for the air quality testing.

23.4.7.2 A line valve shall be installed on the purifier outlet to allow the purifier to be isolated from the downstream air system during inspection, maintenance, and repairs.

23.4.8 A warning label shall be installed at the purifier chambers as follows:

WARNING: Prior to changing purifier cartridges, or performing service or maintenance on the purifier system, release all air pressure in the air compressor system.

23.5* Air Storage Systems.

23.5.1 Transportable Air Tanks.

23.5.1.1 Transportable air tanks shall comply with 49 CFR 178.37, "Specification 3AA and 3AAX seamless steel cylinders," or 29 CFR 1910.169, "Air receivers."

23.5.1.2* The cylinders shall have the data required by the UN/DOT or ASME permanently stamped or labeled (composite cylinders cannot be stamped) according to the regulating agency they are certified under. This data shall include but not be limited to the working pressure, date of manufacture, and date of the most recent test. Cylinders that are not new shall be verified by the supplier that they are acceptable for breathing air use.

23.5.1.3 Relief valves on transportable air tanks shall be of the ASME type on ASME cylinders and of the UN/DOT type on UN/DOT cylinders or equal for the rated pressure.

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

23.5.3 If the installation utilizes cylinders that require periodic testing, a label shall be placed on or near the operator's panel that provides the following:

- (1) The original cylinder test date stamped on the cylinders
- (2) The recommended testing interval
- (3) Five additional open spaces, appropriately labeled, for the user to enter actual retesting dates

23.5.4 The manufacturer's test date (month and year) on each air tank shall be current within 12 months of the apparatus delivery date.

23.5.5 Air tanks shall be marked with a label that reads "High Pressure ____ psi Breathing Air" or "High Pressure ____ kPa Breathing Air."

23.5.6 Air Tank Mounting.

23.5.6.1* Air tanks shall be mounted in an arrangement that will hold the tanks in all types of mobile use.

23.5.6.1.1 A protective device(s) shall be provided to protect the air tank valve(s) and associated piping from damage as a result of accidental impact.

23.5.6.1.2 The protective device(s) shall not prevent access for operation and inspection.

23.5.6.2 The air tank mounting shall facilitate removal of air tanks for inspection, testing, or service.

23.5.6.2.1 Air tanks shall be installed so that all air tanks, control valves, and associated piping are readily accessible.

23.5.6.2.2 Air tanks shall be mounted in such a fashion to permit visual inspection of external surfaces and emergency access to shutoff of tank valves.

23.5.6.2.3 The air tank location shall be away from any heat-producing devices such as the generator engine or exhaust.

23.5.7 Air Tank Valve Control and Monitoring.

23.5.7.1 A slow-operating valve(s) shall be provided to control airflow into and out of the storage system (if applicable).

23.5.7.2 A separate inlet connection shall be provided so that the storage system can be refilled from a remote source.

23.5.7.2.1 The inlet connection fitting shall be compatible with the rated pressure of the storage system as specified by CGA G-7, *Compressed Air for Human Respiration*, and shall be equipped with a dust cap with a chain and "pin hole" to release leaking pressure when not in use.

23.5.7.2.2 A check valve or a line valve shall be provided on the inlet connection.

23.5.7.3 Gauges shall be provided to allow for monitoring pressures from the air storage system or individual air tanks.

23.5.7.3.1 For systems that are capable only of bulk filling, a minimum of a single gauge shall be provided.

23.5.7.3.2 For systems capable of cascade filling, gauges shall be provided for each individually controlled tank or set of tanks.

23.6* Air Booster Systems.

23.6.1 Line valves shall be provided at the air control panel or on the air booster to control the booster inlet air supply line and the booster discharge airflow.

23.6.2 A pressure gauge shall be provided on the supply line and the discharge line from the booster.

23.6.3 A safety valve or high-pressure switch shall be installed on the discharge side of the air booster.

23.6.4 The pressure setting on the safety valve or high-pressure switch shall not exceed the maximum allowable working pressure of the booster, the booster's distribution piping, or the air system components.

23.7 Air Supply Regulation. Air supply regulation shall include the following provisions on an operator's air control panel:

- (1) One air pressure gauge marked with a label that reads "Supply Pressure" between the air supply line valve and the pressure self-relieving regulator
- (2) One slow-operating air supply valve on the intake supply line
- (3) One self-relieving adjustable pressure regulator equipped with a device to prevent unintentional adjustment
- (4) One air pressure gauge downstream of the pressure regulator
- (5) One pressure relief valve preset at not over 10 percent above the pressure regulator output setting
- (6) A warning label installed next to the pressure regulator to indicate working pressure setting and that a relief valve

will release at 10 percent higher than the working pressure

23.8 Air Control Panel.

23.8.1 The air control panel and system piping arrangement for a compressor-supplied breathing air system shall allow the operator to perform the following functions:

- (1) Fill the storage system directly from the compressor/purification system
- (2) Fill SCBA cylinders directly from the compressor/purification system
- (3) Fill SCBA cylinders directly from the storage system (and air booster, if equipped)
- (4) Utilize the cascade method (if system is capable) or bulk fill method of filling SCBA cylinders
- (5) Bypass filling of the storage system to top off SCBA directly from the compressor/purification system
- (6) Regulate the maximum SCBA fill pressure
- (7) Control the SCBA fill rate with a slow-operating valve

23.8.2 When a cascade system is installed without a compressor, an air control panel and the system piping arrangement shall allow the operator to perform the following functions:

- (1) Fill the storage system directly from a remote air compressor
- (2) Fill SCBA cylinders directly from a remote air compressor
- (3) Fill SCBA cylinders directly from the storage system
- (4) Fill SCBA cylinders directly from a booster pump that is supplied by the storage system, if provided
- (5) Utilize the cascade method, the bulk fill method, or both for filling SCBA cylinders, as appropriate to the design of the system
- (6) Regulate the maximum SCBA fill pressure
- (7) Meter airflow to control the SCBA fill rate with a slow-operating valve
- (8) Take an air sample to check air quality (at the panel or at the end of an air reel hose, if applicable)

23.9 SCBA or SCUBA Air Cylinder Fill Station.

23.9.1 If SCBA and/or SCUBA air cylinders are to be filled from a fire apparatus-mounted air system, the fill station shall meet the requirements of 23.9.1.1 through 23.9.1.6.

23.9.1.1 The fill station shall fully enclose the cylinder during filling to contain the fragments if a cylinder ruptures.

23.9.1.2 The fill station shall fully enclose the refill lines to the cylinders.

23.9.1.3 The fill station shall direct the concussive air blast away from the operator and bystanders.

23.9.1.4 A fill station within an enclosed crew area shall have provisions to vent the concussive air blast to the exterior of the fire apparatus.

23.9.1.5 A means shall be provided to prevent SCBA or SCUBA cylinders from being refilled unless the fill station is in the "cylinder fill operation position."

23.9.1.6 A warning sign shall indicate the hazards inherent in the operation of filling SCBA or SCUBA cylinders.

23.9.2 Pressure gauges, pressure-regulating devices, and controls shall be provided to allow the operator to control the SCBA cylinder fill pressure and fill rate on each SCBA fill hose.

23.9.3 A valve(s) on a fill line(s) shall be a slow-operating valve.

23.9.4 A method of bleeding each air cylinder fill hose shall be provided.

23.9.5* The SCBA or SCUBA fill enclosure shall be installed in accordance with requirements of the fill enclosure manufacturer.

23.9.6 Testing and Certification.

23.9.6.1 The manufacturer of the enclosed air refill station shall type test a standard production model by causing a fully charged air cylinder to fail in the refill station to validate the design.

23.9.6.1.1 If the enclosed air fill station is for SCBA cylinders, it shall be tested as described in 23.9.6.1.1.1 and 23.9.6.1.1.2.

23.9.6.1.1.1 The test shall include pressurizing a composite 5500 psi (37,921 kPa) SCBA cylinder that is capable of holding at least 111 SCF (3143 L) of air at 6050 psi (41,713 kPa) to failure.

23.9.6.1.1.2 The failure shall occur when the pressure in the cylinder is not less than 6050 psi (41,713 kPa).

23.9.6.1.1.3 A failure of the cylinder shall be induced by mechanical impact or explosive device.

23.9.6.1.2 If the enclosed air fill station is for SCUBA cylinders, it shall be tested as described in 23.9.6.1.2.1 and 23.9.6.1.2.3.

23.9.6.1.2.1 The test shall include pressurizing a SCUBA cylinder that is capable of holding at least 80 ft³ (2265 L) of air at 3000 psi (20,685 kPa) to failure.

23.9.6.1.2.2 Failure of a pressurized SCUBA cylinder shall occur when the pressure in the cylinder is not less than 3000 psi (20,685 kPa).

23.9.6.1.2.3 A failure of the cylinder shall be induced by mechanical impact or explosive device.

23.9.6.1.3 If the enclosed air fill station is designed for both SCBA and SCUBA cylinders, the refill station shall be tested in accordance with 23.9.6.1.1.

23.9.6.1.4 If the system provides for simultaneously refilling of multiple cylinders, the other chambers shall contain air cylinders equal in capacity and rated pressure to the cylinder in the chamber being tested.

23.9.6.1.5 The test pressure shall be measured at the SCBA or SCUBA fill enclosure.

23.9.6.1.6 The SCBA or SCUBA fill station shall be tested in a configuration that meets the fill station manufacturer's standard installation requirements.

23.9.6.2 The testing shall prove the following:

- (1) The air refill station is capable of containing all fragments of a failed cylinder.
- (2) The cylinders in adjacent chambers do not rupture.
- (3) The venting provisions direct the air-concussive release away from the operator.

23.9.6.3 All tests shall be witnessed.

23.9.6.4 All test results shall be certified by an independent third-party certification organization.

23.10* Air Hose Reels.

23.10.1* Any permanently mounted air hose reel shall be certified by the reel manufacturer for use at the maximum expected working pressure with a safety factor of at least 4:1.

23.10.2 The air hose reel swivel joint, connecting feed hose, check valve, and air supply equipment shall be rated for the maximum working pressure with a safety factor of at least 4:1.

23.10.3 The air hose reel shall be designed to hold at least 110 percent of the intended hose length with a minimum capacity of 100 ft (30 m).

23.10.4 Size of Fluid Path.

23.10.4.1 The air hose reel shall have a full flow-style swivel joint and a hose connection designed and sized to match the hose intended to be used.

23.10.4.2 The air hose reel shall have a fluid path sized for its intended flow and working pressure.

23.10.5 The reel shall be marked with a label to indicate its intended use and the following:

- (1) Utility air or breathing air
- (2) Operating pressure
- (3) Total hose length
- (4) Hose size (ID)

23.10.6 Air Supply to Air Reel.

23.10.6.1 The following equipment shall be provided on the intake air supply line to the reel where the air supply gauge pressure is up to 150 psi (1000 kPa):

- (1) One air pressure gauge
- (2) One slow-operating air supply valve
- (3) One check valve

23.10.6.2 The following equipment shall be provided on the intake air supply line to the reel where the air supply gauge pressure is between 151 psi (1000 kPa) and 300 psi (2000 kPa):

- (1) One air pressure gauge upstream of the air pressure-regulating device
- (2) One slow-operating air supply valve
- (3) One adjustable pressure regulator equipped with a device to prevent inadvertent or accidental adjustment
- (4) One downstream pressure gauge [0 psi to 500 psi (0 kPa and 3400 kPa) range]

23.10.6.3 The following equipment shall be provided on the intake air supply line to the reel where the air supply gauge pressure is over 300 psi (2000 kPa):

- (1) One air pressure gauge upstream of the air pressure-regulating device
- (2) One slow-operating air supply valve
- (3) One adjustable pressure regulator equipped with a device to prevent inadvertent or accidental adjustment
- (4) One downstream pressure gauge
- (5) One preset pressure relief valve set at not over 10 percent above maximum working pressure

23.10.7 The inlet to an air hose reel with an operating gauge pressure of over 300 psi (2000 kPa) shall have a flow-limiting

device, such as a velocity-type valve, or a manually adjustable orifice-type valve.

23.10.7.1 The device shall be adjusted to restrict excessive flow and shall be located or covered to prevent readjustment.

23.10.7.2 The metering device shall not be used for normal shutoff valve purposes.

23.10.8 The final assembler of the air hose reel, piping, and valve system shall test the system at the maximum operating pressure of the system for 10 minutes with no pressure loss.

23.10.8.1 This test shall include the hose, if supplied, on the reel.

23.10.8.2 A permanent label shall be installed adjacent to the air reel controls to indicate the operating pressure range and the type of air provided, low pressure utility air [gauge pressure under 300 psi (2000 kPa)], low pressure breathing air [gauge pressure under 125 psi (800 kPa)], or high-pressure breathing air [gauge pressure over 300 psi (2000 kPa)].

23.10.9 Air Reel Installation.

23.10.9.1 Reels installed in concealed locations shall be accessible for maintenance and servicing, hose access, and reel removal.

23.10.9.2 Rollers and guides shall be installed, where necessary, to prevent damage to the hose at the reel spool or compartment openings and to allow deployment and rewinding of the hose.

23.10.9.3 Reels shall be installed in such a manner so as not to expose the operator to the rewind components.

23.10.9.4 Manually operated reels shall have an operable hand crank with its central midpoint or centerline located not over 72 in. (1830 mm) above the ground or platform that is designed to serve as the operator's standing position.

23.10.9.5 Switches for power rewind-type reels shall be located in a position that allows the operator to safely rewind the hose.

23.10.9.5.1 The rewind control shall not be more than 72 in. (1830 mm) above the operator's standing position.

23.10.9.5.2 The rewind control shall be marked with a label indicating its function and shall be guarded to prevent accidental activation.

23.10.10* Low Pressure Breathing Air Reel.

23.10.10.1 The regulation of the output pressure from the breathing air reel shall be at the reel or at an air control panel.

23.10.10.2 No shutoff valves or flow control valves shall be installed downstream of the pressure regulator except at the end of the hose.

23.10.10.3 The low pressure breathing air supply shall be equipped with a low air pressure audible warning device on the air supply.

23.11 Air Hose.

23.11.1* All low pressure [gauge pressure not over 300 psi (2000 kPa)] air hose and couplings supplied shall comply with their intended application and shall have a pressure rating equal to or greater than the highest pressure expected to be

encountered as input to the hose with a test safety factor of at least 3:1.

23.11.2 All high-pressure [gauge pressure over 300 psi (2000 kPa)] air hose and couplings supplied shall comply with their intended application and shall have a pressure rating equal to or greater than the highest pressure expected to be encountered as input to the hose with a test safety factor of at least 4:1.

23.11.3 Where the hose is attached to an air reel, it shall be done in a manner that allows for its removal.

23.11.4 Discharge Ends.

23.11.4.1* The discharge end of any breathing air hose shall have a threaded connection.

23.11.4.1.1 If no other fittings are installed at the end of the hose, a temporary protective cap shall be installed to prevent internal contamination of the hose during shipping.

23.11.4.1.2 If the discharge end of hose will terminate with a threaded connection when in use, it shall be equipped with a slow-operating valve.

23.11.4.1.3 If the threaded end of the hose terminates in a quick-connection fitting, a slow operating valve and protective cap shall not be required.

23.11.4.1.4 Connections to hose shall comply with 23.2.7.

23.11.4.2 The discharge end of utility air hose shall have either a threaded connection and slow-operating valve or a quick-connection fitting.

23.11.5 Color Coding.

23.11.5.1 The ends of the hose shall be color coded or marked with a label to designate the operating pressure of the hose.

23.11.5.2 If color coding is used, it shall be as follows:

- (1) Blue for utility air hose up to a gauge pressure of 300 psi (2000 kPa)
- (2) White for breathing air hose up to a gauge pressure of 300 psi (2000 kPa)
- (3) Yellow for breathing air hose from a gauge pressure of 301 psi to 3000 psi (2001 kPa to 20,000 kPa)
- (4) Red for breathing air hose over a gauge pressure of 3000 psi (20,000 kPa)

23.11.6* Low pressure breathing air hose shall be a minimum $\frac{3}{8}$ in. (10 mm) ID with a maximum hose length of not more than 300 ft (90 m).

23.11.7 Utility air hose shall be of a flexible type, with a scuff abrasion-resistant outer covering.

23.11.8 The hose shall be oil resistant and shall be compatible with oil, alkalis, kerosene, paraffin, grease, and salt solutions.

23.11.9 The hose connections for utility air hose shall not be the same as for low pressure breathing air hose or high-pressure air hose.

23.12* Low Pressure Utility Air Supply.

23.12.1* The chassis air brake system shall not be used for emergency use applications such as airbags, tools, air reels, and other rescue applications.

23.12.2* Where nonemergency applications are supplied by the chassis air brake system, the air supply shall be from an auxiliary air circuit that is equipped with a pressure protection valve (PPV) and auxiliary air tanks.

23.13 Remote Breathing Air Systems. Remote breathing air systems for pump panels or other remote locations shall comply with 23.13.1 through 23.13.7.

23.13.1 A breathing air system shall be designed to supply breathing air for a minimum of two persons at the specified location.

23.13.2 The system shall include storage for at least 400 ft³ (11,320 L) of breathing air and shall meet the requirements of Section 23.5.

23.13.3 Piping System.

23.13.3.1 The piping system shall be arranged with an air regulator that shall limit the air pressure in the piping to the desired operating pressure.

23.13.3.2 A pressure relief valve set to relieve the pressure at 10 percent above the desired operating pressure shall be installed on the downstream side of the regulator.

23.13.4 All valves, pressure regulators, and gauges shall be protected from accidental damage.

23.13.5 The piping or hose system between the air tanks and point of use shall be installed to prevent damage due to abrasion, bending, or pinching.

23.13.6 A holder or box shall be provided for the storage of the breathing air equipment when it is not in use.

23.13.7 A low air warning system shall be provided that monitors the air volume and provides an audible warning when the air volume is at or below 20 percent.

23.14* Breathing Air System Testing and Delivery.

23.14.1 The complete air system shall be tested by the final system installer after its installation on the fire apparatus is complete, using the testing procedure prescribed by the system manufacturer.

23.14.2 The following items shall be tested or verified on all air systems:

- (1) Pressure test the system to its maximum operational pressure and check all connections made as a part of the installation for leaks with a leak detection device, which could include bubble fluid or electronic means.
- (2) Verify that any leaks detected during the testing in 23.14.2(1) are repaired.
- (3) Visually verify the relief valve set points and working pressure of the air tank.
- (4) Verify the accuracy of all pressure gauges.
- (5) Fully test the operational capabilities of the fill station as established by the manufacturer of the fill station.
- (6) Seal all fill adapter connections to eliminate the introduction of contaminants prior to shipment.

23.14.3 If the system's air supply includes a compressor/purification system, the following additional items shall be tested or verified:

- (1) Confirm that the fluid levels are at the manufacturer's recommended levels, including the lubricant and coolant if the system is liquid cooled.
- (2) Verify the expiration date of the purification filters and cartridges and that they have been installed as required by the manufacturer of the system.
- (3) Operate the air compressor for a minimum of 2 hours or the period required to completely fill the onboard air tanks, whichever is longer.
- (4) Confirm that all compressor interstage pressures are within guidelines as established by the compressor manufacturer.
- (5) Confirm the operation of the compressor shutdown switch at the pressure requested by the purchaser.
- (6) Confirm the set point of the final pressure safety relief valve and pressure maintaining valve.
- (7) Confirm the factory set limits of all electrical shutdown devices, including low oil pressure, automatic condensate drain system, high air temperature, excessive processed air moisture, high carbon monoxide, and motor amperage draw.
- (8) Confirm that the breathing air system is installed in accordance with the breathing air compressor manufacturer's requirements and drawings and confirm that the cooling airflow is adequate.

23.14.4 Breathing Air Quality.

23.14.4.1* Prior to delivery of the apparatus equipped with a breathing air system to the end user, the final system installer shall draw an air sample from the breathing air system and submit the sample to be tested in accordance with NFPA 1989.

23.14.4.2 The breathing air shall meet the air quality standards defined in NFPA 1989.

23.14.5 The results of all tests, including the air quality analysis, shall be documented and shall be delivered with the fire apparatus.

23.14.6 The contractor shall deliver the apparatus with all air tanks, piping, hose, reels, and other fixed equipment charged with breathing air to a gauge pressure of at least 40 psi (275 kPa).

23.15 Utility Air System Testing.

23.15.1 Prior to delivery of an apparatus with a low pressure utility air compressor and piping, the final installer shall test and certify the performance of the system.

23.15.2 The following items shall be tested or verified on all air systems:

- (1) Pressure test the system to its maximum operational pressure and check all connections made as a part of the installation for leaks with a leak detection device, which could include bubble fluid or electronic means.
- (2) Verify that any leaks detected during the testing in 23.15.2(1) are repaired.
- (3) Visually verify the relief valve set points and working pressure of the air tank.

23.15.3 If the system's air supply includes a compressor system, the following additional items shall be tested or verified:

- (1) Confirm that the fluid levels are at the manufacturer's recommended levels, including the lubricant and coolant if the system is liquid cooled.
- (2) Operate the air compressor for a minimum of 1 hour.
- (3) Confirm operation of the compressor shutdown switch at the pressure requested by the purchaser.
- (4) Confirm that the utility air system is installed in accordance with the air compressor manufacturer's requirements and that the cooling airflow is adequate.

23.15.4 The results of the testing and certification required by 23.15.1 through 23.15.3 shall be documented and shall be delivered with the fire apparatus.

Chapter 24 Fire Apparatus — Winches (NFPA 1901/1906)

24.1 General. If a chassis-mounted winch is installed on the apparatus, it shall meet the requirements of this chapter.

24.1.1* The winch shall be designed for the intended use and shall be installed in accordance with the winch manufacturer's recommendations.

24.1.2 All winches shall be equipped with rollers, guides, or both to prevent damage to the winch wire or synthetic rope or the apparatus.

24.1.3 All rollers and guides shall be designed to match the winch capacity and rope size.

24.2 Winch Wire or Synthetic Rope.

24.2.1 The winch shall have a minimum wire rope or synthetic rope length of 75 ft (22 m).

24.2.2 The wire rope or synthetic rope shall be of a type and size recommended by the winch manufacturer.

24.2.3 The wire rope or synthetic rope assembly, including all hardware such as clevises, hooks, and snatch blocks provided for attachment to the winch, shall have a design load rating greater than the line pull capacity of the winch.

24.3 Clutch. The winch shall be equipped with a clutch assembly to permit free spooling and quick removal of the wire or synthetic rope.

24.3.1 The free spooling clutch shall be accessible without reaching under the apparatus.

24.3.2 If the winch is installed under the apparatus or not visible to the operator, the free spooling clutch control shall be remotely controlled.

24.4* Electric Powered Winches.

24.4.1* Controls. Operation of the winch shall be from a remote location at least 12 ft from the winch or within an enclosed area.

24.4.2 Power Supply.

24.4.2.1 Dedicated power and ground circuits shall be utilized.

24.4.2.2 Wiring shall be both of the following:

- (1) Sized in accordance with the winch manufacturer's installation instructions
- (2) In compliance with Chapter 16

24.4.3 Removable Electric Winches.

24.4.3.1 Electric winches that are temporarily attached to the apparatus (at sides, rear, or front) shall meet the same requirements as permanently mounted winches.

24.4.3.2 The attachment to the apparatus shall be with quick-release devices.

24.4.3.3 The attachment system on the apparatus shall meet the requirements of Section 12.11.

24.4.4 Electric Power for Removable Winches.

24.4.4.1 The electrical power supply(ies) from the apparatus to the removable winch shall terminate at a quick disconnect receptacle with a connector plug.

24.4.4.2 The receptacle shall have a label indicating its use.

24.4.4.3 The power cord from the receptacle to the winch shall be sized for the power requirements of the winch.

24.4.4.4 The power cord shall be highly flexible and shall be protected from mechanical damage.

24.5* Hydraulically Driven Winches.**24.5.1 Hydraulic Hose.**

24.5.1.1 All hydraulic hose shall be designed for the hydraulic pressures expected to be encountered.

24.5.1.2 Hose shall be a wire-braided type with a female swivel on one end.

24.5.2 Operation of the hydraulic winch shall be from a remote location at least 12 ft from the winch or within an enclosed area.

24.5.3 Hydraulic Reservoir.

24.5.3.1 The hydraulic system components shall be capable of maintaining, under all operating conditions, oil cleanliness and temperature that comply with the manufacturer's recommendations.

24.5.3.2 A means for checking and filling the hydraulic reservoir shall be readily accessible.

24.5.3.3 The fill location shall be conspicuously marked with a label that reads "Hydraulic Oil Only."

24.5.3.4 The manufacturer shall provide instructions for checking and filling the hydraulic reservoir.

24.5.4 The hydraulic winch engagement controls shall be located in the driving compartment.

24.5.4.1* A "Hydraulic Winch Engaged" indicator shall be provided in the driving compartment to indicate that the hydraulic pump engagement has been successfully completed.

Chapter 25 Fire Apparatus — Trailers (NFPA 1901)

25.1 General. For the purposes of this standard, trailers transporting equipment or other vehicles under emergency response conditions shall be considered fire apparatus, and any components on the trailer designed to support emergency services operations shall meet the applicable requirements defined in Section 7.6.

25.2 Classification of Trailers. Trailers shall be classified as Type I, Type II, or Type III.

25.2.1* Trailers that are designed to remain connected to their tow vehicle throughout the response event and that are dependent on the tow vehicle to provide the required electrical power and conspicuity shall meet the requirements of this chapter for Type I trailers.

25.2.2* Trailers that are designed to allow separation from their tow vehicle after arrival at the response event and that are not dependent on the tow vehicle to provide the required electrical power and conspicuity shall meet the requirements of this chapter for Type II trailers.

25.2.3* Open trailers designed to transport other vehicles, equipment, or containers that will be removed from the trailer after arrival at the response event and that will not be blocking the right-of way during the incident shall meet the requirements of this chapter for Type III trailers.

25.3 Carrying Capacity.

25.3.1 The GVWR of the trailer shall not be greater than the sum of the tongue weight and the GAWR.

25.3.2 The stated load capacity of the trailer shall be the GVWR of the trailer less the empty weight of the trailer and the weight of the permanently mounted equipment.

25.4 Information Labels and Instruction Plates.

25.4.1 In addition to the label required by 49 CFR 567, "Certification," the final stage manufacturer shall permanently affix an information label that includes the following:

- (1) The length and width of the completed trailer in feet/inches (meters)
- (2) The stated load capacity
- (3) For Type I and Type II trailers, the height of the completed trailer in feet/inches (meters)
- (4) The hitch size and type
- (5) Maximum tire pressure
- (6) The tire manufacturer's maximum speed rating
- (7) The proper hitch-locking procedures to secure the trailer to the tow vehicle
- (8) A statement that reads: "It is the vehicle operator's responsibility to ensure that the towing vehicle and hitch are adequate to pull this trailer."

25.4.2 For trailers requiring the use of safety chains, an instruction plate shall be provided at or near the hitch location on the trailer that indicates the proper method of chain attachment to the tow vehicle.

25.4.3 For trailers with a braking system, an instruction plate shall indicate the proper method of connecting the braking system and the breakaway cable connections that apply the emergency brakes in the event the hitch fails.

25.5 Fluids and Pressures Specific to the Trailer Chassis. A permanently mounted informational label shall be provided to specify the following information if it applies:

- (1) Brake fluid for trailer brake systems
- (2) Grease used for the lubrication of axle bearings
- (3) Any other special fluids, pressures, or lubricants required by the trailer manufacturer

25.6 Braking System.

25.6.1* All trailers chassis with a GVWR of 3000 lb (1360 kg) or greater shall be equipped with a braking system on each axle.

25.6.2 All trailers equipped with brakes shall be equipped with a method to use the braking system to limit trailer movement in the event of failure of the hitch mechanism.

25.6.3 All brakes shall be readily accessible for adjustment.

25.6.4 When tow vehicles and trailers are equipped with air brake systems, the service brakes and parking brakes shall be applied by independent means.

25.7 Suspension and Wheels.

25.7.1 Each load-bearing tire and rim shall not carry a weight in excess of the recommended load for the operation of the tires used, as published in *Tire and Rim Association — Year Book* and as recommended by the tire manufacturer.

25.7.2* Any trailer with an angle of departure of less than 8 degrees shall be equipped with means to prevent damage to the trailer if the rear contacts the ground.

25.8 Trailer Hitch.

25.8.1 The trailer hitch shall be selected to meet or exceed the GVWR of the trailer.

25.8.2 The construction and load supported by the trailer frame shall be distributed to maintain a tongue weight at or below the tongue weight rating.

25.8.3 Safety Chains.

25.8.3.1 The installation and use of two safety chains shall be required for trailer hitches designed to use safety chains.

25.8.3.2 Each safety chain and the method of attachment to the trailer and towing vehicle shall have an ultimate strength of not less than the gross weight of the trailer.

25.8.4 When using a fifth wheel hitch, the fifth wheel hitch and trailer body design shall allow full 90-degree jackknifing of the tow vehicle–trailer combination when all doors and exterior mounted items are in the stowed position.

25.9 Wheel Chocks.

25.9.1 For trailers classified as Type II or Type III, four wheel chocks shall be mounted in readily accessible locations.

25.9.2 Each wheel chock shall be designed to hold the trailer on a 10 percent grade when the trailer is loaded to its GVWR and parked independently of the tow vehicle.

25.10 Low Voltage Electrical Systems and Warning Devices.

25.10.1 Any low voltage systems, umbilical cables, and warning devices installed on trailers shall be appropriate for the mount-

ing location and intended electrical load and shall meet the specific requirements of Chapter 10.

25.10.2 If the trailer is classified as Type I or Type II, it shall meet the requirements of Section 10.10.

25.10.3 Power Supply.

25.10.3.1 The final-stage trailer manufacturer shall state the minimum continuous electrical load required to be provided by the tow vehicle.

25.10.3.2 If the trailer is classified as Type I, the combined tow vehicle and trailer shall meet the electrical requirements in Chapter 10.

25.10.3.3 If the trailer is classified as Type II, the combined electrical load for the federally required clearance and marker lighting and the optical warning devices shall not exceed 45 amps.

25.10.3.3.1 An on-board power source shall be provided and sized to power all trailer electrical loads on a continuous basis.

25.10.3.3.2* If a line voltage power source is used, it shall meet the requirements of Chapter 21.

25.10.3.4 If the trailer is classified as Type III, the combined electrical load for the federally required clearance and marker lighting and the optical warning devices shall not exceed 45 amps.

25.10.4* Umbilical Cables and Connections.

25.10.4.1 Umbilical cables shall be constructed of cable that complies with the requirements of Chapter 10.

25.10.4.2 Umbilical cables shall be installed and supported to prevent abrasion or chafing damage during normal operation of the trailer.

25.10.4.3 The umbilical cables shall move freely throughout the trailer's operating range of full turn right to full turn left without damage.

25.10.4.4 For trailers using air brakes, the umbilical cable for the federally required clearance and marker lighting and the ABS brake system shall be connected using a green Type F cable meeting SAE J2394, *Seven-Conductor Cable for ABS Power — Truck and Bus*, and primary connectors meeting SAE J560, *Primary and Auxiliary Seven Conductor Electrical Connector for Truck-Trailer Jumper Cable*. Circuit identification shall conform to SAE J560, Table 4.

25.10.4.5 For trailers using electric or hydraulic brakes, or small trailers without brakes, the umbilical cable for the federally required lighting and brake system shall be connected using a seven-wire heavy-duty cable and a seven-way flat-blade recreational vehicle connector meeting SAE J2863, *Automotive Trailer Tow Connector*.

25.10.4.6 The optical warning device umbilical cable shall be a yellow cable meeting the requirements of SAE J2394 for Type F cable with auxiliary connectors meeting SAE J560.

25.10.4.6.1 The auxiliary connectors shall have inverted ground terminals to prohibit connection to the primary receptacle (male ground terminal in the plug and the female ground terminal in the receptacle).

25.10.4.6.2 Circuit identification shall conform to SAE J560, Table 4, with the unassigned circuits assigned as follows:

- (1) 12 — Green, hazard light signal from trailer (*see 10.10.1*)
- (2) 13 — Brown, calling for right-of-way warning lights
- (3) 14 — Blue, blocking right-of-way warning lights

25.10.5 Optical Warning Devices.

25.10.5.1 If the trailer is a Type I trailer, the optical warning system requirements of Section 10.7 shall be met by considering the combined tow vehicle and trailer as a single unit with its overall length.

25.10.5.2 If the trailer is a Type II trailer, the optical warning system shall meet the requirements of Section 10.7 when the trailer is considered a single unit.

25.10.5.2.1 The trailer's Zone A lighting shall operate only when the trailer's onboard power source is operational and the tow vehicle is disconnected from the trailer.

25.10.5.3 If the trailer is a Type III trailer, the optical warning system shall meet the requirements of Section 10.7 for lower zones B, C, and D.

25.10.6 Work Lighting.

25.10.6.1 Type I and II trailers shall be equipped with ground lighting that meets the requirements of 10.9.1.2.

25.10.6.2 If the trailer has work surfaces, steps, or walkways, those surfaces shall be equipped with surface lighting that meets the requirements of 10.9.3.

25.10.6.3 If the trailer has interior spaces where a person can walk, the trailer shall be equipped with interior lighting that meets the requirements of 10.9.4.

25.10.6.4 If the trailer has compartments, the compartments shall be equipped with compartment lighting that meets the requirements of 10.9.5.

25.10.7 Stop, Tail, and Directional Lighting. The trailer shall be equipped with stop, tail, and directional lighting meeting the requirements of Section 10.12.

25.10.8 Electrical System Performance Tests.

25.10.8.1 Low voltage electrical systems shall be tested in accordance with the testing requirements of Chapter 10 as applicable.

25.10.8.2 Line voltage electrical systems shall be tested in accordance with the testing requirements of Chapter 21 as applicable.

25.11 Reflective Markings.

25.11.1 Type I trailers shall meet the requirements of 12.8.3 when the combined tow vehicle and trailer are considered a single unit with the overall length.

25.11.2 Type II trailers shall meet the requirements of 12.8.3 when the trailer is considered a single unit.

25.11.3 Reflex reflectors and conspicuity tape shall be installed when required by 49 CFR 571.108, "Lamps, reflective devices, and associated equipment."

Chapter 26 Fire Apparatus — Vehicle Protection Systems (NFPA 1906)

26.1 Brush Rails. If brush rails are installed on the fire apparatus, they shall meet the requirements of 26.1.1 through 26.1.4.

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

26.1.2 The rails shall be designed for replacement, if damaged, or for removal for servicing or repairing the vehicle chassis or body without the use of welding or cutting equipment.

26.1.3 The rails shall not impede the normal opening of engine enclosures, access to the driving and crew compartment(s), access to body storage compartments, or access to fire-fighting equipment.

26.1.4 The rails shall not block the full function of any of the vehicle lighting systems, including normal travel lights, warning lights, and work area lights on the vehicle.

26.2 Grille Guard. If a grille guard is installed on the fire apparatus, it shall meet the requirements of 26.2.1 through 26.2.6.

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

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

26.2.3 The grille guard shall be designed for replacement, if damaged, or for removal for servicing or repairing the vehicle chassis without the use of welding or cutting equipment.

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

26.2.5 The guard shall not block the full function of any of the vehicle lighting systems, including normal travel lights, warning lights, and work area lights on the vehicle.

26.2.6 Parts of the radiator that might be exposed and subjected to brush damage from behind and under the front bumper also shall be protected.

26.3* Skid Plates. If skid plates are installed on the fire apparatus, they shall meet the requirements of 26.3.1 through 26.3.5.

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

26.3.2 Skid plates shall be supported directly by the component they are protecting or the chassis frame.

26.3.3 Skid plates shall be removable without the use of welding or cutting equipment.

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

26.3.5 Skid plates shall be designed, located, and installed in a manner that minimizes the trapping of vegetative material between the plate and the component it guards or other components.

26.4 Chassis Component Protection.

26.4.1 Chassis component protection for fluid tanks, lines, and electrical components not guarded by vehicular structure or skid plates shall be protected from mechanical damage by a guard meeting the requirements of 26.4.2 through 26.4.7.

26.4.2 The guards shall be fabricated from metal that will not cause galvanic corrosion when installed.

26.4.3 The guards shall be made of material with a yield strength of at least 35,000 psi (241,316 kPa).

26.4.4 The guards shall be made of material with a wall thickness of no less than $\frac{3}{16}$ in. (4.78 mm).

26.4.5 The guards shall not inhibit the operation of components by providing clearance for moving parts.

26.4.6 The guards shall be removable to provide access for repairs.

26.4.7 The guards shall not permit the trapping of flammable material.

Chapter 27 Fire Apparatus — Wildland Fire Crew Carrier Apparatus (NFPA 1906)

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

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

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

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

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

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

27.2.3 Each internal storage compartment shall be permanently labeled with the load capacity.

27.2.4 If separated, the cab and the crew compartment body bulkheads shall have an aligned opening of at least 150 in.² (96,780 mm²).

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

27.3 Crew Compartment Body Structural Integrity. The crew compartment body shall meet the performance requirements of SAE J3057, *Ambulance Modular Body Evaluation-Quasi-Static Loading for Type I and Type III Modular Ambulance Bodies*.

27.4 Crew Compartment Entry Doors.

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

27.4.2 Door handles shall be designed and installed to protect against accidental or inadvertent opening.

27.4.3 Entry doors and door openings shall be designed to minimize inadvertent snagging of apparel.

27.4.4 When doors are open, the hinges and latches shall not protrude into the access area.

27.4.5 Doors shall be equipped with a hold-open device.

27.4.6 One externally operated lock for each door opening shall be provided.

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

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

27.4.9 Doors shall be equipped with not less than 250 in.² (160,000 mm²) of safety glass area per door.

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

27.5 Crew Compartment Body Means of Escape.

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

27.5.2 Each opening shall comply with 11.1.14.2.

27.5.3 Each means of escape shall be labeled.

27.6 Crew Compartment Seats.

27.6.1* All seats shall face fore or aft.

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

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

Chapter 28 Automotive Ambulances — General Requirements (NFPA 1917)

28.1 Administration.

28.1.1* Scope. Chapters 28 through 34 shall define the minimum requirements for the design, performance, and testing of new and remounted automotive ambulances used for out-of-hospital medical care and patient transport.

28.1.2 Purpose. The purpose of chapters 28 through 34 shall be to establish the minimum requirements for new and remounted automotive ambulances that are safe and reliable when properly maintained and used within their design parameters.

28.1.3 Application.

28.1.3.1 Chapters 28 through 34 shall apply to new and remounted ambulances that are contracted for on or after January 1, 2024.

28.1.3.2 Chapters 28 through 34 shall not apply to the following:

- (1) Vehicles that are used for transport of more than two stretcher-bound patients at the same time
- (2) Mass casualty vehicles
- (3) Military field ambulances
- (4) Vehicles intended for use as fire apparatus as specified in Chapters 4 through 26
- (5) Wheeled chair transport vehicles
- (6) Refurbished vehicles without a remount
- (7) Repairs

28.1.4* Retroactivity. Chapters 28 through 34 shall not be applied retroactively.

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

28.1.5.1 Technical documentation shall be submitted to the authority having jurisdiction (AHJ) to demonstrate equivalency.

28.1.5.2 The system, method, or device shall be approved for the intended purpose by the AHJ.

28.1.6* Units and Formulas.

28.1.6.1 In Chapters 28 through 34, values for measurement in US customary units shall be followed by equivalents in SI units.

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

28.2 General. All ambulances shall comply with Chapters 1 through 3 and 28 through 33.

28.3* Responsibility of the Purchaser.

28.3.1 It shall be the responsibility of the purchaser to consider the amount of equipment and the number of personnel that will be carried on the ambulance and to specify a minimum usable payload that will accommodate this weight once the ambulance is placed in service.

28.3.2 It shall be the responsibility of the purchaser to specify any details of the ambulance that would exceed the minimum specifications of this standard.

28.4 Responsibility of the Contractor.

28.4.1 The contractor shall provide a detailed description of the ambulance, a list of equipment to be furnished, and other construction and performance details to which the ambulance shall conform.

28.4.1.1 The detailed description of the ambulance shall include, but not be limited to, minimum usable payload, wheel-base, curb-to-curb turning clearance radius, principal dimensions, angle of approach, and angle of departure.

28.4.1.2 The purpose of these contractor specifications shall be to define what the contractor intends to furnish and deliver to the purchaser.

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

28.5 Ambulance Components.

28.5.1 All components shall be installed in accordance with the manufacturer's installation instructions or with the written approval of the component manufacturer.

28.5.2 All medical devices furnished shall comply with the U.S. Food and Drug Administration (FDA) regulatory requirements.

28.5.3 Vehicles shall be free from defects that could impair their reliability or serviceability.

28.5.4* All bodies, systems, equipment, and interfaces with the chassis not otherwise specified in this standard shall be maintained in accordance with the chassis original equipment manufacturer's (OEM) body builders' guidelines.

28.6 Legal Requirements. The ambulance shall comply with state regulations as specified by the purchaser.

28.7 Third-Party Certification of Test Results.

28.7.1 The following type tests, when required in Chapters 28 through 34 of this standard, shall be witnessed or performed by an independent third-party organization:

- (1) AMD 006, *Patient Compartment Sound Level Test*
- (2) AMD 008, *Handrail Static Load Test*
- (3) AMD 011, *Equipment Temperature Test*
- (4) AMD 012, *Interior Climate Control Test*
- (5) AMD 016, *Patient Compartment Lighting Level Test*
- (6) AMD 018, *Rear Stepping Surface Load Test*
- (7) AMD 024, *Perimeter Illumination Test*
- (8) SAE J3026, *Ambulance Patient Compartment Seating Integrity and Occupant Restraint*
- (9) SAE J3027, *Ambulance Litter Integrity, Retention, and Patient Restraint*
- (10) SAE J3057, *Ambulance Modular Body Evaluation-Quasi-Static Loading For Type I and Type III Modular Ambulance Bodies*
- (11) SAE J3058, *Ambulance Interior Storage Compartment Integrity*

28.7.2 Organizations that witness or perform the tests listed in 28.7.1 shall meet the requirements of this section.

28.7.3 AMD testing listed in 28.7 shall be witnessed or performed by an organization that is accredited for inspection of ambulances in accordance with ISO/IEC 17020, *Conformity Assessment: Requirements for the operation of various types of bodies performing inspection*, or accredited for testing ambulances to Chapters 28 through 34 of this standard in accordance with ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.

28.7.4 The certification organization shall not be owned or controlled by the final-stage ambulance manufacturer.

28.7.5 The certification organization shall comply with the following:

- (1) Witness all tests
- (2) Refuse to certify any test results for a system if all components of that system requiring testing do not pass the testing required by Chapters 28 through 34 of this standard

28.7.6 Conditional, temporary, or partial certification of test results shall not be permitted.

28.7.7 Appeal Process.

28.7.7.1 The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions.

28.7.7.2 The procedures shall include provisions for the presentation of information from representatives of both sides of a controversy to a designated appeals panel.

28.7.8 The third party that certifies any test results shall supply the following information on the certification organization letterhead:

- (1) Company or business for which the results are certified
- (2) Date of certification
- (3) Ambulance model, components, or equipment being certified
- (4) Certification organization and address
- (5) Date product tested
- (6) Model number and specification data
- (7) Applicable specification references and test requirement
- (8) Summary of the test report
- (9) A certifying statement with official signature

28.7.9* The testing facility for each certification shall supply the following supportive verification data and information on letterhead stationery in electronic format:

- (1) Name of company or business for whom ambulance product was tested
- (2) Report date
- (3) Name of sample product or device
- (4) Contractor's address
- (5) Serial and model number(s)
- (6) Specification referral and amendment number(s), and test requirement(s)
- (7) Test facilities used and location
- (8) Test equipment used
- (9) Test procedure
- (10) Test results
- (11) Verifying test data
- (12) Photographs
- (13) Drawings
- (14) Test conclusion(s)
- (15) Witness(es)
- (16) Authorized signature

28.8 Manufacturer Certification of Test Results.

28.8.1 The ambulance manufacturer shall test and certify each ambulance according to the following standards:

- (1) AMD 005, *Low Voltage Electrical System Test*
- (2) AMD 010, *Water Leak Test*
- (3) AMD 015, *Ambulance Main Medical Gas System Test*
- (4) AMD 021, *Aspirator System Test*
- (5) AMD 025, *Occupant Head Clearance Zones Test*
- (6) AMD 027, *Line Voltage Electrical Systems Test*

28.8.2 Where the standard requires a component to be tested, the ambulance manufacturer shall either test individual components themselves or rely on the component manufacturer's testing and certification on any individual component used in the ambulance.

28.8.3 The ambulance manufacturer shall refuse to certify any test results for a system unless all components of that system requiring testing pass the testing required by Chapters 28 through 34 of this standard.

28.8.4 Conditional, temporary, or partial certification of test results shall not be permitted.

28.8.5 The manufacturer shall have the facilities and equipment necessary to conduct the required testing, a program for the calibration of all instruments, and procedures to ensure the proper control of all testing.

28.8.6 Forms or data sheets shall be provided and used during the testing.

28.8.7 Programs shall be in place for training, proficiency testing, and performance verification of any personnel involved with certification.

28.8.8 An official of the company that manufactures or installs the product shall designate in writing who is qualified to witness tests and certify results.

28.8.9 Certification documentation shall be delivered with the ambulance, including results of the certification tests.

28.8.10 Certification tests performed on a substantially similar ambulance shall be valid for up to 7 years or until such time as the production product changes are so significant that they no longer meet the definition of a substantially similar ambulance.

28.9 Personnel Protection.

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

28.9.2 Electrical insulation or isolation shall be provided where necessary in order to prevent electrical shock from onboard electrical systems.

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

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

28.10 Controls and Instructions.

28.10.1 Illumination shall be provided for controls, switches, gauges, and instruments necessary for the operation of the ambulance and the equipment on it.

28.10.2* All required signs, instruction plates, and labels shall be permanent in nature, securely attached, and meet the requirements of 28.10.2.1 and UL 969, *Standard for Marking and Labeling Systems*.

28.10.2.1 The signs, instruction plates, and labels shall be resistant to damage from the following:

- (1) Fluids to which they will normally be exposed
- (2) Temperatures between -30°F (-35°C) and 176°F (80°C)
- (3) Ultraviolet radiation

28.10.2.2* The exterior-mounted labels relating to safety or critical operational instructions shall be reflective or illuminated.

28.10.2.3 Controls and Switches.

28.10.2.3.1* Controls and switches that are expected to be operated by the belted driver while the ambulance is in motion shall be visible and within reach.

28.10.2.3.2 Controls and switches that are expected to be operated by the belted emergency medical service provider (EMSP) while the ambulance is in motion shall be visible and within reach of the designated primary patient care position.

28.10.2.4 Marking of switches, indicators, and control devices shall be perceptively and permanently identified with at least 3 mm high letters and/or symbol at least 10 mm by 10 mm.

28.10.2.5 The identifications shall be contrasting colors etched or engraved in plastic or metal or printed and laminated translucent plastic, grouped according to function, and mounted in illuminated or backlit panel(s) or the console.

28.11 Component Protection.

28.11.1* Hydraulic hose lines, air system tubing, control cords, and electrical harnesses shall be mechanically attached to the frame or body structure of the ambulance.

28.11.2 The types of equipment described in 28.11.1 shall be furnished with protective looms, grommets, or other devices at each point where they pass through body panels or structural members or wherever they lie against a sharp metal edge.

28.11.3 A through-the-frame connector shall be permitted to be used in place of protective looms or grommets.

28.12* Ambulance Performance.

28.12.1* Where temperature requirements are not otherwise specified, the ambulance shall be designed to function in ambient temperature conditions between 0°F (−18°C) to 110°F (43°C).

28.12.1.1 All interior systems, components, and permanently attached equipment shall function satisfactorily over a temperature range of 32°F to 95°F (0°C to 35°C).

28.12.1.1.1 Compliance of the equipment function shall be validated by testing a substantially similar ambulance in accordance with AMD 011, *Equipment Temperature Test*.

28.12.1.1.2 The ambulance and all systems, components, and equipment shall be capable of being stored at an ambient temperature between 32°F and 95°F (0°C to 35°C) without damage or deterioration.

28.12.2 The ambulance shall be capable of being driven for at least 250 mi (402 km) without refueling.

28.12.3 The vehicle shall be capable of three fordings without water entering patient and equipment compartments while being driven through a minimum of 8 in. (203 mm) of water, at speeds of 5 mph (8 km/hr), for a distance of at least 100 ft (30 m).

28.13 Road Performance.

28.13.1 When loaded to its gross vehicle weight rating (GVWR), the ambulance shall be capable of meeting the following performance criteria on dry, paved roads that are in good condition:

- (1) From a standing start, the ambulance shall be able to attain a speed of 55 mph (88 km/hr) within 25 seconds on a level road.
- (2) The ambulance shall be able to maintain a speed of at least 5 mph (8 km/hr) on any grade up to 35 percent.
- (3) The ambulance shall be able to maintain a speed of at least 55 mph (88 km/hr) on any grade up to 3 percent.

28.13.2 The determination of road performance shall be made by actual test or OEM-certified computer prediction.

28.13.3* The ambulance shall be capable of a sustained speed of not less than 65 mph (105 km/hr) over dry, hard-surfaced, level roads, at sea level, and a passing speed of 70 mph (112 km/hr) when tested under normal ambient conditions.

28.14 Serviceability.

28.14.1 Special Tools.

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

28.14.1.2 Where the purchaser is purchasing multiple ambulances under the same contract, the purchaser shall specify the number of tools required.

28.14.2 Ambulance components that interfere with repair or removal of other major components shall be attached with fasteners, such as cap screws and nuts, so that the components can be removed and installed with ordinary hand tools.

28.14.3 These components shall not be welded or otherwise permanently secured in place.

28.15 Tests on Delivery.

28.15.1 If acceptance tests are conducted at the point of delivery, they shall not be performed in a manner that requires the ambulance or a component to operate outside its designed operating range.

28.15.2 Certification from OEM and individual equipment manufacturers shall be acceptable, provided the equipment has not been altered in a way that would jeopardize the original certification.

28.16* Documentation. Any documentation delivered with the ambulance shall be permitted to be in printed format, electronic format, audiovisual format, or a combination thereof.

28.17 Data Required of Contractor.

28.17.1 Ambulance Documentation. The contractor shall deliver with the ambulance at least one copy of the following documents:

- (1) The manufacturer's record of ambulance construction details, including the following information:
 - (a) Owner's name and address
 - (b) Ambulance manufacturer, model, and serial number
 - (c) Chassis make, model, and vehicle identification number (VIN)
 - (d) GAWR of front and rear axles and GVWR
 - (e) Front tire size and total rated capacity in pounds (kilograms)
 - (f) Rear tire size and total rated capacity in pounds (kilograms)
 - (g) Type of fuel and fuel tank capacity
 - (h) Electrical system voltage and alternator output in amps
 - (i) Paint manufacturer and paint number(s)
 - (j) Company name and signature of responsible company representative

- (k) Documents from a certified scale showing curb weight on the front axle and rear axle(s) (without personnel and equipment)
- (2) Certification of compliance of the optical warning system (*see 31.9.16*)
- (3) Siren manufacturer's certification of the siren (*see 31.10.1.1*)
- (4) Written load analysis and results of the electrical system performance tests

28.17.2 Operations and Service Documentation.

28.17.2.1 The contractor shall deliver with the ambulance at least one set of complete operation and service documentation covering the completed ambulance as delivered and accepted.

28.17.2.2 The documentation shall address at least the inspection, service, and operations of the ambulance and all major components thereof.

28.17.2.3* The contractor shall also deliver with the ambulance the following documentation for the entire ambulance and each major operating system or major component of the ambulance:

- (1) Manufacturer's name and address
- (2) Country of manufacture
- (3) Source for service and technical information
- (4) Parts replacement information
- (5) Descriptions, specifications, and ratings of the chassis
- (6) Wiring diagrams for low voltage and line voltage ambulance-specific systems to include the following information:
 - (a) Circuit logic for all electrical components and wiring
 - (b) Circuit identification
 - (c) Connector pin identification
 - (d) Zone location of electrical components
 - (e) Safety interlocks
 - (f) Alternator battery power distribution circuits
 - (g) Input/output assignment sheets or equivalent circuit logic implemented in multiplexing systems
- (7) Lubrication charts
- (8) Operating instructions for the chassis and any major components
- (9) Instructions regarding the frequency and procedure for recommended maintenance
- (10) Overall ambulance operating instructions
- (11) Safety considerations
- (12) Limitations of use
- (13) Inspection procedures
- (14) Recommended service procedures
- (15) Troubleshooting guide
- (16) Ambulance body, chassis, and other component manufacturer's warranties
- (17) Special data required by this standard
- (18) Safety data sheet (SDS) for any fluid that is specified for use on the ambulance module

28.17.3 Certification and Payload Signage.

28.17.3.1* All ambulances shall have a certification and payload label as shown in Figure 28.17.3.1.

28.17.3.2 The label shall be mounted on the body (module) interior in a conspicuous location.

Ambulance Data	
Manufactured by _____	Mo./Yr. _____
Address _____	
City _____	State _____ Zip _____
VIN _____	Job no. _____
Chassis model _____	Statement of exception applies _____
Vehicle type _____	
Usable cargo/equipment capacity (lb or kg)* _____	
The total occupant weight equals 175 lb (79 kg) times the number of designated seating positions.	
This ambulance is certified by the manufacturer to conform to the edition of NFPA 1917 in effect on the date the ambulance is contracted for, subject to any applicable statement of exception as mandated by this standard.	
*Usable cargo/equipment capacity is the weight of the loose equipment and cot(s) as defined by NFPA 1917 that can be carried in this ambulance without exceeding the GVWR.	

FIGURE 28.17.3.1 Certification and Payload Label.

28.17.3.3 The calculation of the usable payload listed on the label shall also be provided with the ambulance.

28.18 Statement of Exceptions.

28.18.1 The entity responsible for final assembly of the ambulance shall deliver with the ambulance a certification that the ambulance, at the time of delivery, complies with the minimum requirements of this standard.

28.18.2 When exceptions to this standard are required by the purchaser, a statement of exceptions shall be provided and attached to the owner's manual.

28.18.3 The statement of exceptions shall contain for each exception a separate listing of the section(s) of the applicable standard for which an exception has occurred.

Chapter 29 Automotive Ambulances — Chassis (NFPA 1917)

29.1 Carrying Capacity.

29.1.1 The manufacturer shall design the ambulance so that the completed ambulance, when loaded to its required gross vehicle weight rating (GVWR) with all loose equipment distributed to its intended in-service configuration, does not exceed the GVWR or gross axle weight rating (GAWR) of the chassis using the method and values specified in Table 29.1.1.

29.1.2 The manufacturer shall establish the required GVWR during the design of the ambulance using the method and values specified in Table 29.1.1.

29.1.3 Label.

29.1.3.1 The ambulance manufacturer shall provide a high-visibility label in a location visible to the driver while seated.

29.1.3.2* The label shall show the height of the completed ambulance in feet and inches (meters) and the GVWR in tons and pounds (metric tons and kilograms).

29.2 Weight Distribution.

29.2.1 Longitudinal Weight Distribution. When the ambulance is loaded to its GVWR, the front-to-rear weight distribu-

Table 29.1.1 Required GVWR Calculation

Component	Specification	Weight (lb)
Chassis with full fluids		
Complete ambulance body, including permanently mounted equipment		
Loose equipment (Use one of these values unless the required loose equipment is specified by the purchaser.)	Type I & Type III	750
	Type I-AD & Type III-AD	1250
	Type II	500
Belted occupant seating positions	number of seats ×	175
Cot patient		175
Cot	Standard cot	100
	Power cot	250
Minimum GVWR required (sum of all applicable lines above)		

For SI units, 1 lb = 0.45 kg.

tion and vertical center of gravity shall be within the limits set by the chassis manufacturer.

29.2.2* Lateral Weight Distribution. The vehicle, when loaded to its GVWR, shall have a side-to-side tire load variation of no more than 5 percent of the total tire load for that axle when calculated in accordance with AMD 013, *Weight Distribution Guidelines*.

29.2.3* A weight analysis shall be performed for each completed ambulance to determine the following:

- (1) Front and rear axle weights
- (2) Front and rear axle weight distribution (percentage of total vehicle weight on each axle)
- (3) Vertical center of gravity
- (4) Maximum remaining payload capacity with its center of gravity positioned in its expected in-service location that does not result in weights that exceed the vehicle's weight rating capacities

29.2.3.1 The calculation from the weight analysis shall be completed using the following:

- (1) Measured completed vehicle at curb weight
- (2) 175 lb (80 kg) at the horizontal and vertical center of each patient location and at the designated H-point of each seating position

29.2.3.2 A copy of the weight analysis shall be included with the ambulance documentation.

29.3 Reserved.

29.4 Engine Speed Auxiliary Control Device.

29.4.1* An engine speed auxiliary control device (high-idle switch, throttle, or automatic voltage monitor) shall be installed to allow an increase in the engine speed to no more than

1600 revolutions per minute when the ambulance is parked, unless the ambulance's patient compartment primary source of low voltage electrical power is an independent generator.

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

29.5 Exhaust System.

29.5.1 The exhaust piping and discharge outlet shall be located or shielded so as not to expose any portion of the ambulance or equipment to excessive heating.

29.5.2 Where parts of the exhaust system are exposed so that they are likely to cause injury to operating personnel, protective guards shall be provided.

29.5.3 The vertical centerline of the tailpipe outlet shall not terminate within 12 in. (300 mm) of the medical gas storage or patient entry doors or the vertical centerline of the fuel fill opening where these features are located on the same side of the vehicle.

29.6 Braking System.

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

- (1) An automatic moisture ejector
- (2) An air dryer
- (3) A pressure protection valve to prevent all air-operated accessories from drawing air from the air brake system when the air system's pressure drops below a pressure setting no lower than 80 psi (550 kPa)

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

29.7 Suspension.

29.7.1* With the exception of the OEM's furnished and installed components, the ambulance shall provide not less than the following clearance:

- (1) Approach angle of 10 degrees
- (2) Ramp breakover of 10 degrees
- (3) Departure angle of 10 degrees

29.7.2* If electronic traction control (ETC) is available from the manufacturer on the chassis specified, it shall be provided.

29.7.3 Any ambulance with an air-ride suspension shall include an air dryer and automatic heated moisture ejection device to ensure that the air system is provided with dry air to protect the suspension control components.

29.8 Wheels and Tires.

29.8.1 Hub caps or wheel covers shall be removable without loosening the lug nuts so that wheels can be observed for inspection.

29.8.2 Tires shall be matched to vehicle performance in terms of traction, load-carrying ability, rolling diameter, and speed rating.

29.8.3 Mud Flaps.

29.8.3.1 Mud flaps, at least as wide as the tire(s), shall be provided behind the front and rear wheels.

29.8.3.2 Mud flaps shall be permitted to be incorporated into the running boards.

29.8.4 Bodies designed with wheel openings shall have the rear wheels centered, within ± 2 in. (± 52 mm) of those openings.

29.8.5* Each tire shall be equipped with a visual indicator or monitoring system that indicates tire pressure.

29.9* Vehicle Stability. If electronic stability control (ESC) is available from the manufacturer on the chassis specified, it shall be provided.

29.10* Rear Bumpers. Where a rear bumper is not furnished by the chassis OEM, the rear of the ambulance shall be furnished with a bumper that meets the requirements of 29.10.1 through 29.10.11.

29.10.1 The rear bumper shall extend to within 6 in. (152 mm) of each side of the ambulance.

29.10.2 The rear bumper shall be secured to the vehicle's chassis frame.

29.10.3 The rear bumper of Type I and Type III vehicles shall be provided with an integrated step.

29.10.4 The step shall be both of the following:

- (1) Designed to prevent the accumulation of mud, ice, or snow
- (2) Made of anti-skid open grating material

29.10.5 The step shall not be located or exposed to the interior of the ambulance when the door(s) is closed.

29.10.6 The step shall be at least the width of the door opening for which it is provided.

29.10.7 The stepping surface shall have a minimum depth of 5 in. (127 mm) and a maximum depth of 10 in. (254 mm).

29.10.8 If the step protrudes more than 7 in. (178 mm) from the rear of the vehicle, a fold-up step shall be furnished.

29.10.9 The rear stepping surface shall withstand a load of 500 lb (227 kg) with no more than 1.0 in. (25.4 mm) of deflection or 0.25 in. (6.4 mm) of permanent deformation.

29.10.10 Compliance of the rear step surface shall be validated by testing a substantially similar ambulance or bumper and step structure in accordance with AMD 018, *Rear Stepping Surface Load Test*.

29.10.11 The distance from the road surface to the top surface of the first step at the rear bumper shall not exceed 22 in. (559 mm) with the vehicle loaded to its GVWR or the suspension in the kneeling condition.

29.11 Stepping Surface.

29.11.1* Steps shall be provided in the side passenger door opening(s).

29.11.2 Step wells shall be illuminated.

29.11.3 Step surfaces shall be constructed with anti-slip material.

29.11.4 All steps shall comply with both of the following:

- (1) Have a minimum area of 35 in.² (22,580 mm²)
- (2) Be of such a shape that a 5 in. (125 mm) diameter disk does not overlap any side when placed on the step

29.12 Cab Seal.

29.12.1 If the cab and the patient compartment are separate enclosures, a flexible, weather-tight, bellows-type seal fabricated from durable material that meets the operating temperature requirements and resists deterioration shall be provided between the cab and modular body.

29.12.2 The seal shall be fabricated from a material resistant to ozone, sunlight, oil, and fungus.

29.12.3 The seal shall remain flexible in temperatures between -20°F and 110°F (-29°C and 43°C).

29.12.4 The seal shall be designed for proper fit and finish and be able to absorb lateral, vertical, and torsional displacement due to body/cab movement.

29.13 Front Seats.

29.13.1 The driver's seat shall have the OEM's full, unobstructed seat track travel range of longitudinal adjustment and a minimum of 30 percent of the range of inclination, but not less than the angle furnished on the OEM's standard nonreclining high back seat.

29.14* Rear Visibility.

29.14.1 A backup camera shall be installed on or near the back of the ambulance.

29.14.2 When the vehicle is shifted into reverse, the camera shall display a rearview image on a monitor in the cab that is within clear view of the driver.

29.14.3 All primary side-view mirrors used by the driver shall be adjustable from the driver's position.

29.14.4 Hardware and mirror heads shall have a corrosion-resistant exterior finish.

29.15 Cab Integrity. Cabs on ambulances with a GVWR greater than 26,000 lb (11,800 kg), where applicable, shall meet the requirements of SAE J2420, *COE Frontal Strength Evaluation — Dynamic Loading Heavy Trucks*, and SAE J2422, *Cab Roof Strength Evaluation — Quasi-Static Loading Heavy Trucks*.

Chapter 30 Automotive Ambulances — Patient Compartment (NFPA 1917)

30.1 Patient Compartment Configuration. The patient compartment shall provide a minimum of 275 ft³ (7.7 m³) of space, less volume for cabinets, while complying with 30.1.2 and 30.1.3.

30.1.1* Self-contained breathing apparatus (SCBA) mounts shall not be located in the patient compartment.

30.1.2 The distance from the rear door to the edge of the cot mattress shall be determined by the AHJ.

30.1.3* The compartment shall provide a clear aisle walkway on at least one side of the patient cot.

30.2 Mounting. If the body is of modular construction, it shall be mounted per the allowed and/or recommended methods of the chassis manufacturer.

30.3 Structural Integrity — Roof Loading.

30.3.1 Any Type I, Type I-AD, Type III, or Type III AD ambulance body shall meet the performance requirements of SAE J3057, *Ambulance Modular Body Evaluation-Quasi-Static Loading For Type I and Type III Modular Ambulance Bodies*.

30.3.2* Any Type II ambulance with a modified roof and a gross vehicle weight rating of greater than 10,000 lb (4536 kg) shall meet the performance requirements described in SAE J3057, *Ambulance Modular Body Evaluation-Quasi-Static Loading For Type I and Type III Modular Ambulance Bodies*.

30.4 Body Sealing.

30.4.1 Sealing Out Water.

30.4.1.1 There shall be no water leakage into the cab, any exterior compartment, or the patient compartment.

30.4.1.2 Compliance of the body sealing out water shall be validated by the manufacturer by testing each finished ambulance in accordance with AMD 010, *Water Leak Test*.

30.4.2 Sealing Out Exhaust Gas.

30.4.2.1 The body shall be sealed and vented so that the interior carbon monoxide level does not exceed 10 ppm of carbon monoxide (CO).

30.4.2.2 The patient compartment shall include a listed CO detector in accordance with UL 2034, *Standard for Single and Multiple Station Carbon Monoxide Alarms*.

30.5 Wheel Housings.

30.5.1 Wheel housings of modular bodies shall include splash shields between the body wheel housing and the wheels, extending over the top of the tires to the bottom of the body side skirting.

30.5.2 Wheel housing openings shall allow for tire chain usage and easy tire removal and service and conform to SAE J683, *Tire Chain Clearance — Trucks, Buses (Except Suburban, Intercity, and Transit Buses), and Combinations of Vehicles*.

30.5.3 The OEM's standard wheel housings on Type II ambulances shall be acceptable.

30.6 Patient Compartment to Cab Partition.

30.6.1 A bulkhead partition shall be provided between the cab and the patient compartment.

30.6.2 The partition(s) shall be located behind the driver's seat and the cab passenger seat when in the rearmost position and the seat back is reclined a minimum of 15 degrees.

30.6.3 The partition shall extend from the floor to the ceiling.

30.6.4 The partition shall be wide enough to cover the width of each cab seat excluding arm rests.

30.6.5* The cab and body bulkheads shall have an aligned window opening of at least 150 in.² (96,780 mm²) or other means of visual and hands-free audio communication.

30.6.6 If so equipped, a window in the cab or body shall be of the sliding or hinged type, aligned, and connected with the modular body window opening.

30.6.7 The window shall be a transparent, shatterproof panel, which is latchable from the cab side.

30.7 Access Handrails or Handholds.

30.7.1* Interior or exterior access handrails or handholds shall be provided at each entrance to the patient compartment and at each position where steps or ladders for climbing are located.

30.7.2 An overhead handrail shall be provided on the ceiling of the patient compartment.

30.7.3 Exterior access handrails shall be between 1 in. and 1½ in. (25 mm and 42 mm) in diameter and have a minimum clearance between the handrails and any surface of at least 2 in. (50 mm).

30.7.4 All exterior and interior access handrails shall be designed and mounted to reduce the possibility of hand slippage and to avoid snagging of equipment or clothing.

30.7.5 Access handrails supplied by the chassis manufacturer on a commercial chassis shall be permitted to be used to meet the requirements of this section.

30.7.6 Handrail Testing.

30.7.6.1 Handrails shall withstand a force of 300 lb (136 kg) applied in any direction without detaching, loosening, or permanently deforming.

30.7.6.2 Compliance of the handrail shall be validated by testing a substantially similar ambulance or body structure in accordance with AMD 008, *Handrail Static Load Test*.

30.8 Patient Compartment Entry Doors.

30.8.1 The patient compartment shall be equipped with at least one primary access door opening with minimum dimensions of 44 in. (1117 mm) wide by 46 in. (1168 mm) high.

30.8.2 Door handles shall be designed and installed to protect against accidental or inadvertent opening.

30.8.3* Entry doors and door openings shall be designed to minimize inadvertent snagging of apparel.

30.8.4 When doors are open, the hinges and latches shall not protrude into the access area.

30.8.5 Doors shall be equipped with a hold-open device.

30.8.6 One externally operated lock for each door opening shall be provided.

30.8.7* An internal lock on each patient compartment primary entry door shall be provided.

30.8.8 All patient compartment entry door locks shall be identically keyed.

30.8.9 Patient loading doors shall be equipped with not less than 250 in.² (161,300 mm²) of safety glass area per door.

30.8.10 Doors shall be designed to prevent leakage of exhaust fumes, dust, water, and air into the patient compartment.

30.9 Means of Egress.

30.9.1 Any interior area to be occupied by personnel shall have a minimum of two means of egress.

30.9.2* Each means of egress opening shall be a minimum of 30 in. (762 mm) by 46 in. (1168 mm).

30.9.3 Secondary egress doors shall not be blocked by patient compartment structures that would prevent the unloading of a patient on a backboard.

30.9.4 The egress and cot loading doors shall have an identifiable secondary emergency release mechanism.

30.10 Exterior Stepping Surfaces and Interior Steps.

30.10.1 Where specified, a slip-resistant surface shall be provided.

30.11 Exterior Storage.

30.11.1 All exterior compartment doors shall have latches with locks that hold the door in a closed position.

30.11.2 All hinged doors wider than 15 in. (381 mm), excluding battery compartments, shall have positive hold-open devices that permit one-hand closure.

30.11.3 Hardware shall be rust resistant.

30.11.4 The interior of all exterior compartments greater than 4 ft³ (0.11 m³) shall be both automatically illuminated when a door is opened and meet the requirements of 31.11.7.1.

30.11.5 The finish of the entire exterior storage, including interiors of storage cabinets, shall be as follows:

- (1) Resistant to soap, water, body fluids, and disinfectants
- (2) Mildew resistant
- (3) Able to be cleaned and disinfected

30.12 Floor.

30.12.1* The patient compartment floor shall be flat, except where the area near the rear entrance door is sloped for a lower entering height.

30.12.2 With the exception of cot retention hardware, the floor shall be free of obstructions in the doorway(s) and work area.

30.12.3 The floor shall be designed to eliminate voids or pockets where water or moisture can become trapped.

30.12.4 The subfloor construction shall cover the full length and width of the patient compartment.

30.12.5 If plywood is used in the subfloor, it shall be marine or exterior grade.

30.12.6 If the ambulance has a modular body, the subfloor shall be designed to prevent water penetration.

30.12.7 Body Floor Structural Integrity.

30.12.7.1 If the subfloor is constructed of plywood, the plywood shall have an American Plywood Association (APA) floor rating of 16 in. (406 mm) on center or better.

30.12.7.2 If the subfloor is constructed of other than plywood, it shall be tested using a 1 in. (25 mm) disk and have a maximum of 0.125 in. (3 mm) deflection at 200 lb (91 kg) force and a minimum ultimate load of 400 lb (181 kg) for a 16 in. (406 mm) on center load.

30.12.7.2.1 The maximum floor structure spacing shall be used for testing.

30.12.7.2.2 Compliance of the floor structural integrity shall be validated by testing the midpoint of the longest unsupported section of a substantially similar ambulance or floor structure in accordance with the concentrated static load test procedure in ASTM E661, *Standard Test Method for Performance of Wood and Wood-Based Floor and Roof Sheathing Under Concentrated Static and Impact Loads*.

30.12.7.2.2.1 If panel joints occur at the maximum span location, they shall be present in the test sample as a worst-case scenario.

30.12.7.3 A drawing of the floor structure and fastening schedule of the subfloor material to the structure shall be required in the certification report.

30.13 Floor Covering.

30.13.1 Floor covering shall be nonpermeable and seamless.

30.13.2 The floor covering shall cover the entire length and width of the compartment's exposed floor.

30.13.3 Joints where the floor covering meets the sidewalls shall be sealed and bordered with corrosion-resistant cove molding, or the floor covering shall extend at least 3 in. (76 mm) up the sidewalls.

30.14 Insulation.

30.14.1 Where the patient compartment is insulated, it shall be insulated with a nonsettling type, verminproof, mildew-proof, nontoxic, and nonhygroscopic material that meets the requirements of 49 CFR 571, FMVSS 302.

30.14.2 If fiberglass insulation is used, it shall be protected from exposure to water.

30.15* Interior Storage.

30.15.1 The interior of the patient compartment shall provide enclosed storage space.

30.15.2 Compartment(s) under the floor that have opening panel(s) inside the patient compartment shall not be acceptable.

30.15.3 Where furnished, top-opening squad bench lids shall be fitted with an automatic hold-open device and a quick-release slam-type latching device.

30.15.4 Storage compartment door handles, where provided, shall not protrude as follows:

- (1) More than 1 in. (25 mm) if located 14 in. (356 mm) or higher above the floor
- (2) More than 2 in. (51 mm) if located lower than 14 in. (356 mm) above the floor

30.15.5 Doors shall be designed to remain closed during transport.

30.15.6* Storage compartments shall be fastened to the body structure.

30.15.7 Each interior storage compartment shall be permanently labeled with its maximum load capacity.

30.15.8 Each storage compartment shall be tested in accordance with the requirements described in SAE J3058, *Ambulance Interior Storage Compartment Integrity*.

30.16 Interior Surfaces.

30.16.1 Exposed edges on the interior of the patient compartment shall have a radius of curvature of not less than $\frac{3}{32}$ in. (2.5 mm).

30.16.2* The finish of the entire patient compartment, including interiors of storage cabinets, shall be as follows:

- (1) Resistant to soap, water, body fluids, and disinfectants
- (2) Mildew resistant
- (3) Able to be cleaned and disinfected

30.16.3 Countertop horizontal surface shall be seamless and impervious to contaminants.

30.16.4 All edges that meet vertical cabinets shall be sealed.

30.16.5 Countertop horizontal surfaces shall be surrounded by a lip of not less than $\frac{1}{2}$ in. (12 mm) in height.

30.17 Equipment Mounting.

30.17.1 Medical Supplies and Equipment Storage Mounting. Supplies, devices, tools, and other equipment shall be stored in enclosed compartments or fastened to secure them during vehicle motion.

30.17.2 Equipment weighing 3 lb (1.36 kg) or more stored in a driving or patient compartment shall be mounted or contained in an enclosed compartment.

30.17.2.1 Equipment mounts or retention devices shall meet the performance requirements of SAE J3043, *Ambulance Equipment Mounts*.

30.17.3 Built-in communication devices installed in the patient compartment shall be within reach of EMSPs while seated and restrained in the designated primary patient care seat.

30.18* Waste and Sharps Disposal. A receptacle for general waste and an OSHA-compliant container for sharps disposal shall be both of the following:

- (1) Provided in the patient compartment
- (2) Within reach of the EMSP while remaining seated and restrained in the designated primary patient care seat

30.19 Fire Extinguishers. One 5 lb ABC fire extinguisher shall be accessible within the patient compartment and be mounted

using a quick-release bracket meeting the requirements of SAE J3043, *Ambulance Equipment Mounts*.

30.20 Holder for Intravenous Fluid Containers.

30.20.1 One mounted device specifically designed for holding and securing an IV fluid container against accidental release during normal transport activity shall be provided.

30.20.2 The device shall not protrude more than 1.0 in. (25 mm) in the stowed position.

30.21* Patient Compartment Seats.

30.21.1* Seat Integrity. Any seat mounted in a patient compartment shall meet the performance requirements specified in SAE J3026, *Ambulance Patient Compartment Seating Integrity and Occupant Restraint*.

30.21.2* Occupant Crash Protection.

30.21.2.1* Each designated seating position shall be provided with occupant crash protection.

30.21.2.2 Signs that read “Occupants Must Be Seated and Belted When Ambulance Is in Motion” shall be visible from each seated position.

30.21.3 Seated Head Clearance.

30.21.3.1 The minimum seat-to-ceiling dimension from the top surface of the seat bottom cushion to the nearest overhead obstruction for each designated seating position shall be 43 in. (1092 mm).

30.21.3.2 The measurement shall be in accordance with AMD 025, *Occupant Head Clearance Zones Test*.

30.21.4 Seat Adjustment. Where independent horizontal seat adjustment is provided, it shall be fully adjustable within 10 seconds.

30.21.5 Seating Position Width. Each designated seating space shall have a minimum width of 24 in. (610 mm) measured from the seat surface to 43 in. (1092 mm) above the seating surface.

30.21.6 Seat Size.

30.21.6.1 The seat bottom cushion height shall be a maximum of 21 in. (533 mm) measured from the floor.

30.21.6.2 Seat bottom cushions shall be a minimum of 18 in. (460 mm) in width.

30.21.6.3* Seat bottom cushions shall be between 15 in. (380 mm) and 19 in. (483 mm) from the front of the cushion to the face of the seat back.

30.21.6.4* Each seat shall provide back and head support.

30.21.6.5 For any seat not covered by 49 CFR 571, FMVSS 202, the top of the seat back or head rest shall be a minimum of 10 in. (254 mm) in width.

30.21.7 Access to Patient.

30.21.7.1 If the primary patient care seat is at the patient torso position, it shall be capable of being adjusted such that the seat bottom cushion is within 6 in. (152 mm) of the patient cot.

30.21.7.2 If the primary patient care position is at the patient torso position, the fore-aft position of the seat shall be capable

of lining up within 6 in. (152 mm) of the midpoint between the head end of the cot and the backrest hinge.

30.21.7.3 If the primary patient care seat is at the patient head position, it shall be capable of being adjusted such that the nearest edge of the seat bottom cushion is within 6 in. (152 mm) of the nearest edge of the patient cot.

30.21.7.4 If the designated primary patient care seat is at the patient head position, the longitudinal centerline of the seat shall line up within 11 in. (280 mm) of the longitudinal centerline of the cot.

30.21.8 Child Seating Restraints.

30.21.8.1 Any seat with a built-in system for transporting a child shall be oriented and installed in accordance with the seat manufacturer's instructions

30.21.8.2 If the ambulance is designed to transport children in a seat, it shall include a child restraint seat or have provisions to accommodate a child car seat.

30.22* Patient Cot Retention.

30.22.1 A cot fastener assembly with a quick-release latch shall be furnished.

30.22.2 The installed cot fastener device(s) for wheeled cots shall comply with both of the following:

- (1) The performance requirements of SAE J3027, *Ambulance Litter Integrity, Retention, and Patient Restraint*
- (2) Be installed in accordance with the cot fastener manufacturer's directions

30.22.3 The floor substructure shall be tested in accordance with SAE J3102, *Ambulance Patient Compartment Structural Integrity Test to Support SAE J3027 Compliant Litter Systems*.

30.23* HVAC. Connecting hoses for the heating and air-conditioning system shall be supported by rubber-insulated metal clamping devices at least every 18 in. (457 mm).

30.23.1 Heating.

30.23.1.1 A heating system shall be provided that is capable of raising the interior temperature from 32°F to 68°F (0°C to 20°C) within 30 minutes.

30.23.1.2 Compliance of the heating system shall be validated by testing a substantially similar ambulance in accordance with AMD 012, *Interior Climate Control Test*.

30.23.2 Air Conditioning.

30.23.2.1 An air-conditioning system shall be provided that is capable of lowering the interior temperature from 95°F to 78°F (35°C to 25°C) at a minimum of 40 percent relative humidity within 30 minutes.

30.23.2.2 Compliance of the air-conditioning system shall be validated by testing a substantially similar ambulance in accordance with AMD 012, *Interior Climate Control Test*.

30.23.3 Ventilation.

30.23.3.1 A patient care compartment air exhaust fan shall be provided.

30.23.3.2 Ventilation shall be separately controlled within the cab and the patient compartment.

30.23.3.3 Fresh air intakes shall comply with the following:

- (1) Be provided
- (2) Not be located near the engine exhaust outlet

30.24 Interior Noise.

30.24.1 The interior sound level in the patient compartment shall not exceed 80 decibels.

30.24.2 Compliance of the patient compartment interior sound level shall be validated by testing a substantially similar ambulance in accordance with AMD 006, *Patient Compartment Sound Level Test*.

30.25* Reflective Striping.

30.25.1* A retroreflective stripe, a combination of retroreflective stripes, or Battenburg markings shall be affixed to the ambulance in the following proportions:

- (1) 25 percent of the length of each of the cab side surfaces when approached from each side
- (2) 75 percent of the length of each patient compartment side surfaces when approached from each side

30.25.2 The stripe or combination of stripes shall be a minimum of 6 in. (152 mm) in total vertical width.

30.25.3 The 6 in. (152 mm) wide stripe or combination of stripes shall be permitted to be interrupted by objects (e.g., receptacles, cracks between slats in roll-up doors), provided the full stripe is conspicuous as the ambulance is approached.

30.25.4 A retroreflective graphic design shall be permitted to replace all or part of the required striping material on the sides of the vehicle if the design or combination thereof covers at least the same surface area as required by 30.25.1.

30.25.5 Any vertically hinged door shall have at least 60 in.² (38,710 mm²) of retroreflective material affixed to the inside of the door.

30.25.6* At least 50 percent of the rear-facing vertical surfaces other than glass and lenses, visible when facing from the rear of the ambulance, shall be equipped with retroreflective material.

30.25.6.1 Where chevrons are used, each stripe in the chevron shall be a single color alternating between two high-contrast colors.

30.25.6.2 Each stripe shall be 6 in. (152 mm) in width.

30.25.6.3 Where Battenburg markings are used, each box in the Battenburg markings shall be 144 in.² (92,903 mm²).

30.25.7 All retroreflective material shall conform to the requirements of ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1, for Type I Sheeting.

30.25.8 All retroreflective materials that are colors not listed in ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1, shall have a minimum coefficient of retroreflection of 10 with an observation angle of 0.2 degrees and an entrance angle of -4 degrees.

30.25.9 Any printed or processed retroreflective film construction shall conform to the standards required of an integral colored film as specified in ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, Section 6.1.1.

30.26 Metal Finish. Where dissimilar metals that pose a galvanic corrosion or reactive threat are to be mounted together, the mounting base material shall have an isolation barrier prior to assembly to prevent dissimilar metal reaction.

30.27 Painting.

30.27.1 All exposed ferrous metal surfaces that are not plated or stainless steel shall be cleaned, prepared, and painted or coated.

30.27.2 The paint or coating, including any primer, shall be applied in accordance with the paint or coating manufacturer's recommendation.

30.28 Medical Gas — Main Supply and Installation.

30.28.1 The ambulance shall have a medical gas system capable of supplying a minimum of 793 gal (3000 L) of medical gas.

30.28.2 If a compressed gas cylinder is used, a cylinder-changing wrench shall be secured within the medical gas storage compartment.

30.28.3* All medical gas system controls shall be accessible from inside the vehicle.

30.28.4 A medical gas-capacity indicator shall be visible from the designated primary patient care seating position.

30.28.5 The medical gas port shall be accessible from the designated primary patient care seating position.

30.28.6 The purchaser shall specify the quantity and location of medical gas ports.

30.28.7 Medical gas system shall include the following:

- (1) A pressure regulator
- (2) Low pressure, electrically conductive hose and fittings approved for medical gas
- (3) Medical gas piping that is concealed and not exposed to the elements, securely supported to prevent damage, and readily accessible for inspection and replacement
- (4) Medical gas that is piped to a medical gas port with a minimum flow rate of 26.4 gpm (100 L/min) at the outlet
- (5) Outlet(s) that is marked and identified and does not interfere with the suction outlet

30.28.8 Medical gas and suction ports shall be within reach of EMSPs while remaining seated and restrained in the designated primary patient care position.

30.28.9 Medical Gas Pressure Regulator.

30.28.9.1 The medical gas pressure reducing and regulating valve system shall be provided with the following features:

- (1) An inlet filter at the cylinder
- (2) A line relief valve set at 200 psi (1380 kPa) maximum
- (3) A gauge or digital monitor with a minimum range of 0 psi to 2500 psi (0 kPa to 17,237 kPa) graduated in not more than 100 psi (690 kPa) increments
- (4) A locking adjustment preset at 50 psi $\pm$ 2 psi (345 kPa $\pm$ 14 kPa) line pressure

30.28.9.2 The regulator shall meet the performance required by 30.28.9.3 at an inlet pressure range from 150 psi to 2500 psi (1034 kPa to 17,237 kPa).

30.28.9.3 With the regulator set at 50 psi $\pm$ 2 psi (345 kPa $\pm$ 14 kPa), a 26.4 gpm (100 L/min) minimum flow rate shall be available at all medical gas ports.

30.28.10 Medical Gas Tank Storage.

30.28.10.1 Storage for an “M” or “H” size main medical gas cylinder shall be accessible for replacement from an outside position.

30.28.10.2 Any exterior medical gas compartment, if so equipped, shall be provided with at least 9 in.² (580 mm²) of open vent to dissipate or vent leaking medical gas to the outside of the ambulance.

30.28.10.3 Medical gas cylinder compartment shall comply with the following:

- (1) Not be utilized for storage of any other equipment
- (2) Be labeled “Medical Gas Storage Only”

30.28.11 Medical Gas Tank Retention.

30.28.11.1 A medical gas cylinder(s) shall be mounted with a restraining device(s) that meets the requirements of SAE J3043, *Ambulance Equipment Mounts*, in the lateral and longitudinal directions of the vehicle.

30.28.11.2 Compliance of the medical gas tank retention device, in the lateral and longitudinal directions of the vehicle, shall be validated by testing a sample retention device using a substantially similar ambulance or body structure in accordance with the testing requirements of SAE J3043, *Ambulance Equipment Mounts*.

30.28.11.3 A medical gas cylinder(s) shall be mounted with a restraining device(s) that meets the requirements of AMD 028, *Vertical Component Retention — Static Test*, in the vertical direction.

30.28.11.4 Compliance with the medical gas retention device in the vertical direction shall be validated by testing a sample retention device using a substantially similar ambulance or body structure in accordance with the testing requirements of AMD 028, *Vertical Component Retention — Static Test*.

30.28.12 Medical Gas System Integrity and Flow Capacity.

30.28.12.1 The medical gas system of each ambulance shall be tested prior to delivery in accordance with AMD 015, *Ambulance Main Medical Gas System Test*.

30.28.12.1.1 The medical gas system shall lose no more than 5 psi (34 kPa) of pressure in a 2-hour period.

30.28.12.1.2 Each port shall be capable of delivering at least 26.4 gpm (100 L/min) of medical gas.

30.28.12.2 A label shall be provided near the medical gas tank stating the following: The integrity of this medical gas system was tested in accordance with AMD 015, *Ambulance Main Medical Gas System Test*, and meets the requirements thereof.

30.28.12.3 The label shall be signed and dated by an authorized representative of the ambulance manufacturer or test agency.

30.29 Suction Aspirator.

30.29.1 A mountable battery-powered or electrically powered suction aspirator system shall be furnished.

30.29.2 The vacuum control, vacuum indicator, and collection bottle or bag shall be located so that it can be operated from a position near the head of the patient.

30.29.3 Any permanently mounted suction pump shall be located in an area that is accessible for service.

30.29.4 Any permanently mounted suction pump shall be vented to the vehicle's exterior.

30.29.5 A vacuum control and a shutoff valve, or combination thereof, shall be provided to adjust vacuum levels.

30.29.6 A vacuum indicator gauge graduated at least every 2 in. (51 mm) Hg and a minimum total range of 0 in. to 30 in. (0 mm to 762 mm) Hg shall be provided.

30.29.7 The collection bottle or bag shall be shatter resistant and transparent with a minimum 0.26 gal (1000 ml) capacity.

30.29.8 Compliance of the aspirator system shall be validated by the manufacturer by testing each individual aspirator system installed in accordance with AMD 021, *Aspirator System Test*.

30.29.9 Aspirator System Performance.

30.29.9.1 The aspirator system shall provide a free airflow of at least 1.06 ft³/min (30 L/min).

30.29.9.2 The aspirator system shall achieve a minimum of 5.8 psi (300 mm) Hg vacuum within 4 seconds after the suction tube is closed.

30.29.9.3 Compliance of the aspirator system shall be validated by the manufacturer by testing each individual aspirator system installed in accordance with AMD 021, *Aspirator System Test*.

Chapter 31 Automotive Ambulances — Low Voltage Electrical Systems and Warning Devices (NFPA 1917)

31.1* General. Any low voltage electrical systems or warning devices installed on the ambulance shall be appropriate for the mounting location and intended electrical load and meets the specific requirements of Chapter 31.

31.1.1 Printed Circuits.

31.1.1.1 Where printed circuits are utilized, they shall conform to IPC A-610H, *Acceptability of Electronic Assemblies*.

31.1.1.2 Printed circuit assemblies installed by the FSAM shall comply with IPC A-610H, *Acceptability of Electronic Assemblies*, Classification 1.4.1.

31.1.2 Electrical System Performance Tests. The low voltage electrical system performance test shall be done in accordance with AMD 005, *Low Voltage Electrical System Test*.

31.2 Wiring.

31.2.1 All electrical circuit wiring supplied and installed by the ambulance manufacturer shall meet the requirements of 31.2.1.1 through 31.2.1.6.

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

31.2.1.2 Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent.

31.2.1.3 The installation of star washers by the final-stage ambulance manufacturer for circuit ground connections shall not be permitted.

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

31.2.1.5 Only electrical components directly related to the delivery of onboard medical gas and other circuits needed for required lighting or medical gas tank lifts shall terminate in the medical gas storage compartment.

31.2.1.6 Electrical harnesses or wires that pass through the medical gas compartment shall be enclosed in conduit.

31.2.2 Wiring and Wire Harness Construction.

31.2.2.1 All insulated wire and cable shall conform to SAE J1127, *Low Voltage Battery Cable*, or SAE J1128, *Low Voltage Primary Cable*, type SXL and/or GXL.

31.2.2.1.1 All conductors shall be constructed in accordance with SAE J1127 or SAE J1128, except where good engineering practice dictates special strand construction.

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

31.2.2.1.3 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127 or SAE J1128, except where good engineering practice dictates special conductor insulation.

31.2.2.2 The overall covering of conductors or jacketed cables shall be moisture-resistant loom or braid that has a minimum continuous rating of 300°F (149°C).

31.2.2.3 The overall covering of jacketed cables shall be moisture resistant and have a minimum continuous temperature rating of 300°F (149°C).

31.2.2.4 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection.

31.2.2.4.1 The wiring connections and terminations shall be installed in accordance with the device manufacturer's instructions.

31.2.2.4.2 Wire nut, insulation displacement, and insulation piercing connections shall not be used.

31.2.2.5 All ungrounded electrical terminals and electrical panels shall have protective covers or be in enclosures.

31.2.2.6 A minimum 6 in. (152 mm) service loop of wire or harness shall be provided at all electrical components, terminals, and connection points.

31.2.2.7 Exterior connections for lights and fixtures shall utilize sealed connectors or sealed splices.

31.2.2.8 Wiring Protection.

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

31.2.2.8.2 Wiring shall not be secured to brake lines and/or fuel lines.

31.2.2.9* Wiring Identification. Wiring shall be uniquely identified at least every 4 in. (101 mm) by color coding or permanent marking with a circuit function code and the wire referenced on a wiring diagram as listed in 28.17.2.3(6).

31.2.2.10 Circuit Protection.

31.2.2.10.1 Circuits shall be provided with rated low voltage overcurrent protective devices.

31.2.2.10.2 Such devices shall be accessible and protected against heat in excess of the overcurrent device's design range, mechanical damage, and water spray.

31.2.2.10.3 Circuit protection shall be accomplished by utilizing fuses, circuit breakers, fusible links, or solid state equivalent devices.

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

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

31.2.2.11 Terminals.

31.2.2.11.1 All terminals shall be permanently numbered or coded.

31.2.2.11.2 A terminal strip(s) block(s) or a multi-pin connector(s) shall be accessible for checking and service.

31.2.2.12 Hard-wired patient compartment electrical systems shall incorporate a master circuit breaker panel with circuit breakers or other electronic nondisposable current protection devices, in each circuit, that comply with SAE J553, *Circuit Breakers*, Type I or Type III (if circuit breaker is accessible for resetting by the driver or EMSP).

31.2.2.12.1 Multiplexed patient compartment electrical systems shall incorporate centralized circuit protection devices on each power circuit supplying the multiplexing system's components.

31.2.2.13 One extra circuit, minimum 15 amperes, shall be provided for future use.

31.2.2.14 Grounding.

31.2.2.14.1 All electrical components or appliances shall be electrically grounded in accordance with the component manufacturer's recommendations.

31.2.2.14.2 The use of appliance mounting screws/hardware shall not be used for grounding purposes unless specifically designed for that purpose.

31.2.2.15 All switches, indicators, and controls shall be located and installed in a manner that facilitates easy removal.

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

31.2.2.17 The patient compartment interior and exterior electrical circuits shall be powered by circuit(s) separate and distinct from vehicle chassis circuits, unless specific chassis circuits are supplied for that purpose by the chassis manufacturer.

31.3 Power Supply.

31.3.1 A 12 volt or greater electrical alternator shall be provided.

31.3.2* Low Idle Alternator Output.

31.3.2.1 The alternator shall have a minimum output at low idle to meet the minimum electrical load test conditions of the ambulance between 60°F and 110°F (15°C and 43°C) ambient temperature.

31.3.2.1.1 Minimum electrical load test conditions, which are tested under low-idle conditions, shall consist of the following:

- (1) The propulsion engine and transmission
- (2) All legally required clearance and marker lights, headlights, and other electrical devices except windshield wipers and four-way hazard flashers
- (3) The radio(s) at a duty cycle of 10-percent transmit and 90-percent receive (for calculation and testing purposes, a default value of 5 amperes continuous)
- (4) Cab air conditioning (at coldest setting with highest blower speed)
- (5) Patient compartment air conditioning (at coldest setting with highest blower speed)
- (6) The lighting necessary to illuminate walking surfaces at entry points

31.3.2.2 Compliance of the minimum electrical load test conditions shall be validated by testing each ambulance in accordance with the "Alternator Performance Test at Idle" as specified in AMD 005, *Low Voltage Electrical System Test*.

31.3.3 The alternator shall be provided with full automatic regulation.

31.3.4 High-Idle Alternator Output.

31.3.4.1 The alternator shall have a minimum output at high idle to power the operational electrical load test conditions between 60°F and 110°F (15°C and 43°C) ambient temperature.

31.3.4.2 Compliance of the high-idle alternator output shall be validated by the final-stage ambulance manufacturer by testing each ambulance in accordance with the "Alternator Performance Test at High Idle" as specified in AMD 005, *Low Voltage Electrical System Test*.

31.4 Operational Electrical Load Test Conditions.

31.4.1 The minimum continuous electrical load under operational electrical load test conditions shall consist of the total amperage required to simultaneously operate the following in a stationary mode during emergency operations:

- (1) The propulsion engine and transmission
- (2) All legally required clearance and marker lights, headlights, and other electrical devices except windshield wipers and four-way hazard flashers
- (3) The radio(s) at a duty cycle of 10-percent transmit and 90-percent receive (for calculation and testing purposes, a default value of 5 amperes continuous)
- (4) The lighting necessary to illuminate walking surfaces at entry points and 50 percent of the total compartment light load as required by this standard
- (5) The minimum optical warning system required in Section 31.8, where the ambulance is blocking the right-of-way

- (6) The continuous electrical current required to simultaneously operate an additional 20-ampere load
- (7) Cab air conditioning (at coldest setting with highest blower speed)
- (8) Patient compartment air conditioning (at coldest setting with highest blower speed)
- (9) Patient compartment dome lighting (in the high intensity setting)
- (10)* Other warning devices and electrical loads defined by the purchaser as critical to the mission of the ambulance

31.4.2 If the ambulance is equipped to tow a trailer, an additional 20 amperes shall be added to the minimum continuous electrical load to provide electrical power for the federally required clearance and marker lighting and the optical warning devices mounted on the trailer.

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

31.4.3.1 The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the electrical system voltage.

31.4.3.2 Voltage Alarm.

31.4.3.2.1 The alarm shall sound if the system voltage at the battery or at the master load disconnect switch drops below 11.8 volts for 12-volt nominal systems, 23.6 volts for 24-volt nominal systems, or 35.4 volts for 42-volt nominal systems for more than 120 seconds.

31.4.3.2.2 Compliance of the voltage alarm shall be validated by testing each ambulance in accordance with the "Low Voltage Alarm Test" as specified in AMD 005, *Low Voltage Electrical System Test*.

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

31.5 Load Management.

31.5.1* If the total continuous electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 31.4.1, an automatic electrical load management system shall be required.

31.5.2 The minimum continuous electrical loads specified in 31.4.1 shall not be subject to automatic load management.

31.5.3 Engine Speed Auxiliary Control Device.

31.5.3.1 Installed engine speed auxiliary control devices shall have an interlock to prevent the operation of the engine speed auxiliary control device unless the parking brake is engaged and the transmission is in neutral or park, or the parking brake is engaged and the engine is disengaged from the drive wheels.

31.6* Batteries.

31.6.1 Continuous Electrical Load.

31.6.1.1 With the engine off, the battery system shall be able to provide the minimum electrical load test conditions specified in 31.4.1 for 10 minutes and then be able to restart the engine.

31.6.1.2 Compliance of the battery system shall be verified on every ambulance prior to delivery in accordance with the "Reserve Capacity Test" as specified in AMD 005, *Low Voltage Electrical System Test*.

31.6.2 The battery system cold cranking amps (CCA) rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer.

31.6.3 The batteries shall be mounted to prevent movement during ambulance operation and protected against accumulations of road spray, snow, and road debris.

31.6.3.1 The batteries shall be readily accessible for examination, testing, and maintenance.

31.6.3.2 Where an enclosed battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes and separated from the occupant compartments.

31.6.3.3* The batteries shall be protected against vibration and temperatures that exceed the battery manufacturer's recommendation.

31.6.4 A means shall be provided for jump-starting the engine if the batteries are not accessible without lifting the cab of a tilt-cab ambulance.

31.6.5* An onboard battery conditioner or charger shall be provided for maintaining batteries in a fully charged condition.

31.6.5.1 The onboard charger shall be tested to the requirements of the "Onboard Battery Charger Test" as specified in AMD 027, *Line Voltage Electrical Systems Test*.

31.6.6 Any associated line voltage electrical power system shall be installed in accordance with Chapter 32.

31.6.7* A master load disconnect shall be provided between the main power source and the patient compartment electrical loads.

31.6.8 Alternators shall not be wired through the master load switch.

31.6.9 A sequential switching device shall be permitted to energize the optical warning devices required in Section 31.9 and other high current devices, provided the switching device first energizes the electrical devices required in Section 31.9 within 5 seconds.

31.6.10 Two automotive power point-type connectors shall be furnished in the patient compartment.

31.6.10.1 The power point circuits shall prevent discharge of chassis batteries by permitting the charging of portable devices only when the vehicle's ignition is on or the automatic charger/conditioner is connected to shore power.

31.6.10.2 The power point circuits shall be protected by a minimum 10 amp circuit breaker.

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

31.8* Electromagnetic Interference. Electromagnetic interference suppression shall be provided, as required, to satisfy

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

31.9 Optical Warning Systems. Each ambulance shall have an optical warning system that meets or exceeds the requirements of this section.

31.9.1* The optical warning system shall include an upper and a lower level of optical warning devices.

31.9.2 The requirements for each level shall be met by the warning devices in that particular level without consideration of the warning devices in the other level.

31.9.3 For defining and measuring the required optical performance (not the physical device mounting locations), the upper and lower warning levels shall be divided into four warning zones.

31.9.3.1 The four warning zones shall be determined by lines drawn from the vehicle centerline out through the corners of the ambulance at 45 degrees to a line drawn lengthwise through the geometric center of the ambulance.

31.9.3.2* The four warning zones shall be designated A, B, C, and D in a clockwise direction, with zone A to the front of the ambulance, as shown in Figure 31.9.3.2.

31.9.3.3 Optical system compliance by zone shall be provided.

31.9.3.4* An optical warning system shall consist of eight individual zones — four zones on the upper level and four zones on the lower level.

31.9.4 Each optical warning device shall be installed on the ambulance and connected to the ambulance's electrical system in accordance with the requirements Chapters 28 through 34, of this standard and the requirements of the manufacturer of the device.

31.9.5* A master optical warning system switch that energizes all the optical warning devices shall be provided.

31.9.6* The optical warning system on the ambulance shall be capable of at least two separate signaling modes during emergency operations.

31.9.6.1 One mode shall signal to drivers and pedestrians that the ambulance is responding to an emergency and is calling for the right-of-way.

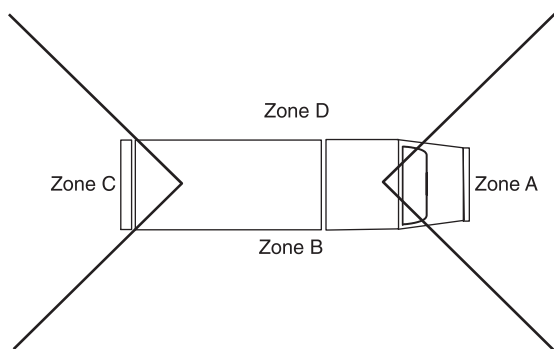


FIGURE 31.9.3.2 Warning Zones for Optical Warning Devices.

31.9.6.2 One mode shall signal that the ambulance is stopped and is blocking the right-of-way.

31.9.6.3 Any optical characteristic change made within any mode shall meet the minimum requirements of this chapter.

31.9.7 Mode Selection.

31.9.7.1 A switching system shall be provided that senses the position of the parking brake or the park position of an automatic transmission.

31.9.7.2 When the master optical warning system switch is enabled and the parking brake is released or the automatic transmission is not in park, the warning devices signaling the call for the right-of-way shall be energized.

31.9.7.3 When the master optical warning system switch is enabled and the parking brake is on or the automatic transmission is in park, the warning devices signaling the blockage of the right-of-way shall be energized.

31.9.7.4 Any method used in changing a signaling mode shall comply with the requirements of this chapter.

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

31.9.9* The optical warning devices shall not impair the effectiveness of lighting devices required under 49 CFR 571.108, including headlights, turn signals, clearance lights, and brake lights.

31.9.10* The optical warning light system shall have optical sources on each level and in each zone so that failure of a single optical source does not create a zone without a visible warning signal at a distance of 100 ft (30 m) from the geometric center of the ambulance.

31.9.11 Flash Rate.

31.9.11.1 The flash rate of any optical source shall be between 60 and 240 flashes per minute.

31.9.11.2 The optical energy provided by nonflashing optical sources, or the steady burning part of an optical flash characteristic, shall not be included in the calculations of the zone's total optical power.

31.9.12 Color of Warning Lights.

31.9.12.1 Permissible optical colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table 31.9.12.1.

31.9.12.1.1 The optical energy provided by green optical sources shall not be included in the calculations of the zone's total

Table 31.9.12.1 Zone Colors

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

optical power or meeting the requirements for any required lights.

31.9.12.2 All colors shall be as specified in SAE J578, *Chromaticity Requirements of Ground Vehicle Lamps and Lighting Equipment*, for red, blue, yellow, green, or white.

31.9.13* Requirements for Large Ambulances.

31.9.13.1 If the ambulance has a bumper-to-bumper length of 25 ft (7.6 m) or more or has an optical center on any optical warning device greater than 8 ft 6 in. (2.6 m) above level ground, the requirements of 31.9.13.2 through 31.9.13.6 shall apply.

31.9.13.2 Upper-Level Optical Warning Devices.

31.9.13.2.1 To define the clearance lines of the ambulance, the upper-level optical warning devices shall be mounted high and as close to the corner points of the ambulance as is practicable.

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

31.9.13.3 Lower-Level Optical Warning Devices.

31.9.13.3.1 To define the clearance lines of the ambulance, the optical center of the lower-level optical warning devices in the front of the ambulance shall be mounted on or forward of the front axle centerline and close to the front corner points of the ambulance.

31.9.13.3.2 The optical center of the lower-level optical warning devices at the rear of the ambulance shall be mounted on or behind the rear axle centerline and as close to the rear corners of the ambulance as is practicable.

31.9.13.3.3 The optical center of any lower-level device shall be between 18 in. and 62 in. (460 mm and 1600 mm) above level ground.

31.9.13.4 Midship Optical Warning Devices.

31.9.13.4.1 A midship optical warning device shall be mounted on both the right and the left sides of the ambulance if the distance between the front and rear lower-level optical devices exceeds 25 ft (7.6 m) at the optical center.

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

31.9.13.4.3 The optical center of any midship-mounted optical warning device shall be between 18 in. and 62 in. (460 mm and 1600 mm) above level ground.

31.9.13.5* For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone total optical power requirements shown in Table 31.9.13.5.

31.9.13.6 No individual photometric measurement point shall be less than that shown in Table 31.9.13.5.

31.9.14* Requirements for Small Ambulances.

31.9.14.1 If the ambulance has a bumper-to-bumper length of less than 25 ft (7.6 m) and has the optical center of all optical warning devices at 8 ft 6 in. (2.6 m) or less above level ground, the requirements of 31.9.14.2 through 31.9.14.5 shall apply.

31.9.14.2 Upper-Level Optical Warning Devices.

31.9.14.2.1 The upper-level optical warning devices shall be mounted as high as practicable, but not over 8 ft 6 in. (2.6 m), at the optical center.

31.9.14.2.2* The upper-level optical warning devices shall consist of a single optical warning device providing 360 degrees of conspicuity or a combination of optical devices creating 360 degrees of conspicuity.

Table 31.9.13.5 Minimum Optical Power Requirements for Large Ambulances

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

H = Horizontal plane passing through the optical center.

Notes:

(1) All values are in candela-seconds/minute.

(2) The values in the *H*Total columns are the total of 19 data point values for each light, with data points on the boundary between zones counted in both zones.

31.9.14.3 Lower-Level Optical Warning Devices.

31.9.14.3.1 One or more lower-level optical warning devices shall be visible from the front and the side of the ambulance.

31.9.14.3.2 To define the front clearance lines of the ambulance, the optical center of the lower-level optical warning devices in the front of the ambulance shall be mounted on or forward of the front wheel centerline and as close to the front corner points of the ambulance as is practicable.

31.9.14.3.3 The optical center of the device(s) shall be between 18 in. and 48 in. (460 mm and 1220 mm) above level ground.

31.9.14.4 For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone's total optical power requirements shown in Table 31.9.14.4.

31.9.14.5 No individual photometric measurement point shall be less than that shown in Table 31.9.14.4.

31.9.15 Tests of Optical Warning Devices.

31.9.15.1 Mechanical and Environmental Test. All optical warning devices and components shall be tested in accordance with SAE J845, *Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles* and comply with the following performance requirements of that standard:.

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

31.9.15.2 Photometric Test Procedures for Optical Devices.

31.9.15.2.1 Testing shall be performed by, or on behalf of, the device manufacturer.

31.9.15.2.1.1 Testing Results.

(A) The results of the testing shall be used to determine compliance with this standard.

(B) All required photometric data shall be made available, upon request, from the optical warning device manufacturer.

31.9.15.2.1.2 All optical warning devices shall be tested with the test procedures of SAE J845, *Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, under the following conditions:

- (1) Optical measurements shall be made in candela-seconds per minute.
- (2) Optical measurements shall be made for the photometric measurement points defined in 10.7.16.2.2.
- (3) Optical power shall be measured at photometric stability, not adjusted back to 1-minute photometric performance.

31.9.15.2.2 Photometric Measurement Points.

31.9.15.2.2.1 Measurements shall be made along the horizontal plane that passes through the optical center, beginning at the optical center and repeated at 5-degree intervals to the left and to the right of the optical center throughout the active horizontal angle of light emission of the optical source.

31.9.15.2.2.2 Measurements shall be repeated at 5 degrees up and 5 degrees down from the horizontal plane that passes through the optical center, beginning at a point on the vertical plane passing through the optical center and be repeated at 5-degree intervals to the left and to the right of this vertical plane throughout the active horizontal angle of light emission of the optical source.

31.9.16* Compliance Documentation. The ambulance manufacturer shall demonstrate compliance of the optical warning system by one of the following methods:

- (1) Certification that the optical warning devices were installed within the geometric parameters specified by the manufacturer of the devices and referencing certification

Table 31.9.14.4 Minimum Optical Power Requirements for Small Ambulances

		Mode of Operation					
		Calling for Right-of-Way			Blocking-Right-of-Way		
Zone	Level	H Total	At Any H Point	At Any Point 5 Degrees Up or 5 Degrees Down from H	H Total	At Any H Point	At Any Point 5 Degrees Up or 5 Degrees Down from H
A	Upper	1,000,000	10,000	3,500	400,000	10,000	3,500
B	Upper	200,000	8,000	3,500	200,000	8,000	3,500
C	Upper	400,000	10,000	3,500	800,000	10,000	3,500
D	Upper	200,000	8,000	3,500	200,000	8,000	3,500
A	Lower	150,000	3,750	1,300	150,000	3,750	1,300
B	Lower	75,000	1,875	650	75,000	1,875	650
C	Lower	0	0	0	0	0	0
D	Lower	75,000	1,875	650	75,000	1,875	650

Notes:

H = Horizontal plane passing through the optical center.

(1) All values are in candela-seconds/minute.

(2) The values in the H Total columns are the total of 19 data point values for each light, with data points on the boundary between zones counted in both zones.

by the optical warning device manufacturer that the system meets or exceeds the minimum optical power requirements for the specified zone and level

- (2) Certification that a mathematical calculation based on photometric test reports for individual optical sources provided by the manufacturer of the devices and performed by a qualified person demonstrates that the combination of individual devices as installed meets the requirements for the specified zone and level

31.10 Audible Warning Devices.

31.10.1 Audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren shall be provided.

31.10.1.1 The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens*.

31.10.1.2* A means shall be provided to allow the activation of the siren within convenient reach of the driver.

31.10.2 Where furnished, air horns, electric siren(s), and electronic siren speaker(s) shall be mounted low and far forward on the ambulance.

31.10.3 Audible warning equipment shall not be mounted on the roof, on the front of the module, or behind the ambulance operator.

31.11 Exterior and Interior Lighting.

31.11.1 All light level measurements shall be made with a light meter with a hemispherical light sensor held against the surface, facing perpendicular to the surface, and not deliberately pointed toward the light source.

31.11.2 Scene Lighting.

31.11.2.1 Scene lights shall be located on both the sides of the ambulance.

31.11.2.2 Scene lights shall be not less than 75 in. (1.9 m) above the ground and unobstructed by open doors.

31.11.2.3 Scene light switches shall comply with the following:

- (1) Be located on the cab console
- (2) Control each side independently

31.11.3 Load Lighting.

31.11.3.1 The loading area shall be illuminated to a level of at least 1 footcandle (fc) within the first 5 ft (1.5 m) from the vehicle and 0.3 fc up to 10 ft (3 m) from the vehicle.

31.11.3.2 Compliance of the load lighting illumination shall be validated by testing a substantially similar ambulance in accordance with AMD 024, *Perimeter Illumination Test*.

31.11.3.3 Load lights shall be not less than 75 in. (1.9 m) above the ground and unobstructed by open doors.

31.11.3.4 Load lights shall turn on whenever the rear patient entry doors are opened and the module power is on.

31.11.3.5 Load light switches shall allow for manual operation when the doors are closed.

31.11.4 Ambulance Exterior DOT Lighting. The exterior ambulance lighting shall include all required 49 CFR 571, FMVSS 108 lighting.

31.11.5 Ground Lighting.

31.11.5.1 The ambulance shall be equipped with lighting that is capable of providing illumination at a minimum level of 0.3 fc on ground areas within 30 in. (800 mm) of the edge of the ambulance in areas designed for personnel to climb into or onto the ambulance or descend from the ambulance to the ground level.

31.11.5.2 Lighting designed to provide ground illumination for safe egress as described in 31.11.5.1 shall be switchable but automatically activates when the exit doors are opened.

31.11.5.3 All other ground area lighting shall be switchable.

31.11.6 Interior Lighting.

31.11.6.1* The ambulance shall have sufficient lighting to provide an average level of 1 fc (10.764 lx) at each seating surface in the driving compartments.

31.11.6.2 Driving compartment lighting shall be designed and located so that no glare is reflected into the driver's eyes or line of vision from switch control panels or other areas that are illuminated while the vehicle is in motion.

31.11.6.3* Patient Compartment Illumination.

31.11.6.3.1 The ambulance interior lighting configuration shall be designed to minimize electrical loads.

31.11.6.3.2 Any lighting circuit shall have separately protected and controlled circuits.

31.11.6.3.3 All interior lighting fixtures shall not protrude more than 1½ in. (38 mm) from the mounting surface.

31.11.6.3.4 The patient compartment lighting shall have the two levels of lighting, high and low, at a minimum.

31.11.6.3.4.1 In the high setting, the patient compartment floor shall have a minimum of 15 fc of illumination, measured along the centerline of the clear floor.

31.11.6.3.4.2* In the high setting, the primary cot shall be provided with a minimum of 35 fc of illumination, measured on at least 90 percent of the cot's surface area.

31.11.6.3.4.3 In the low setting, the patient compartment floor shall have a minimum of 3.5 fc of illumination, measured along at least 85 percent of the centerline length.

31.11.6.3.4.4 In the low setting, the side entry step shall have a minimum of 2.0 fc of illumination, measured in the center of the step area.

31.11.6.3.4.5 Compliance of the requirements in 31.11.6.3.4.1 through 31.11.6.3.4.4 shall be validated by testing a substantially similar ambulance in accordance with AMD 016, *Patient Compartment Lighting Level Test*.

31.11.6.3.5 The patient compartment lighting shall be automatically activated when the side entry or rear entry patient compartment doors are opened and the module power is on.

31.11.7 Compartment Lighting.

31.11.7.1 Each exterior storage compartment that is greater than 4 ft³ (1.2 m³) and having an opening greater than 144 in.² (92,900 mm²) shall have compartment lighting to provide a minimum of 1 fc (10.764 lx) at any location on the floor of the

compartment without any shelves, dividers, or equipment in the compartment.

31.11.7.2 Compartment lighting shall be automatically enabled when the compartment door is opened and module power is on.

31.11.7.3 The lights shall be arranged or protected to minimize accidental breakage.

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

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

31.12 Do-Not-Move Ambulance Light.

31.12.1* A red flashing or rotating light or electronic display within the forward view of the driver shall be illuminated automatically whenever the ambulance's ignition circuit is energized, the parking brake is not fully engaged, and either of the following conditions exists:

- (1) Any passenger door, patient entry door, or equipment compartment door is not closed.
- (2) Any other device permanently attached to the ambulance is open, extended, or deployed in a manner that is likely to cause damage to the ambulance if the ambulance is moved.

31.12.2 Compartments meeting all the following conditions shall be permitted to be exempt from the requirements of 31.12.1:

- (1) The volume is less than or equal to 4 ft³ (0.11 m³).
- (2) The compartment has an opening less than or equal to 144 in.² (92,900 mm²).
- (3) The open door does not extend sideways beyond the mirrors or up above the top of the ambulance.

31.12.3 If the ambulance is equipped with a do-not-move ambulance light, the light shall be labeled to read "Do Not Move Unit."

31.13* Backup Alarm.

31.13.1 An electric or electronic backup alarm shall be provided that meets the Type D (87 dBa) requirements of SAE J994, *Alarm — Backup — Electric Laboratory Performance Testing*.

31.13.2 The backup alarm shall be enabled any time the vehicle is in reverse.

31.14 Stop, Tail, and Directional Lights.

31.14.1 The ambulance shall be equipped with all 49 CFR 571, FMVSS 108 legally required stop, tail, and directional lights.

31.14.2 Directional lights shall be visible according to 49 CFR 571, FMVSS 108.

31.14.3 On ambulances 30 ft (10 m) or longer in length, a turn signal shall be mounted approximately midway along the ambulance at running board height.

31.14.4 Equipment shall not be mounted in a manner that obscures the stop, tail, or directional lights.

31.14.5* Emergency warning lights shall not be used as brake lights, tail lights, or turn signals if they exceed the maximum candela output requirements in 49 CFR 571, FMVSS 108.

31.14.6 Warning lights that do not exceed the maximum candela rating in 49 CFR 571, FMVSS 108 and are used as primary or auxiliary brake lights shall not be mounted higher than 72 in. (1829 mm) above the ground nor lower than 15 in. (381 mm) from the ground.

31.15 Communications Equipment.

31.15.1 Any two-way radio equipment shall be installed in accordance with the requirements of the radio equipment manufacturer.

31.15.2 Built-in communication devices installed in the patient compartment shall be secured within maximum functional reach of EMSPs, from a 5th percentile female through a 95th percentile male, while seated and restrained.

31.15.3 Onboard Data Management and Communications Equipment. The purchaser shall specify what the contractor needs to provide in terms of onboard data management and communications equipment for the apparatus.

31.15.3.1 For each category of equipment listed in 31.15.3.5, the purchaser shall specify what equipment the contractor is to supply and install.

31.15.3.2 For each category of equipment listed in 31.15.3.5, the purchaser shall specify what purchaser-supplied equipment the contractor is to install.

31.15.3.3* For each category of equipment listed in 31.15.3.5, the purchaser shall specify what accommodations such as space, power, antenna bases, or other accommodations the contractor is to provide to support purchaser-installed equipment.

31.15.3.4 For each category of equipment listed in 31.15.3.5, the purchaser shall specify if no equipment in that category is to be supplied, installed, or have any accommodations provided.

31.15.3.5 The purchaser shall provide the information identified in 31.15.3.1 through 31.15.3.4 for the following:

- (1) Radio communication equipment
- (2) Mobile data terminals or other computer equipment
- (3) Traffic preemption equipment
- (4)* Vehicle data recorder
- (5)* V2X communications

Chapter 32 Automotive Ambulances — Line Voltage Electrical Systems (NFPA 1917)

32.1 General. The ambulance shall be furnished with an alternating current (ac) line voltage electrical system consisting of a power source and a 2-wire plus ground wiring system that meets the applicable requirements of this chapter.

32.2 General Requirements.

32.2.1 Conformance with *National Electrical Code*. All components, equipment, and installation procedures shall conform to *NFPA 70*, as specified by the requirements of this chapter.

32.2.1.1* Where available, line voltage electrical system equipment and materials included on the ambulance shall be listed and used only in the manner for which they have been listed.

32.2.1.2 All equipment and materials shall be installed in accordance with the manufacturer’s instructions.

32.2.2 Shorepower Inlet.

32.2.2.1* The ambulance shall be equipped with a line voltage power inlet known as a shorepower inlet.

32.2.2.2 The shorepower inlet shall be permanently mounted with a male recessed-type receptacle with cover, having a minimum rating of 15 amperes and conforming to the National Electrical Manufacturers Association (NEMA) configuration appropriate for the voltage rating.

32.2.2.3 The shorepower inlet shall be wired directly to the system or device to be powered or wired to a transfer switch as required in Section 32.8.

32.2.2.4 Where more than one shorepower inlet is provided on the same circuit, the unused shorepower inlet shall be de-energized.

32.2.2.5 A proper-mating, weatherproof, female connector body conforming to the NEMA configuration provided in 32.2.2.2 shall also be furnished without cable and labeled with the size, the type of wire necessary, and the polarity of the future hookup.

32.2.2.6 The connection shall be permanently labeled as shown in Figure 32.2.2.6.

32.2.2.7 The protective ground from the shorepower inlet shall be bonded to the vehicle frame.

32.2.3 Stability of Frequency and Voltage.

32.2.3.1 Any fixed line voltage power source producing alternating current (ac) shall produce electric power at 60 Hz ± 3 Hz when producing power at all levels between no load and full-rated power.

32.2.3.2 Any fixed line voltage power source shall produce electric power at the rated voltage ±10 percent when producing power at all levels between no load and full-rated power.

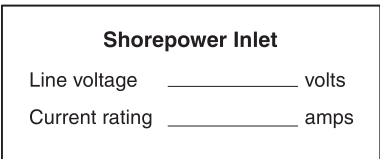


FIGURE 32.2.2.6 Shorepower Inlet Power Label.

32.2.3.3 The maximum voltage supplied to portable equipment shall not exceed 275 volts to ground.

32.2.3.4 Higher voltage shall be permitted only when used to operate fixed wired, permanently mounted equipment on the ambulance.

32.2.4 Location Ratings.

32.2.4.1 Any equipment used in a dry location shall be listed for dry locations.

32.2.4.2 Any equipment used in a wet location shall be listed for wet locations.

32.2.4.3 Any equipment, except a PTO-driven generator, used in an underbody or underchassis location that is subject to road spray shall be either listed as Type 4 or mounted in an enclosure that is listed as Type 4.

32.2.4.4* If a PTO-driven generator is located in an underbody or underchassis location, the installation shall include a shield to prevent road spray from splashing directly on the generator.

32.2.5 Line Voltage Electrical System Testing. Electrical system testing shall be performed according to AMD 027, *Line Voltage Electrical Systems Test*.

32.3 Grounding and Bonding.

32.3.1* Grounding.

32.3.1.1 Grounding shall be in accordance with 250.34(A) and 250.34(B) of *NFPA 70*.

32.3.1.2 Grounding shall be in accordance with 250.6, “Object-ionable Current,” of *NFPA 70*.

32.3.1.3 Ungrounded systems shall not be used.

32.3.1.4* Only stranded copper with green colored insulation or green with yellow tracer insulation or braided copper conductors shall be used for grounding and bonding.

32.3.1.5 The grounded current-carrying conductor (neutral) shall be insulated from the equipment-grounding conductors and from the equipment enclosures and other grounded parts.

32.3.1.6 The neutral conductor shall have white or gray colored insulation in accordance with 200.6, “Means of Identi-fying Grounded Conductors,” of *NFPA 70*.

32.3.1.7 Bonding screws, straps, or buses in the distribution panelboard or in other system components between the neutral and the equipment-grounding conductor shall be removed and discarded, except for the ground-to-neutral bond at an onboard electrical power source.

32.3.2 Interior Equipment Grounding.

32.3.2.1 In the line voltage electrical system, all exposed metal components shall be bonded to the grounding terminals or enclosure of the distribution panelboard.

32.3.2.2 Grounding of electrical equipment shall be done in one of the following ways:

- (1) Connection to a metal raceway, conduit, or electrical metallic tubing
- (2) A connection between one or more equipment-grounding conductors and a metal box by means of a

listed grounding device or a grounding screw that is used for no other purpose

32.3.2.2.1 The equipment-grounding conductor shall be permitted to be secured under a screw, other than a mounting screw or cover screw, that is threaded into the fixture canopy.

32.3.2.2.2 The equipment-grounding conductor and fixture attachment screws shall be permitted to be attached to a listed grounding means (plate) in a nonmetallic outlet box for fixture mounting.

32.3.2.2.3 A connection between the one or more equipment-grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box that requires grounding.

32.3.2.2.4 Where more than one equipment-grounding conductor or branch circuit enters a box, all such conductors shall be in electrical contact with each other and the arrangement such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

32.3.2.2.5 Cord-connected appliances shall be grounded by means of an approved cord with an equipment-grounding conductor and grounding attachment plug, unless they are double-insulated tools or appliances supplied with an approved two-wire cord and plug.

32.3.3 Bonding.

32.3.3.1 The neutral conductor of the onboard power source shall be bonded to the vehicle frame.

32.3.3.2 The neutral bonding connection shall occur only at the onboard power source.

32.3.3.3 In addition to the bonding required for the low voltage return current, each body and each driving or crew compartment enclosure shall be bonded to the vehicle frame by a copper conductor.

32.3.3.3.1 The conductor shall have a minimum amperage rating, as defined in 310.15 of *NFPA 70*, of 115 percent of the rated amperage on the power source specification label.

32.3.3.3.2 A single conductor that is sized to meet the low voltage and line voltage requirements shall be permitted to be used.

32.3.3.3.3 All exposed non-current-carrying metal parts that could become energized shall be bonded to the grounding terminal or enclosure of the distribution panelboard.

32.3.3.3.4 A bonding conductor shall be connected between the distribution panelboard and an accessible terminal on the chassis.

32.3.3.3.4.1 Aluminum or coppered aluminum conductors shall not be used.

32.3.3.3.4.2 Any ambulance that employs a unitized metal chassis-frame construction to which the distribution panel is fastened with a bolt and nut shall be considered to be bonded.

32.3.3.3.5 The ambulance body and exterior covering shall be considered bonded if the metal panels overlap or are welded to one another and are attached to the chassis frame by metal fasteners, metal straps, or welding.

32.3.3.3.6 Metal circulating air ducts shall be bonded to the chassis.

32.3.3.3.7 The compressed gas pipes shall be bonded to the chassis.

32.4* Ground-Fault Circuit Interrupters. All line voltage receptacles of the ambulance shall be protected by listed ground-fault circuit interrupters (GFCIs) in accordance with UL 498, *Attachment Plugs and Receptacles*.

32.5* Wiring Methods. Fixed wiring systems shall be limited to the following:

- (1) Metallic or nonmetallic liquidtight flexible conduit rated at temperatures not less than 194°F (90°C) with stranded copper wire rated for wet locations and temperatures not less than 194°F (90°C)
- (2) Type SOW, SOOW, SEOW, or SEOOW flexible cord rated at 600 volts and at temperatures not less than 194°F (90°C)

32.5.1 Electrical cord or conduit shall not be attached to chassis suspension components, water or fuel lines, air or air brake lines, medical gas lines, hydraulic lines, exhaust system components, or low voltage wiring and shall be arranged as follows:

- (1) Separated by a minimum distance of 12 in. (300 mm) from exhaust piping or shielded from such piping
- (2) Separated from fuel lines by a minimum distance of 6 in. (152 mm)

32.5.1.1 Line voltage wiring shall not be routed through the medical gas compartment.

32.5.2 A means shall be provided to allow “flexing” between the driving and crew compartment, the body, and other areas or equipment whose movement would stress the wiring.

32.5.3 Electrical cord or conduit shall be supported within 6 in. (152 mm) of any junction box and at a minimum of every 24 in. (600 mm) of run.

32.5.3.1 Supports shall be made of nonmetallic materials or of corrosion-resistant or corrosion-protected metal.

32.5.3.2 All supports shall be of a design that does not cut or abrade the conduit or cord and shall be mechanically fastened to the ambulance.

32.5.4 Only fittings and components listed for the type of cord or conduit being installed shall be used.

32.5.4.1 Where rigid metal conduit or intermediate metal conduit is terminated at an enclosure with a lock nut and bushing connection, two lock nuts shall be provided, one inside and one outside the enclosure.

32.5.4.2 All cut ends of conduit shall be reamed or otherwise finished to remove rough edges.

32.5.5 Splices shall be made only in a listed junction box.

32.5.6 Additional Requirements for Flexible Cord Installations.

32.5.6.1 Where flexible cord is used in any location where it could be damaged, it shall be protected by installation in conduit, enclosures, or guards.

32.5.6.2 Where flexible cord penetrates a metal surface, rubber or plastic grommets or bushings shall be installed.

32.5.7 Wiring Identification.

32.5.7.1 Each line voltage circuit originating from the main panelboard shall be identified.

32.5.7.2 The wire or circuit identification either shall reference a wiring diagram or wire list or shall indicate the final termination point of the circuit.

32.5.7.3 Where prewiring for future power sources or devices exists, the unterminated ends shall be marked with a label showing their wire size and intended function.

32.6 Wiring System Components.

32.6.1 Only stranded copper conductors with an insulation rated for temperatures of at least 194°F (90°C) and wet locations shall be used.

32.6.1.1 Conductors in flexible cord shall be sized in accordance with Table 400.5(A)(1) of *NFPA 70*.

32.6.1.2 Conductors used in conduit shall be sized in accordance with 310.15 of *NFPA 70*.

32.6.1.3 Aluminum or copper-clad aluminum conductors shall not be used.

32.6.2 All boxes shall conform to and be mounted in accordance with Article 314 of *NFPA 70*.

32.6.2.1 All boxes shall be accessible using ordinary hand tools.

32.6.2.2 Boxes shall not be permitted behind welded or pop-riveted panels.

32.6.2.3 The maximum number of conductors permitted in any box shall be in accordance with 314.16, "Number of Conductors in Outlet, Device, and Junction Boxes, and Conduit Bodies," of *NFPA 70*.

32.6.3 All wiring connections and terminations shall provide a positive mechanical and electrical connection.

32.6.3.1 Connectors shall be installed in accordance with the manufacturer's instructions.

32.6.3.2 Wire nuts or insulation displacement and insulation-piercing connectors shall not be used.

32.6.4 Each switch shall comply with the following:

- (1) Indicate the position of its contact points (i.e., open or closed)
- (2) Be rated for the continuous operation of the load being controlled

32.6.4.1 All switches shall be marked with a label indicating the function of the switch.

32.6.4.2 Circuit breakers used as switches shall be "switch rated" (SWD) or better.

32.6.4.3 Switches shall simultaneously open all associated line voltage conductors.

32.6.4.4 Switching of the neutral conductor alone shall not be permitted.

32.6.4.5 Line voltage circuits controlled by low voltage circuits shall be wired through properly rated relays in listed enclosures that control all nongrounded current-carrying conductors.

32.6.5 Receptacles and Inlet Devices.

32.6.5.1 The patient compartment shall be furnished with a minimum of three line voltage duplex receptacles conforming to a minimum of a NEMA 5-15.

32.6.5.2 All interior outlets shall be installed in accordance with 210.7, Multiple Branch Circuits, of *NFPA 70*.

32.6.5.3 Any receptacle shall be at least 12 in. (300 mm) from any medical gas outlet.

32.6.5.4 An indicator shall be located within each line voltage receptacle as a line monitor indicating a live (hot) circuit.

32.6.5.5 Wet and Dry Locations.

32.6.5.5.1 All wet location receptacle outlets and inlet devices, including those on hardwired, remote power distribution boxes, shall be of the grounding type, provided with a wet location cover, and installed in accordance with 406.9 of *NFPA 70*.

32.6.5.5.2 All receptacles located in a wet location shall be not less than 24 in. (600 mm) from the ground.

32.6.5.5.3 Receptacles on off-road ambulances shall be a minimum of 30 in. (760 mm) from the ground.

32.6.5.6 All receptacles located in a dry location shall comply with the following:

- (1) Be of the grounding type
- (2) Be at least 12 in. (300 mm) above the interior floor height

32.6.5.7 No receptacle shall be installed in a face-up position.

32.6.5.8 The face of any wet location receptacle shall be installed in a plane from vertical to not more than 45 degrees off vertical.

32.6.5.9 Receptacle Label.

32.6.5.9.1 Each receptacle shall be marked with a label indicating the nominal line voltage (120 volts or 240 volts) and the current rating in amps of the circuit.

32.6.5.9.2 If the receptacle is other than single phase, that information shall also be marked on the label.

32.6.5.10 All receptacles and electrical inlet devices shall be listed to UL 498, *Attachment Plugs and Receptacles*, or other recognized performance standards.

32.7 Cord Reels.

32.7.1 All permanently mounted cord reels shall be rated for continuous duty and installed to be accessible for removal, cord access, maintenance, and servicing.

32.7.2 The power rewind cord reel spool area shall be visible to the operator during the rewind operation or the reel spool encapsulated to prevent cord from spooling off the reel.

32.7.3 Rollers or guides shall be provided, where required, to prevent damage to the cord at reel spools or compartment openings.

32.7.4 Rewind Provision.

32.7.4.1 Manually operated reels shall have a hand crank.

32.7.4.2 Power rewind-type reels shall have the control in a position where the operator can observe the rewinding operation.

32.7.4.3 If a reel is in an enclosure or out of direct view, the cord entry point to the enclosure shall be visible to the operator of the reel control.

32.7.4.4 The rewind control or crank shall not be more than 72 in. (1830 mm) above the operator's standing position.

32.7.4.5 The rewind control shall comply with the following:

- (1) Be marked with a label indicating its function
- (2) Be guarded to prevent accidental operation

32.7.5 The reel shall be designed to hold 110 percent of the capacity needed for the intended cord length.

32.7.6 Wire Size.

32.7.6.1 The wire size shall be in accordance with Table 400.5(A)(1) of *NFPA 70*.

32.7.6.2 Wire size shall not be smaller than 12 AWG in any case.

32.7.7 Electrical cord shall be Type SEOOW, Type SOOW, or Type STOOW.

32.7.8 A label that indicates the following information shall be provided in a visible location adjacent to any permanently connected reel:

- (1) Current rating
- (2) Current type
- (3) Phase
- (4) Voltage
- (5) Total cord length

32.7.9 Where a power distribution box is hardwired to the end of a cord that is stored on a fixed cord reel or other fixed storage means, the requirements in 32.7.9.1 through 32.7.9.6 shall apply.

32.7.9.1 The remote power distribution box shall be listed for use in a wet location.

32.7.9.2 The distribution box shall be as follows:

- (1) Protected from corrosion
- (2) Capable of being carried with a gloved hand
- (3) Designed to keep the exterior electrical components above 2 in. (51 mm) of standing water

32.7.9.3 Inlets, receptacles, circuit breakers, or GFCI devices shall not be mounted in a face-up position.

32.7.9.4 Branch circuit breakers shall be installed in the remote power distribution box if the overcurrent device protecting the feed cord to the box is too large to protect the wiring supplying the devices plugged onto the distribution box.

32.7.9.5 Remote power distribution boxes shall have a light on the box to indicate the power is on.

32.7.9.5.1 The light shall be visible in a 360-degree plane from a minimum of 200 ft (60 m) in complete darkness.

32.7.9.5.2 The light shall be mechanically protected to prevent damage.

32.7.9.6 The hardwired portable cord connection to the box shall have strain relief and meet the intended usage requirements.

32.8 Transfer Switch Applications.

32.8.1 A transfer switch shall be required to isolate one power source from another where a circuit(s) is intended to be supplied from more than one power source.

32.8.2 Transfer equipment, including transfer switches, shall operate such that all ungrounded connectors of one power source are disconnected before any ungrounded conductors of the second power source are connected.

32.8.3 The neutral connector shall be switched through the transfer switch.

32.9 Scene Lighting Systems.

32.9.1 Where fixed scene lights are supplied, the requirements in 32.9.2 through 32.9.5 shall apply.

32.9.2 All scene lights shall comply with the following:

- (1) Be provided with a lens or a means for preventing damage from water spray
- (2) Be listed for wet location usage

32.9.3 Handle on Lights.

32.9.3.1 If the light is adjustable, a handle shall be provided.

32.9.3.2 The design of the light shall not allow the temperature of the handle to exceed 131°F (55°C).

32.9.4 The manufacturer of the device shall have the scene light tested by a nationally recognized testing laboratory and listed to UL 153, *Portable Electric Luminaires*, or UL 1598, *Luminaires*.

32.9.5 If manually operated floodlights are not operable from the ground, access steps and handrails that meet the requirements of Chapter 30 shall be provided to allow the user to reach the floodlights.

32.10 Appliance Accessibility and Fastening.

32.10.1 All electrical appliances shall be accessible for inspection, service, repair, and replacement without removal of permanent construction.

32.10.2 Appliances shall be fastened in accordance with the manufacturer's directions.

Chapter 33 Automotive Ambulances — Line Voltage Power Source (NFPA 1917)

33.1 General Requirements.

33.1.1 An instruction plate(s) that provides the operator with the essential power source operating instructions, including the power-up and power-down sequence, shall be permanently attached to the ambulance at any point where such operations can take place.

33.1.2 The power source shall be located so that neither it nor its mounting brackets interfere with the routine maintenance of the ambulance.

33.1.3 Access shall be provided to permit both routine maintenance and removal of the power source for major servicing.

33.1.4 The power source, at any load, shall not produce a noise level that exceeds 90 dBA in any driving compartment or patient compartment with windows and doors closed or at any operator's station on the ambulance.

33.1.5 If there is permanent wiring on the ambulance that is designed to be connected to the power source, a power source specification label that is permanently attached to the ambulance at the operator's control station shall provide the operator with the information detailed in Figure 33.1.5.

33.1.6 The rating on the power source specification label shall not exceed the declared rating from the power source manufacturer.

33.2 Requirements by Generator Size.

33.2.1 Generators Rated Below 8 kW General Requirements.

33.2.1.1 If the power source is rated at less than 3 kW, a "Power On" indicator shall be provided.

33.2.1.2 If the power source is rated at 3 kW or more but less than 8 kW, a voltmeter shall be provided.

33.2.2 Power Sources of 8 kW or Larger. Power sources of 8 kW or larger shall meet the following:

- (1) The rating requirements of 21.4.3.1
- (2) The instrumentation requirements of 21.4.6.3 through 21.4.6.4.3
- (3) The operation requirements of 21.4.8

33.3 Power-Source-Type Specific Requirements.

33.3.1 Direct-Drive (PTO) Generators. If the generator is driven by any type of power takeoff (PTO), it shall meet the requirements of 21.5.1.

33.3.2 Hydraulically Driven Generators. If the generator is driven using hydraulic components, it shall meet the requirements of 21.5.2.

33.3.3 Fixed-Auxiliary-Engine-Driven Generators 8 kW and Larger. If the generator is driven by a fixed auxiliary engine, it shall meet the requirements of 21.5.3.

33.3.4 Mechanically Driven Power Sources. If the power source is mechanically driven and mounted on the vehicle, it shall comply with Article 445 of *NFPA 70*.

33.3.5 Line Voltage Power from an Inverter. If the power source is an inverter, the power source shall meet the requirements of 33.3.5.1 through 33.3.5.3.

Power Source Specifications	
Operational Category	Continuous Duty Rating
Rated voltage(s) and type (ac or dc)	
Phase	
Rated frequency	
Rated amperage	
Continuous rated watts	
Power source engine speed	

FIGURE 33.1.5 Power Source Specification Label.

33.3.5.1 The low-voltage power supply system shall be installed in compliance with the requirements of Chapter 31.

33.3.5.2 The alternator and the battery system shall be able to provide power for continuous operation for a minimum of 1 hour at nominal listed power output.

33.3.5.3 The inverter shall be tested to the requirements of the "Inverter Test" as specified in AMD 027, *Line Voltage Electrical Systems Test*.

33.4 Wiring for Portable Generator. Installations shall meet the requirements of 21.6.3.

Chapter 34 Automotive Ambulances — Remounted Ambulance Patient Compartments (NFPA 1917)

34.1 Application.

34.1.1 This chapter is applicable to automotive ambulances contracted for remounting on or after January 1, 2024; however, nothing shall prevent the voluntary application of this chapter to ambulances contracted for remounting prior to January 1, 2024, if the purchaser and contractor agree to do so.

34.1.1.1 This chapter of the standard shall not be applied retroactively.

34.2 Equivalency. Nothing in this chapter shall prevent or discourage the use of any systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by the other chapters of this standard.

34.3 General.

34.3.1 The patient compartment shall be mounted in accordance with the allowed or recommended methods and practices established by the chassis manufacturer.

34.3.2 All new or upgraded components utilized in the remount shall meet the component requirements for a new automotive ambulance as outlined in other chapters of this standard, unless otherwise specified in this chapter.

34.3.3 Any upgraded system or component shall be compatible with its associated components.

34.3.4 Systems or components that are not compatible shall not be installed on the remounted automotive ambulance.

34.3.5 At a minimum, the remounted ambulance patient compartment and its components and systems shall comply with the functional requirements of the design standard or purchasing specification that was applicable to the patient compartment when it was originally constructed.

34.3.6 The entity performing the patient compartment remount is the final stage manufacturer (FSM) for that vehicle and shall comply with all NHTSA requirements applicable to a final stage vehicle manufacturer.

34.3.7 The remounted ambulance shall be fully compliant with all applicable state and federal laws and regulations.

34.3.8 The installed cot fastener device(s) for wheeled cots shall comply with both of the following:

- (1) Meet the performance requirements of SAE J3027, *Ambulance Litter Integrity, Retention, and Patient Restraint*

- (2) Be installed in accordance with the cot fastener manufacturer's directions

34.3.9 The floor substructure shall meet the requirements of SAE J3102, *Ambulance Patient Compartment Structural Integrity Test to Support SAE J3027 Compliant Litter Systems*, validated by either testing or analytical methods.

34.4 Responsibility of the Purchaser.

34.4.1 The purchaser shall specify which components and systems of the ambulance are to be upgraded or replaced by the contractor during the remount process.

34.4.2 It shall be the responsibility of the purchaser to consider the amount of equipment and personnel that will be carried on the in-service ambulance and to specify to the contractor a minimum usable payload requirement that will accommodate the anticipated maximum in-service weight.

34.4.3 The purchaser shall specify the work to be performed by the contractor during the remount process, including any components to be supplied by the contractor; the construction and performance details, and any other work to be completed to address existing problems or deficiencies.

34.4.4 It shall be the responsibility of the purchaser to specify any aspect of the ambulance patient compartment remount project that is intended to differ from or exceed the minimum requirements of this standard.

34.4.5 Following acceptance of the remounted ambulance and thereafter, the purchaser shall be responsible for ongoing training of personnel to develop and maintain proficiency regarding the proper and safe use of the ambulance and its associated equipment, components, and systems.

34.5 Responsibility of the Contractor.

34.5.1 The contractor shall inspect the automotive ambulance to be remounted and provide a detailed description of the work to be performed, a list of components to be furnished, and other construction and performance details to which the ambulance shall conform, to the extent that any such information differs from that specified by the purchaser in compliance with 34.4.3.

34.5.1.1 The purpose of these contractor specifications shall be to define what the contractor intends to furnish and deliver to the purchaser when the project is completed.

34.5.2 The contractor shall notify the purchaser in writing of any additional problems, deficiencies, issues, or nonconformities discovered during inspection of the ambulance.

34.5.3 The contractor shall provide a detailed description of the remounted automotive ambulance, including, without limitation, wheelbase, curb-to-curb turning radius, principal dimensions, angle of approach, and angle of departure.

34.5.4 A weight analysis shall be performed for each completed ambulance to determine the following:

- (1) Front and rear axle weights
- (2) Front and rear axle weight distribution (i.e., percentage of total vehicle weight on each axle)
- (3) Vertical center of gravity
- (4) The maximum remaining payload capacity with its center of gravity positioned in its expected in-service location

that does not result in weights that exceed the vehicle's weight rating capacities

34.5.4.1 The calculation from the weight analysis shall be completed using the following:

- (1) Measured completed vehicle at curb weight
- (2) 175 lb (79 kg) at the horizontal and vertical center of each patient location and at the designated H-point of each seating position

34.5.4.2 A copy of the weight analysis shall be included with the ambulance documentation.

34.5.5 Longitudinal Weight Distribution. When the ambulance is loaded to its GVWR, the front-to-rear weight distribution and vertical center of gravity shall comply with the axle weight distribution limits established by the chassis manufacturer.

34.5.6 Lateral Weight Distribution. The vehicle, when loaded to its GVWR, shall have a side-to-side tire load variation of no more than 5 percent of the total tire load for the affected axle.

34.5.7 The front axle loads shall not be less than the minimum axle loads specified by the chassis manufacturer under full load and all other loading conditions.

34.5.8 The contractor shall perform all of the AMD tests (other than type testing) for each remounted ambulance patient compartment and its associated components and systems using either the latest AMD standards or the AMD standards that were applicable to the ambulance patient compartment at the time that it was originally constructed.

34.5.9 Documentation showing successful completion of all tests shall be furnished to the purchaser by the contractor.

34.5.10 Responsibility for the remounted automotive ambulance and equipment shall rest with the contractor until transfer of such responsibilities are accepted by the purchaser.

34.5.11 To the extent that any of the original configurations, components, or systems of the ambulance are changed or modified by the contractor during the remount process, the contractor shall supply to the purchaser, at the time of delivery, at least one copy of complete operation, service, and parts manuals covering any new or modified components or systems on the ambulance as delivered and accepted.

34.5.12 The requirement for furnishing either complete or partial manuals shall be specified by the purchasing authority.

34.6 Remounted Ambulance Components.

34.6.1 All components shall be installed in accordance with the manufacturer's published installation instructions, or as otherwise approved in writing by the component manufacturer.

34.6.2 All medical devices furnished shall comply with all applicable U.S. Food and Drug Administration (FDA) or other governmental regulatory requirements.

34.6.3 All connections to or interfaces with the ambulance chassis shall be made in accordance with the chassis OEM Body Builders Guidelines and OEM Incomplete Vehicle Manual unless otherwise specified in this standard.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.2 Examples of vehicles without wheels are track, amphibious, or cushion type vehicles.

A.1.3 An AHJ incorporating NFPA 414, NFPA 1901, NFPA 1906, NFPA 1917 or any combination of the four, can replace those references with chapters and still reference similar content. For example, if an AHJ incorporated the 2020 edition of NFPA 414 (i.e. in accordance with the 2020 edition of NFPA 414), and they wish to update to the latest information, they can do so by incorporating chapters 1 through 3, 4 through 6, and Annexes A through D of the 2023 edition of NFPA 1900 (i.e. in accordance with Chapters 1 through 3, 4 through 6 and Annexes A through C of the 2023 edition of NFPA 1900).

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the “authority having jurisdiction” may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The “authority having jurisdiction” may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction. The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA standards in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.9 Aircraft Rescue and Firefighting (ARFF). Additionally, ARFF personnel will enter the aircraft to provide assistance to the extent possible in the evacuation of the occupants. Although life safety is primary to ARFF personnel, responsibilities such as fuselage integrity and salvage should be maintained to the extent possible. [440, 2024]

A.3.3.13 Air Tank. Air tanks might be designated as cylinders, receivers, or vessels.

A.3.3.16.1 Substantially Similar Ambulance. It is not practicable to test every production vehicle to validate performance compliance. The term *substantially similar* allows those requirements that call for a test on a substantially similar ambulance to be performed once rather than on every production vehicle.

A.3.3.17.1 Angle of Approach. The angle of approach is determined by the horizontal ground line and the line tangent to the loaded radius of the front tire extended forward to that fixed point on the vehicle that forms the smallest angle.

A.3.3.17.2 Angle of Departure. The angle of departure is determined by the horizontal ground line and the line tangent to the loaded radius of the rear tire extended rearward to that fixed point on the vehicle that forms the smallest angle.

A.3.3.24 Automatic Regulating Foam Proportioning System. The automatic adjustments of the foam proportioning system are made based on changes in waterflow or conductivity.

A.3.3.34 Boom. The term *boom* is used to refer either to a single straight structure or two or more pieces connected by knuckle(s). The boom construction can be of stressed-skin box-beam-type, tube-type, trussed-lattice-type, or open “U” truss-type design.

A.3.3.46 Center of Gravity. Where a vehicle is tipped to such a degree that a vertical line passing through the center of gravity falls on the ground outside the tire track, it is unstable and can turn over.

A.3.3.47 Chassis. Common usage might, but need not, include a cab (or cowl).

A.3.3.57 Complementary Extinguishing Agent. These agents can extinguish by means of chemical reaction, cooling, or removal of oxygen and are applied to special fire situations such as three-dimensional running fuel fires.

A.3.3.59 Compound Gauge. On most gauges, zero equals atmospheric pressure. Gauges typically measure pressure above atmospheric pressure in pounds per square inch (psi) [kilopascals (kPa)] and below atmospheric pressure in inches of mercury (in. Hg) [kilopascals (kPa)].

A.3.3.60 Compressed Air Foam System (CAFS). A CAFS consists of a compressed air source, pressurized source of foam solution, and discharge hardware.

A.3.3.65 Contractor. The contractor might not necessarily manufacture the fire apparatus or any portion of the fire apparatus but is responsible for the completion, delivery, and acceptance of the entire unit.

A.3.3.72 Diagonal Opposite Wheel Motion. This measurement is compared diagonally — from right front to left rear wheels of the vehicle — or opposing corners of the vehicle.

A.3.3.81 Eductor. The pressure at the throat of a venturi is below atmospheric pressure, allowing foam concentrate or other firefighting agent at atmospheric pressure in storage to flow into the water stream.

A.3.3.82 Ejector. An ejector operates on the same principle as a jet pump.

A.3.3.83 Electric Siren (Electromechanical). Only one type of warning sound can be produced by electric sirens, but the level or pitch can be varied by the speed of the motor.

A.3.3.87 Electronic Siren. Varied types of warning sounds can be produced by electronic sirens, such as a wail, yelp, or simulated air horn.

A.3.3.92 Engine. Examples include an internal combustion (IC) engine or an electrical vehicle (EV) motor.

A.3.3.113 Forward-Looking Infrared (FLIR). The FLIR system, which consists of FLIR camera, monitor, and controlling devices, provides the operator with an image that can be used to drive aircraft rescue and firefighting (ARFF) vehicles under 0/0 visibility conditions.

A.3.3.123 Grade. A 45-degree slope is equal to a 100-percent grade.

A.3.3.126 Ground-Fault Circuit Interrupter (GFCI). See UL 943, *Ground-Fault Circuit Interrupters*, for further information. Class A ground-fault circuit interrupters trip when the ground-fault current is 6 mA or higher and do not trip when the ground is less than 4 mA. [70, 2023]

A.3.3.148 Intended Airport Service. See NFPA 460 for further information concerning aircraft rescue and firefighting services at airports.

A.3.3.149 Interaxle Clearance (Ramp Breakover Angle). Interaxle clearance is determined by the horizontal ground line and whichever of the following lines forms the smaller angle:

- (1) The line tangent to the loaded radius of the front tire extended rearward to that fixed point on the vehicle, ahead of a vertical line midway between the two axles, that determines the smallest angle
- (2) The line tangent to the loaded radius of the rear tire extended forward to that fixed point on the vehicle, behind a vertical line midway between the two axles, that determines the smallest angle

A.3.3.165 Loose Equipment. Such equipment can include, but is not limited to, medicines, first-aid supplies, medical gas tanks, child seats, and personal dunnage.

A.3.3.171 Maximum Pump Close-Off Pressure. Multistage series/parallel pumps are measured with the pump in the pressure (series) setting.

A.3.3.180 Net Pump Pressure. When operating from a hydrant, the net pump pressure typically is less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psi (1034 kPa) and the intake (suction) gauge reads 20 psi (138 kPa), the net pump pressure equals 130 psi (896 kPa). When operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge reads 145 psi (1000 kPa) and the intake (suction) gauge reads 10 in. Hg (34 kPa) vacuum, the net pump pressure will be 150 psi (1034 kPa) (1 in. Hg = 0.5 psi = 3.4 kPa).

A.3.3.182 Neutral Point. At the neutral point of the system, the vectorial sum of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential.

A.3.3.188 Off-Pavement Performance. “Other than paved surfaces” includes dirt roads and trails and open cross-country of all kinds. This ability sometimes is referred to as off-road mobility or cross-country mobility. All of these terms are synonymous.

A.3.3.189 Off-Road Use Vehicle. An off-road use vehicle is not automatically an all-wheel-drive vehicle. Off-road vehicles are just as susceptible as on-road vehicles to becoming stuck if they are driven in areas where the ground does not support the vehicle weight.

A.3.3.196 Optical Source. An optical source can consist of a single optical element or a fixed array of any number of optical elements whose geometric positioning relative to each other is fixed by the manufacturer of the optical source and is not intended to be modified. There can be one or more optical sources in an optical warning device. To be considered a single optical source, the optical elements must be adjacent and operate simultaneously.

A light bar is a typical example of an optical warning device that consists of multiple optical sources (individual lights within the light bar, possibly individually controlled, different colors, different flash patterns) and each optical source can include multiple optical elements (such as multiple LEDs mounted within the optical source).

A.3.3.199 Overall Height, Length, and Width. These dimensions include all fixed protrusions that could in any way hinder the passage of the vehicle. Dimensions that include a movable protrusion are determined with the protrusion in its normally stored position.

A.3.3.205 Percent Grade. A change in elevation of 15.2 m (50 ft) over a horizontal distance of 15.2 m (50 ft) is equivalent to a grade of 100 percent.

A.3.3.210 Portable Generator. The device has an integral distribution panel with overcurrent protection and receptacle outlets.

A.3.3.215 Preconnected Hose Line. A preconnected hose line is commonly called a bucket line, cross lay, speed lay, or matty-dale.

A.3.3.219 Propellant Gas. Nitrogen, air, argon, and carbon dioxide are propellant gases that can be used with an agent. The quality of these gases is specified according to guidelines provided by the manufacturer of the agent. The guidelines can include moisture and dew point qualifications. During discharge, the gas provides an energy source, which aids in propelling the agent to meet its performance standards.

A.3.3.234 Quint. The primary purpose of this type of apparatus is to combat structural and associated fires and to support firefighting and rescue operations by positioning personnel-handling materials, providing continuous egress, or discharging water at positions elevated from the ground.

A.3.3.241 Rechargeable Energy Storage System. Batteries, capacitors, and electro-mechanical flywheels are all examples of rechargeable energy storage systems.

A.3.3.247 Rubber-Gasketed Fitting. It incorporates a rubber seal held in place by a two-piece clamp that also engages annular grooves near the end of each pipe to prevent pullout under pressure.

A.3.3.256 Slip-On Firefighting Module. Slip-on firefighting modules typically can be placed on and removed from the vehicle with a minimum of time and effort.

A.3.3.258 Special Services Fire Apparatus. These services could be rescue, command, hazardous material containment, air supply, electrical generation and floodlighting, or transportation of support equipment and personnel.

A.3.3.265 Structural Fire Apparatus. The terms *structural fire apparatus* and *wildland fire apparatus* together make up *fire apparatus*.

A.3.3.274.1 Driver's Enhanced Vision System (DEVS). The DEVS comprises three systems: (1) *Navigation*, which displays the ARFF vehicle's position on a moving map display mounted in the cab; (2) *Tracking*, which provides two-way digital communication between the ARFF vehicle and the Emergency Command Center; and (3) *Vision*, which allows the ARFF vehicle operator to see in 0/0 visibility conditions.

A.3.3.274.2 Electronic Stability Control System. It incorporates sensors for determining vehicle parameters as well as an electronic control unit to modulate braking and traction forces.

A.3.3.274.3 Global Positioning System (GPS). The user equipment — that is, GPS receiver — provides the user with position, velocity, and time information. Aircraft rescue and firefighting (ARFF) vehicle position provided by the driver's enhanced vision system (DEVS) is derived from the system's GPS receiver and displayed on the moving map display.

A.3.3.279 Turning Clearance Radius. An aerial fire apparatus might have a larger overall clearance diameter if measured at the forwardmost point of the aerial device.

A.3.3.280 Turntable. Some turntables contain an operator's control station.

A.3.3.282.1 Boom-Mounted Turret. A boom-mounted turret might be extendable and mounted either on a rotational or nonrotational base with a power-operated boom or booms.

A.3.3.282.2 Primary Turret. Extinguishing agents are discharged from ARFF vehicles in several ways depending on the firefighting scenarios. In order to establish common terminology in the field, the following information is provided.

A turret is a pivoted and revolvable device that holds the nozzle. Turrets are either primary or auxiliary depending on discharge rate and method of attack. Bumper turrets are mounted on the front bumper and are remotely operated from the cab of the vehicle. Primary turrets might be mounted on booms and located on the front end or top deck of the vehicle. Roof turrets are mounted on a vehicle roof and are manually or remotely operated.

A nozzle is the final piece of hardware in the extinguishing agent delivery system that disperses the extinguishing agent in a manner that effectively extinguishes the fire or serves another purpose, such as providing cooling to protect a piece of equipment. A “primary turret nozzle” is one that is mounted on a turret and complies with the primary turret nozzle discharge requirements of Table 4.2.1.2(c) and Table 4.2.1.2(d). A “single agent nozzle” is one that only discharges one type of extinguishing agent such as foam or dry chemical. “Parallel multiple agent nozzles” are nozzles that are joined in parallel and discharge more than one type of extinguishing agent either

together or separately. An “entrained multiple agent nozzle” is a nozzle that is designed to discharge multiple entrained fire extinguishing agents.

Manufacturers of vehicles with booms should provide a diagram to the purchaser depicting the capabilities of the boom showing the side and top views of the vehicle.

A.3.3.283 Twenty-Five Percent Drainage Time. A method of measuring drainage time is provided in NFPA 460.

A.3.3.290 Type 4 Rating. Equipment rated NEMA Type 4 will be undamaged by the formation of ice on the equipment.

A.3.3.294 Underbody Clearance. Underbody clearance dimensions include all components of the vehicle, except those that are part of the axle assemblies, that could hinder the passage of the vehicle.

A.3.3.301.1 Fully Loaded Vehicle. Vehicle manufacturers use ballast weights to represent masses that are not able to be installed during vehicle testing. For instance, it is not practical to have crew or equipment in the cab during a tilt table test.

The crew allowance is 102 kg (225 lb) per seating position. The ballast used for crew allowance should be carried in the seats, strapped in by the three-point restraints. Ballast for the driver's seat will need to be added after the driver positions the vehicle for the tilt table test. The driver must stay in the driver's seat during the body and chassis flexibility test (*see 6.3.14*) and the weight/weight distribution test (*see 6.4.2*).

Unless otherwise specified, the equipment allowance is 113.3 kg (250 lb) per storage compartment, up to a maximum of 453.6 kg (1000 lb). Where the customer specifications require that more equipment be carried, the actual weight of the equipment is to be included. The ballast used for the equipment allowance should be placed in compartments, on shelves, or installed on slide-out trays.

The water and foam tanks should be filled with water.

For vehicles equipped with complementary agent, the ballast should be securely mounted on top of the complementary agent tank, or in a location that simulates the weight (relative to center of gravity) as when the agent vessel is full of agent.

Any ballast used to represent the mass of any component must be located at the same center of gravity of that component.

A.3.3.301.2 Prototype Vehicle. A given chassis, body, and firefighting system and fully loaded weight condition constitute a vehicle configuration. Product improvements and customer options negate previously conducted prototype tests only if they substantially affect a performance factor.

A.3.3.302 Vehicle Types. The term *wheel* in this designation is interpreted to mean either a single tire or a set of dual tires operating as one tire. The first number is the number of wheels, the second number is the number of driving wheels.

A.3.3.303 Wall-to-Wall Turning Diameter. It is, therefore, the diameter of the smallest circle that can be described by the outermost point on the vehicle as it negotiates a 360 degree turn to the right or left.

A.3.3.305 Weather Resistant. This term is not intended to describe items that are watertight or submersible.

A.3.3.306.1 Gross Axle Weight Rating (GAWR). It is a requirement of the National Highway Traffic Safety Administration (NHTSA) that the GAWR be posted in the vehicle on a permanently affixed label. The axle system includes, but is not limited to, the axle, tires, suspension, wheels, frame, brakes, and applied engine torque.

A.3.3.306.2 Gross Combination Weight Rating (GCWR). A combination vehicle is the combination of a towing vehicle and one or more towed units (trailers). Where a trailer is detachable, the GCWR limits the maximum loaded weight for any replacement trailer. The in-service weight or gross combination weight, including any connected trailer, should always be equal to or less than the GCWR.

A.3.3.306.3 Gross Vehicle Weight Rating (GVWR). It is a requirement of the National Highway Traffic Safety Administration (NHTSA) that the GVWR of a vehicle be posted in the vehicle on a permanently affixed label. The GVWR can be equal to or less than the sum of the front GAWR and the rear GAWR. The in-service weight or gross vehicle weight should always be equal to or less than the GVWR.

A.3.3.310 Wildland Fire Apparatus. Wildland fire apparatus is designed primarily to be used for wildland fires response for both on-road and off-road locations. To a limited degree, these apparatus can be used to protect exposures or fight structure fires from the exterior. These apparatus are not intended to replace or supersede the function of pumpers or initial attack fire apparatus. The terms *structural fire apparatus* and *wildland fire apparatus* together make up *fire apparatus*.

A.4.1.1.1 The basic NFPA recommendations on the use and provision of this equipment are contained in NFPA 440 and NFPA 460. Field testing procedures for aircraft rescue and fire-fighting vehicles utilizing foam are provided in NFPA 460.

A.4.1.3 Local technical standards might be determined equivalent when their performance meets or exceeds the minimum requirements of this NFPA document, even if the language is not matching identically. The end user should work with the manufacturer to evaluate and determine equivalency between the local technical standard and this document.

A.4.2 The minimum size of the firehouse garage door(s) for a major firefighting vehicle should be at least 5.5 m (18 ft) wide by 5.5 m (18 ft) high.

When creating the response roadways from the firehouse to the incident area(s), the airport designer should consider the information in Table A.4.2(a) and Table A.4.2(b) when sizing the radius of curves. ARFF vehicles accelerate much faster than over-the-road vehicles and are very capable of obtaining higher speeds in a very short distance.

A.4.2.1 For cold weather operation where temperatures periodically fall below 0°C (32°F), some type of winterization system should be specified by the purchaser. For hot weather operation where temperatures periodically range above 43°C (110°F), some type of additional cooling system should be specified by the purchaser.

A.4.2.3 New multi-agent delivery technology systems are available that deliver multiple agents simultaneously with higher than conventional discharge pressures. These systems can also deliver agents independently at lower flow rates than a typical system. They also deliver the fire extinguishing agents in a form that improves the fire suppression performance of each agent

Table A.4.2(a) Vehicle Speed over Distance from a Standing Start

Distance Traveled from a Standing Start of the Vehicle		Speed of Vehicle at the Given Distance					
		Vehicle Water Tank Capacity ≥227 to ≤1999 L (≥60 to ≤528 gal)		Vehicle Water Tank Capacity >1999 to ≤6000 L (>528 to ≤1585 gal)		Vehicle Water Tank Capacity >6000 L (>1585 gal)	
m	ft	kph	mph	kph	mph	kph	mph
30.5	100	29.0	18	32.2	20	29.0	18
76.2	250	40.2	25	48.3	30	40.2	25
152.4	500	48.3	30	64.4	40	48.3	30
228.6	750	64.4	40	72.4	45	64.4	40
304.8	1000	72.4	45	80.5	50	72.4	45

Table A.4.2(b) Minimum Radius of a Curve Based on Speed

Speed		Minimum Radius of a Curve with a 0.04 Superelevation (Almost Flat)*	
		m	ft
kph	mph		
32.2	20	39.6	130
48.3	30	92.0	302
64.4	40	174.6	573
80.5	50	291.1	955
88.5	55	436.5	1432
96.6	60	498.9	1637

*Values were extracted from the AASHTO publication, "A Policy on Geometric Design of Highways and Streets."

when compared to the agents delivered in a conventional manner (for example, dry chemical suspended dry within the fire envelope, halogenated agent suspended as a vapor within the fire envelope, and foam delivered independently to minimize contamination or wetting of dry chemical to create a vapor barrier and/or further cool the fire environment). These delivery technologies are designed to improve the fire suppression capability of all agents.

A.4.2.5 The following is a list of available options that can be ordered from ARFF vehicle manufacturers:

- (1) General ARFF vehicle options:
 - (a) Winterization system providing sufficient insulation and heating capacity, by means of hot circulating liquids or forced-air exchangers, to permit satisfactory operation of the vehicle and firefighting systems for a period of at least 4 hours at ambient temperatures as low as -40°C (-40°F) with the vehicle fully operational and the engine running. At the end of the 4-hour period, the vehicle should be capable of successfully discharging its agent(s). The winterization system should not detract from the performance of the vehicle and firefighting system in ambient temperatures up to -43.5°C (-46.3°F).
 - (b) Pintle-hook-type towing connection rated at 13,607 kg (30,000 lb) gross trailer weight, attached to the vehicle's frame at the rear of the vehicle

- (c) Roll-up-type compartment doors (other than service doors)
- (d) Windshield deluge system (*see 4.13.4.6*)
- (e) Training video tape covering the operation of the vehicle
- (f) Navigation system of a driver's enhanced vision system (DEVS) (*see 4.13.4.7*)
- (g) Monitoring and data acquisition system (MADAS) (*see 4.13.7*)
- (2) Dimensional, safety, and stability enhancement options:
 - (a) Added payload capacity (GVWR) to carry special equipment where the purchaser identifies added equipment
 - (b) Increased overall width of the vehicle to facilitate increased performance and maneuverability with no concern for movement on public highway(s)
 - (c) Audiovisual devices that meet or exceed the field of vision provided by wide-angle mirrors
- (3) Engine(s) with related options:
 - (a) Engine that operates at necessary performance above 609.6 m (2000 ft) elevation
 - (b) Radiator shutters (*see 4.5.2.3.3*)
 - (c) Engine coolant filter
 - (d) Silicone coolant and heater hoses
 - (e) Heated diesel fuel–water separator
 - (f) Automatic drain(s) for the diesel fuel–water separator
 - (g) Auxiliary fuel tank(s) commensurate with need to meet local requirements
 - (h) Stainless steel exhaust systems and muffler(s)
- (4) Vehicle electrical and lighting options:
 - (a) Automatic eject-type electrical receptacles
 - (b) On-board battery charger/conditioner (*see 4.6.4*)
 - (c) Line voltage electrical systems in accordance with Chapter 25
 - (d) High-intensity spotlight(s) on the left and right side of the windshield, hand adjustable type, with controls for beam adjustment inside the truck cab
 - (e) High-intensity spotlight(s) mounted on the primary turret nozzle(s), with controls located in the cab instrument group
 - (f) Two high-intensity floodlights, mounted on each side of the vehicle
 - (g) Two high-intensity fog-type driving lights mounted on the front bumper
 - (h) Two high-intensity driving lights mounted on the front bumper
 - (i) Two high-intensity floodlights on the rear of the vehicle
 - (j) Map lights on each side of the dash; a control switch on the instrument group panel in the cab for control of the lights
 - (k) Rotating beacon-type lights on the top roof deck and visible for 360 degrees in the horizontal plane; a control switch on the instrument group panel in the cab for control of the light
 - (l) Strobe-type light(s) on the top roof deck and visible for 360 degrees in the horizontal plane; a control switch on the instrument group panel in the cab for control of the light(s)
 - (m) Fused radio electrical connection in the cab adjacent to the radio mounting location (power ratings to be provided by purchaser)
- (5) Suspension, mobility, and tire options:
 - (a) Reduced underaxle and underbody clearances to provide a more stable performance on pavement when the vehicle suspension is designed to permit instantaneous adjustment to the required height for off-pavement travel
 - (b) Tag or other nonpowered axle(s) to assist in weight distribution or stability requirements
 - (c) Vehicle stability systems
 - (d) Passive or active suspension components to increase the stability of the vehicle while decreasing the roll-over threshold
 - (e) Spare tire(s)
 - (f) Bead locks on tires and rims
 - (g) Run-flat devices in all tires and wheels mounted on the vehicle
 - (h) Rear-wheel steering system
- (6) Vehicle brake options:
 - (a) Air brake reservoirs drain valve(s) actuated by the driver from a location or compartment not requiring a creeper to access the actuator
 - (b) Auto-eject-type connectors air connection used to charge brake air tanks from an external air source
- (7) Vehicle cab operating and driving options:
 - (a) Tilt and telescoping steering wheel
 - (b) Supplementary designated seat positions for additional crew members
 - (c) Quick access passage to the roof
 - (d) Cab air-conditioning meeting current automotive-truck and environmental protection standards for vehicle air-conditioning (acceptable pass/fail criteria not changed by the use of air-conditioning)
 - (e) Air-suspension-type driver [passenger(s)] seat(s), with vertical, fore, and aft adjustment
 - (f) Crew seat back(s), with storage of self-contained breathing apparatus (SCBA) with quick-release-type holders incorporated into the seat cushion
- (8) Firefighting systems' options:
 - (a) Water tank design that allows access with each baffled compartment of the tank for internal and external inspection/service
 - (b) Automatic foam proportioning system, permitting use of 3 percent and 6 percent foam concentrates automatically when selected (change of proportioning plates not required)
 - (c) Electronic foam proportioning system
 - (d) Foam tank drain valve(s), drain line, and hose that facilitate draining the tank into specified container(s) positioned on the ground within 3 m (10 ft) in either horizontal direction of the foam tank drainage system
 - (e) Manually operated roof turret with controls located in the cab, the operation force of the controls requiring less than 134.4 N (30 ft-lb) including in-cab indicator of turret elevation and azimuth
 - (f) Manually operated roof turret with controls located on the cab roof platform, the operation force of the controls requiring less than 224 N (50 ft-lb)
 - (g) Turret controls located in the cab or on the roof platform
 - (h) Manual override of roof turret functions in the cab not exceeding 134.4 N (30 ft-lb) operation forces

- (i) Turret(s) controls accessible both to the driver and the crew member
- (j) Turret(s) equipped with an auxiliary agent discharge (*see 4.25.1*)
- (k) Boom-mounted-type primary turret (*see 4.20.6*)
- (l) Color camera mounted on the boom-mounted turret (*see 4.20.6*)
- (m) Video recorder for color or FLIR camera(s)
- (n) Aircraft skin penetrator/agent applicator mounted on the boom-mounted turret (*see 4.20.6*)
- (o) Pre-connect handlines and nozzles (water/foam/combined/auxiliary agent/mounted parallel entrained streams)
- (p) Bumper turret (*see Section 4.22*)
- (q) High-capacity bumper turret
- (r) Two or more undertruck nozzles (*see 4.22.1 and 4.22.3*)
- (s) Fire system pressure gauge/light/warning on the cab instrument panel grouping or on the side structural control panel
- (t) Foam-liquid tank level gauge/light/warning on the cab instrument panel grouping
- (u) Remote foam/water liquid level gauge/light/warning on the side panel or supply/service locations
- (v) Bumper turret and/or ground sweep valve controls located in the cab
- (w) Undertruck nozzle valve control in the cab
- (x) Auxiliary agent pressurization control on the cab instrument grouping
- (y) Remote mounted instrument and control panel (structural panel)

A.4.3.1 A minimum 1-year warranty should be supplied by the contractor. Purchasers should require that bids be submitted with a detailed description of the vehicles offered and drawings showing general arrangements, weights, and dimensions. Information data similar to that provided in Figure B.1 also should be required.

A.4.3.2.5.10 The parts manuals and service manuals for commercial chassis are prohibitively expensive, hard to obtain, and in some cases do not exist. If a manufacturer provides a custom-built chassis (such as those provided for a Class 4 or 5 heavy ARFF vehicle), then a complete parts and service manual must be provided for the vehicle.

A.4.4.1 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 a maximum GVWR or maximum total weight, which should not be exceeded by the apparatus manufacturer or by the purchaser after the vehicle has been placed in service. For tractor-drawn vehicles, the in-service weight of the apparatus should not exceed the gross combination weight rating (GCWR). 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 and wheel loading, and the distribution of the weight between the front and rear wheels.

Water Tank. One of the most critical factors is the size of the water tank. Water weighs approximately 8.3 lb/gal (1 kg/L). A value of 10 lb/gal (1.2 kg/L) can be used when estimating the weight of the tank and its water, making a 500 gal (2000 L) tank and its water about 5000 lb (2400 kg).

Miscellaneous Equipment. If the finished apparatus is not to be overloaded, the purchaser should provide the contractor with

the weight of equipment to be carried if it is in excess of the allowance determined by the purchaser and contractor.

Large Compartment Capacity. Purchasers should specify the equipment to be carried on the vehicle and should work closely with the vehicle manufacturer to ensure that the compartment capacity and GVWR are sufficient to carry the intended equipment.

FAMA provides a worksheet for use by purchasers to calculate the portable equipment weight and volumetric requirements.

This volume does not include space occupied by generators, reels, air systems, ladders, hose, and so forth, that are not in the miscellaneous equipment allowance. Total equipment weight varies significantly depending on the density of the equipment and how tightly the fire department chooses to pack it.

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

Underloading. Brake equipment on heavy vehicles can be sensitive to the weight distribution of the vehicle. Specifying a GVWR significantly greater than the intended in-service weight can lead to poor brake performance, chatter, and squeal. Purchasers who specify configurations with limited compartment volume on a high-capacity chassis should consult the manufacturer to ensure that a vehicle with an underloaded condition will not result.

Fire apparatus should be able to perform its intended service under adverse conditions that might require operation off paved streets or roads. Chassis components should be selected with the rigors of service in mind.

It is important to consider the need to conserve weight and space on initial-response ARFF vehicles. Rapid response, acceleration, top speed, and vehicle stability are vital to the mission.

It is, therefore, preferable that tools and equipment above what is necessary to perform initial operations be transported by other means, as needed.

The purchaser should specify the particular item required for the following:

- (1) One ground ladder that meets the requirements of NFPA 1931
- (2) One section of hose of minimum 63.5 mm (2½ in.) diameter for tank fill
- (3) Appropriate spanner wrenches for the fittings on the vehicle
- (4) One hydrant wrench or other wrench necessary to activate the local water supply
- (5) A SCBA meeting the requirements of NFPA 1981 and NFPA 1500 available for each assigned firefighter
- (6) Skin penetrator/agent applicator
- (7) Appropriate wheel chocks
- (8) 30.5 m (100 ft) of utility rope
- (9) Two axes, non-wedge type
- (10) Fire-resistant blanket
- (11) Bolt cutters, minimum 609.6 mm (24 in.)
- (12) Multipurpose, forcible entry tool

- (13) Intrinsically safe handlight(s)
- (14) Two harness cutting tools
- (15) Hook, grab, or salvage tool
- (16) First aid kit
- (17) 1.8 kg (4 lb) hammer

For a detailed discussion of rescue tools, see NFPA 440.

It is important that additional features such as structural firefighting equipment do not interfere with the basic ability of the vehicle to perform its primary aircraft rescue and firefighting function. It is considered preferable to have separate vehicles for structural firefighting equipped with the needed complement of hose and tools, since the quantity of such equipment carried on an aircraft rescue and firefighting vehicle needs to be limited to conserve weight and space.

A.4.4.1.2 The intent of the weight distribution requirements is to produce the most equally divided weight distribution possible across all axles and wheels. Ideally, the front axle should not be the heaviest loaded axle. It is important to realize, however, that certain customized features not covered in the major firefighting vehicle chapter (such as complementary agent systems) might necessitate that the 5 percent allowance for the front axle be exceeded. Where these situations occur, the vehicle manufacturer needs to be consulted to determine the final weight distribution and to confirm that none of the established component weight ratings is exceeded and that the brake performance of the vehicle still complies with this standard.

A.4.4.2.1 Although the measurement of the axle clearance is with tires inflated to highway inflation pressure, it is understood that the actual clearance in soft soil and rough terrain could be less as tires could be deflated somewhat in order to achieve better off-road mobility.

A.4.5.1.2 At higher altitudes, the performance of a vehicle can be affected due to the reduced density of the air drawn into the engine. The resulting reduction in power is more noticeable on a normally aspirated engine (e.g., non-turbo-charged).

To assess the difference in performance at higher altitudes, it is important to obtain from the manufacturer the reduced power rating of the engine at the operating altitude. From this rating, the reduced level of acceleration performance or reduced water capacity extinguishing agent can be estimated.

A.4.7.4.2 Vehicle types are designated as 4×4 , 6×6 , and so forth. These designations indicate the number of wheels on the vehicle and the number of wheels that propel or drive the vehicle. The term *wheel* in this context means either a single tire or a set of dual tires operating as one tire.

A.4.8 The physical characteristics of an airport can require special suspensions, such as active, passive, or semipassive, to meet required response times.

A.4.9.2 The mobility and handling characteristics of the vehicle greatly depend on tire selection. The off-pavement tractive limit of a tire is related to the strength of the soil, power available, load, number of driving wheels, tire diameter, tire deflection, contact area, and tread pattern.

To assist the purchaser in providing a site-specific tire description, the following guidelines are recommended:

- (1) Facilities with hard off-pavement conditions and small snow accumulations require a low level of flotation. For

these conditions the purchaser can specify tires of a relatively small diameter and narrow sectional width operating at a high inflation pressure. This configuration can be made to maximize high-speed performance and handling while the small contact area and resulting poor off-pavement performance will have little if any impact on the effectiveness of the vehicle. A typical example of this configuration is a tire of size 16.00R20 operating within a load range of 4535.9 kg to 5443.1 kg (10,000 lb to 12,000 lb) at an inflation pressure of approximately 586 kPa (85 psi).

- (2) Experience has demonstrated that tires with a relatively large diameter and wide sectional width and operating at medium inflation pressure can provide a reasonable compromise between off-pavement mobility needs and on-pavement performance and handling. Tires meeting these specifications are considered to provide reasonable flotation and are suitable for many facilities where soil is not extremely soft or wet and snow accumulations are moderate. A typical example of this configuration is a tire of size 24R21 operating within a load range of 4535.9 kg to 5443.1 kg (10,000 lb to 12,000 lb) at an inflation pressure of approximately 448.2 kPa (65 psi).
- (3) Where local conditions require very high flotation to traverse obstacles of deep mud, sand, or snow, the purchaser can specify an even larger tire diameter, a larger tire cross-section, a greater tire deflection, lower wheel loads, and reduced tire inflation pressure. These specifications can be made to maximize off-pavement performance, but they can also result in some degradation of high-speed performance and handling characteristics. While such a vehicle has a higher probability of traversing difficult off-road terrain, its effectiveness should also be judged based on the longer response time needed over the paced portion of the access route. A typical example of this configuration is a tire of size 24R21 operating within a load range of 4535.9 kg to 5443.1 kg (10,000 lb to 12,000 lb) at an inflation pressure below 275.8 kPa (40 psi) with severe restrictions to top speed capability. The purchaser can also consider devices capable of providing reliable control of the tire inflation pressure while the vehicle is in motion as a means of broadening the overall performance envelope.

A.4.9.3 To optimize flotation under soft ground conditions, tires of larger diameter or width, or both, than is needed only for bearing weight should be specified. Similarly, the lowest tire pressure compatible with the high-speed performance requirements also should be specified. Vehicle and tire manufacturers should be consulted for the tread design most suitable for the specific soil composition at individual airports.

A.4.10 Recovery of the vehicle from adverse conditions should be made by attaching the vehicle to the axles.

A.4.11.1 It is customary for manufacturers of rescue and firefighting vehicles to provide a braking system based on normal commercial practice, usually connected to a recognized standard that might have legal status in worldwide territories. These standards offer certain advantages and disadvantages that can vary from one another. Operators should consider these advantages and disadvantages with respect to their particular operating conditions and legal requirements.

A.4.11.2 By preventing wheel lock-up, antilock braking systems (ABS) can significantly enhance driver control and

vehicle stability under certain conditions. The purchaser should consider the applicability of this option.

A.4.12.3 A rear-wheel steering (RWS) system can be used on vehicles to improve the vehicle clearance circle radius and reduce tire wear.

A.4.13.3.6 The US standards developed by SAE and the United Nations ECE regulation mirror each other except that SAE J2422, *Cab Roof Strength Evaluation — Quasi-Static Loading Heavy Trucks*, requires a roof preload impact prior to the roof crush. The ECE standard was established in 1958, while the SAE standards did not add performance criteria until 2003. Both the SAE and ECE standards are viable minimum measures of cab integrity. Manufacturers can test in excess of the standards.

A.4.13.4.2 The illuminated instruments and backlighting should not reflect on the windshield or distract the driver/operators with a direct reflection.

A.4.13.4.4 Depending on the type of vehicle driveline specified, the purchaser can consider adding or deleting instruments and warning lights. Based on the driveline specified, some of the base instruments and lights might not be applicable to that driveline configuration. Alternatively, some driveline systems might require new instruments and warning lights based on that particular technology that might be needed to alert the operator in the operation of the vehicle. The purchaser should consider that driveline is being specified and specify the appropriate instruments and lights for that technology.

A.4.13.4.6 The windshield deluge system is included to cool the windshield and to provide operator visibility during fire-fighting operations.

A.4.13.4.7 A detailed description of the navigation system of the DEVS is provided in Annex C. A detailed description of the low-visibility enhanced vision system is provided in Annex C.

A.4.13.4.7.2(2) Note: A duplicate or second navigation system as described in 4.13.4.7.1 is not required, and a duplicate or second FLIR system as described in 4.13.4.8 is not required.

A.4.13.4.8 The FLIR camera should be mounted in a position that allows a driving default position as close as possible to the horizontal and vertical fields of vision of the driver.

The onboard monitor for the FLIR camera should be mounted in a position as close as possible to the line of vision of the driver.

A.4.13.5.2 SCBA units and other equipment stored in the crew compartment can cause injuries to occupants of the compartment if they fly around the compartment as the result of an accident or other impact. Departments should check their pack and bottle weight to ensure that it does not exceed the published rating of the SCBA holder to be provided.

A.4.13.5.2(4) A new holder can be employed for each test.

A.4.13.7.3 If equipment is going to be installed after delivery, such as radio or data communications equipment, it might be a good idea to consult with the future installer for what accommodations they would like to have the apparatus manufacturer provide to make their work easier.

A.4.13.7.5(1) Where specified, a monitoring and data acquisition system (MADAS) should be installed for the collection of

various performance measurements to monitor, as a minimum, the following:

- (1) Vehicle speed
- (2) Vehicle heading
- (3) Lateral acceleration
- (4) Vertical acceleration
- (5) Longitudinal acceleration and deceleration
- (6) Engine rpm
- (7) Throttle position
- (8) Steering input
- (9) Vehicle braking input (pedal position and brake pressure)
- (10) Date, time, and location for all data collected

The data acquisition system should be capable of storing the measurements and the time intervals, starting at least 120 seconds before and ending at least 15 seconds after any serious incident.

The data acquisition system should be designed so that the data being recorded will not be lost or overwritten immediately after the incident due to the use of an emergency shutoff or a master electrical disconnect switch.

A.4.13.7.5(4) If a vehicle data recorder (VDR) is provided, it should have the following minimum capabilities:

- (1) The VDR should be capable of recording the data shown in Table A.4.13.7.5(4)(a) at least once per second.
- (2) Data should be stored at the sampling rate in a 48-hour loop.
- (3) Memory should be sufficient to record 100 engine hours' worth of minute-by-minute summary showing the data in Table A.4.13.7.5(4)(b).
- (4) When the memory capacity is reached, the system should erase the oldest data first.

All data stored in the VDR should be uploadable by the user to a computer or fire department management/engineering system via cable, Wi-Fi, data channel, cellular data, or other technology.

As a minimum, the user should have the capability to view the data as follows:

- (1) Raw second-by-second data over a specified data/time range
- (2) Daily log for the time the engine is running for a given date (minute-by-minute output of all values)
- (3) Weekly summary (i.e., maximum values each hour for each day of the week)
- (4) Monthly summary (i.e., maximum values each day for each day of the month)

A.4.13.7.5(5) V2X (i.e., vehicle to everything) communications provide information from a vehicle to other systems. This can include communications through dedicated short-range communications; cellular communications; WLAN; WiFi (in station); and, in the case of emergency vehicles, existing radio network data channels. Vehicles can communicate with other vehicles (V2V), infrastructure such as traffic signals and other fixed infrastructure (V2I), pedestrians (V2P), networks (V2N), devices such as smartphone apps or other portable devices (V2D), power grids (V2G), and other systems such as maintenance/engineering departments and other technologies. This is a rapidly growing and developing area of technology with almost unlimited possibilities to improve safety and efficiency. Purchasers need to research available equipment and capabilities.

ties, and then direct the contractor to provide the capabilities desired. There are many standards related to these communications, including NFPA 950.

A.4.13.8 Where specified, a lateral acceleration force indicator that provides both visual and audio signals and warnings to the driver should be provided. The sensitivity of the indicator should be adjustable by the fire department to account for the individual operating capabilities of different vehicles.

A.4.14.9 It is important to consider the need to conserve weight and space on initial-response ARFF vehicles. Rapid response, acceleration, top speed, and vehicle stability are vital to the mission. It is, therefore, preferable that tools and equipment above what is necessary to perform initial operations be transported by other means, as needed.

Altering locations of tools and equipment should not be permitted as this action could have an effect on vehicle stability. Final mounting locations for tools and equipment should be at the discretion of the manufacturer if the tool or equipment installation could alter the stability of the vehicle.

Table A.4.13.7.5(4)(a) VDR Data

Data	Unit of Measure
Vehicle speed	mph
Acceleration (from speedometer)	mph/sec
Deceleration (from speedometer)	mph/sec
Engine speed	rpm
Engine speed control position	% of full speed control
Antilock braking system event	on/off
Seat occupied status	Occupied: yes/no by position
Seat belt status	Buckled: yes/no by position
Master optical warning device switch	on/off
Time	24-hour clock
Date	year/month/day

Table A.4.13.7.5(4)(b) VDR Summary Data

Data	Unit of Measure
Maximum vehicle speed	mph
Maximum acceleration (from speedometer)	mph/sec
Maximum deceleration (from speedometer)	mph/sec
Maximum engine speed	rpm
Maximum engine speed control position	% of full speed control
Antilock braking system event	on/off
Seat occupied with seat belt unbuckled	yes/no by position at 30 sec into minute
Master optical warning device switch	on/off at 30 sec into minute
Time	24-hour clock
Date	year/month/day

A.4.15.3 These items could include the tanks, piping, fill troughs, and screens.

A.4.18 An around-the-pump proportioning system operates with an eductor installed between the water pump discharge and intake. A small flow of water from the water pump discharge passes through the eductor, which creates a vacuum, causing foam concentrate to be inducted and discharged into the pump intake. Around-the-pump systems are available with fixed or variable rate proportioning. Manual variable proportioning [see Figure A.4.18(a)] is accomplished by an operator-controlled metering valve that corresponds to a calibrated rating chart. With this system, the operator must determine flow in order to set the metering valve. Automatic variable proportioning systems [see Figure A.4.18(b)] rely on a flowmeter monitoring system for total solution flow and foam concentrate flow. The flow data are fed into a microprocessor that provides readout and operator control of the foam solution percentage. Around-the-pump systems are relatively inexpensive, but they have the following limitations:

- (1) Water pump intake pressure cannot exceed approximately 69 kPa (10 psi).
- (2) Water and foam solution cannot be discharged simultaneously from the pump. Once activated, the system produces foam solution from all open pump discharge outlets.
- (3) It is difficult to match foam concentrate with the performance required.
- (4) Internal components require frequent maintenance.

Premixed foam systems utilize a separate tank to contain the foam solution that has been premixed at a specific percentage. There are two types of premix systems.

Pressure-type systems use a pressure vessel for the tank and compressed gas, usually nitrogen, to propel the premixed foam solution from the discharge device. These systems are usually installed on a quick attack-type apparatus to take advantage of the instant activation feature of this type of foam system. Pressure-type premix systems [see Figure A.4.18(c)] have the following limitations:

- (1) Fixed foam solution percentage, once the foam solution is prepared.
- (2) Size and weight of the pressure vessel.
- (3) Pressure limitation of the pressure vessel.
- (4) System cannot be recharged while the system is in operation.

Suction-type systems use an atmospheric tank that is connected to the water pump intake. The premixed foam solution is drawn directly into the pump and discharged as required. A suction system can be created by adding the correct amount of foam concentrate to the water tank on the fire apparatus. Suction-type premix systems have the following limitations:

- (1) Fixed foam solution percentage, once foam solution is prepared.
- (2) Water and foam solution cannot be discharged simultaneously from the pump. Once activated, the system produces foam solution from all open pump discharge outlets.
- (3) System is difficult to recharge when system is in operation.
- (4) Foam concentrates must be mechanically mixed with water to create foam solution.

CAUTION: Adding foam directly to the water tank on a piece of apparatus that was not specifically designed for premix usage will cause damage to the tank, plumbing, and pump.

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 (proportioned) located in the water pump discharge. By adjusting the area of the orifices to a particular ratio, the percent of injection can be adjusted if inlet 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 methods of balancing the pressures are systems without a foam concentrate pump and systems with a concentrate pump.

Balanced pressure systems without a foam concentrate pump are referred to as “pressure proportioning systems.” [See Figure A.4.18(d).] 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 foam proportioner at a pressure equal to the water pressure. These systems are easy to operate and offer fixed or variable rate proportioning. Pressure proportioning systems have the following limitations:

- (1) Size and weight of the pressure vessel.
- (2) Capacity of the pressure vessel.
- (3) Pressure limitation of the pressure vessel.
- (4) Unit cannot be recharged when the system is in operation.

A balanced pressure system with a foam concentrate pump can be one of two basic types. A “bypass” [see Figure A.4.18(e)] system utilizes a diaphragm valve in the concentrate pump-to-tank line that automatically controls foam pump pressure by bypassing excess foam concentrate back to the tank. A “demand” system [see Figure A.4.18(f)] controls the pump speed, which controls pump pressure. Balanced pressure systems have no real operating limitations except by specific design. These systems have no water intake limitations, and discharge capacity and pressure are limited only by design. Foam solution can be discharged from any water pump outlet, equipped with a proportioning device, at various percentage rates up to system design capacity. Water and foam solution can be discharged simultaneously from the water pump. Accurate foam proportioning is available over a wide range of flow and pressure. The foam concentrate pump can be used to refill the foam concentrate tank at any time, even when the system is operating.

Balanced pressure foam proportioning systems are more complex than other types of systems and generally more expensive. However, they have the following advantages:

- (1) There is no water inlet pressure limitation.
- (2) Discharge capacity is limited only by design.
- (3) Foam solution can be discharged from any water pump outlet equipped with a proportioning device at various percentage rates up to the system design capacity.
- (4) Water and foam solution can be discharged simultaneously.

Direct injection foam proportioning systems [see Figure A.4.18(g)] utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. A flowmeter(s) is installed into the water pump discharge to measure the water flow rate. The flowmeter(s) signal is used by a microprocessor to control the output of the foam concentrate pump. A measurement of the foam concentrate pump output is fed back to the microprocessor to maintain the foam concentrate flow rate at the proper proportion to the water flow rate. Direct injection systems have no real operating limitations except by specific design. Water and foam solution can be discharged simultaneously from the water pump. Accurate foam proportioning is available over a wide range of flow and pressure. Direct injection systems have the following advantages:

- (1) They do not introduce a pressure loss into the water pump discharge.
- (2) They automatically adapt to changing water pump inlet or discharge pressure conditions.
- (3) They are simple to operate.
- (4) The foam concentrate can be refilled during operation.
- (5) Injection rates are operator adjustable.

Compressed air-foam systems (CAFS) [see Figure A.4.18(h)] are a derivation of the direct injection foam proportioning system. This type of system incorporates an onboard foam agent pump and air compressor in conjunction with a water pump. The foam agent system monitors water flow with a flowmeter installed in the water pump discharge. Foam agent pump output is regulated by an agent metering control unit that provides accurate control of the foam agent percent of injection. Air injection is controlled by an air pressure regulator. Foam agent and compressed air are properly mixed by a mixer unit installed in the water pump discharge.

A.4.18.3.1 Polyvinyl chloride, epoxies, and polyesters are among the acceptable classes of resins.

A.4.19.1.1 Care should be exercised that the premixed solution is mixed to exact proportions.

A.4.19.2.1.5 Means to guide in recharging partial loads can be a suitably marked dipstick or level gauge approved for the application.

A.4.20.6.7 The proposed concept would be to penetrate above window areas, above interior seat back height, and below baggage storage bins or through the window. Providing water extinguishment from ceiling to floor for a distance of 7.6 m (25 ft) along the fuselage left and right of the centerline of the penetration point would stop fire growth and protect the interior until other vehicles could extinguish the exterior fuel fire.

A.4.22.1 Where the boom-mounted turret is capable of supplying agent as specified as a primary turret, as a bumper turret, or as a ground sweep nozzle(s), the requirement for a bumper turret or ground sweep nozzle(s) can be permitted to be omitted at the option of the purchaser.

A.4.23.1.6 Where specified, the vehicle should come with a closed system to aid in resupplying the dry chemical.

A.4.24.4.7 Halogenated agents are generally incompatible with some types of seal materials.

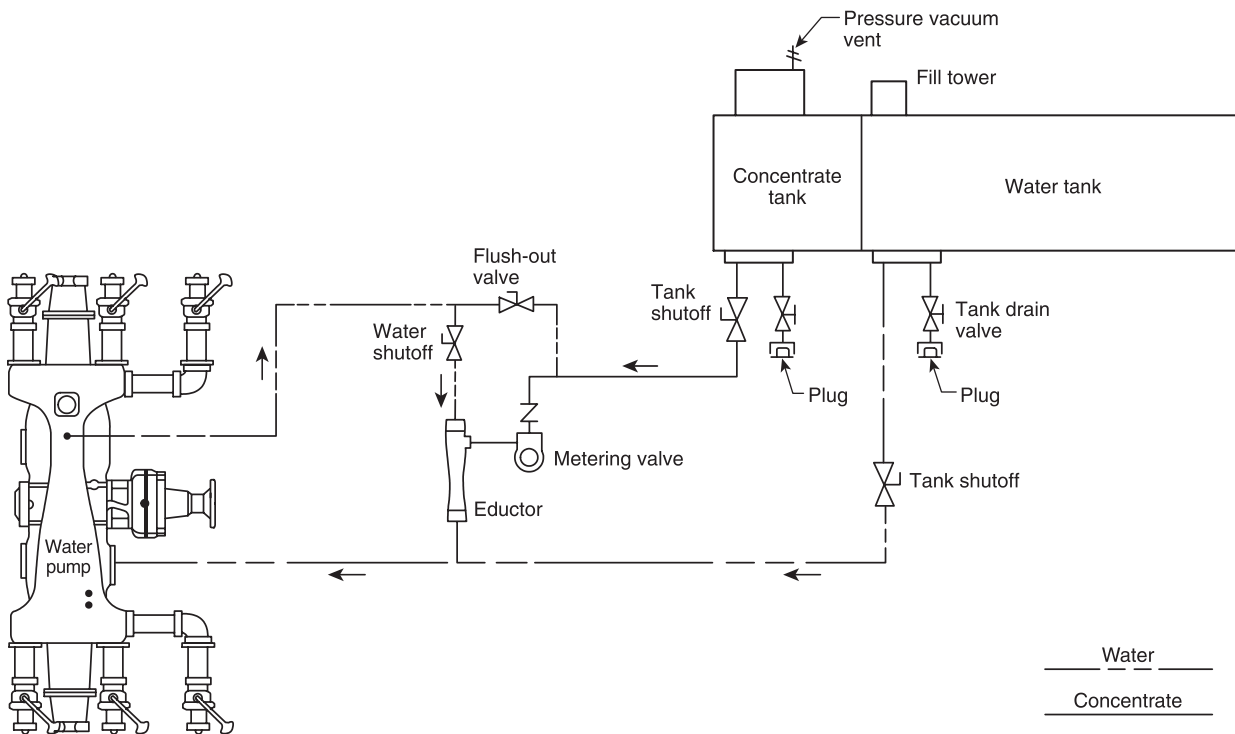


FIGURE A.4.18(a) Manual Variable Metering, Around-the-Pump Proportioning System.

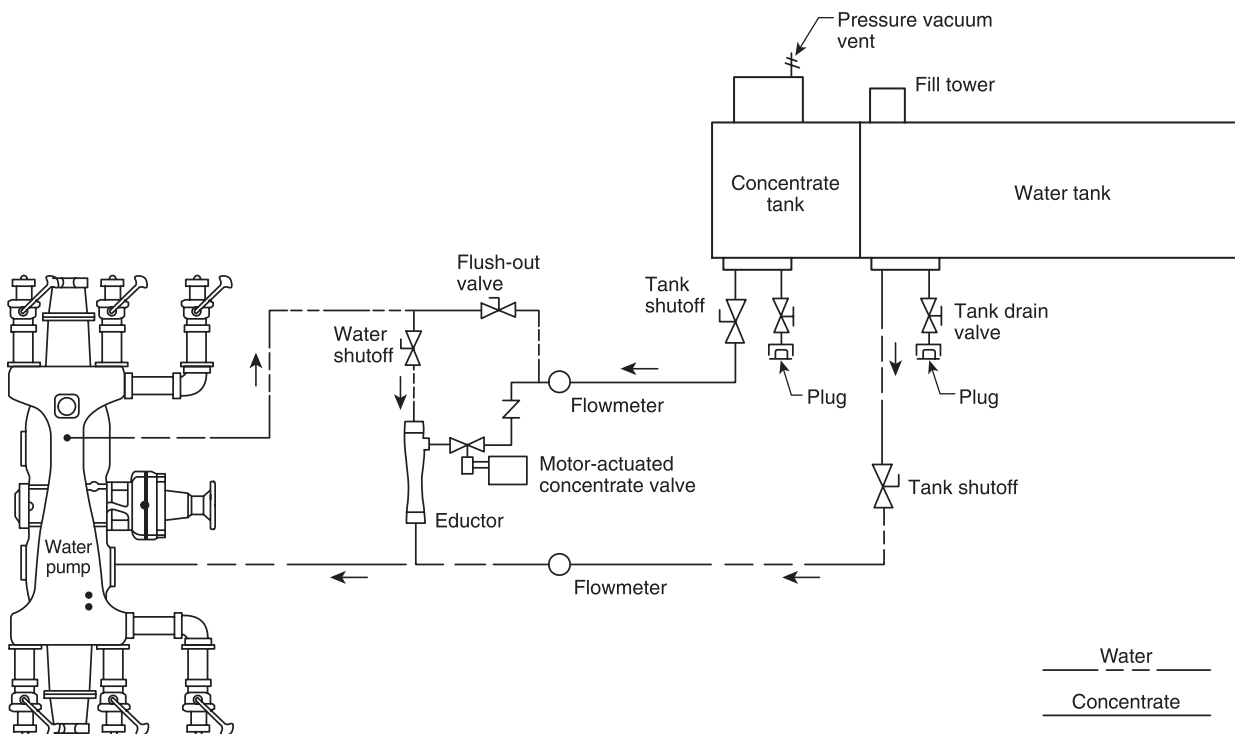


FIGURE A.4.18(b) Automatic Variable Metering, Around-the-Pump Proportioning System.

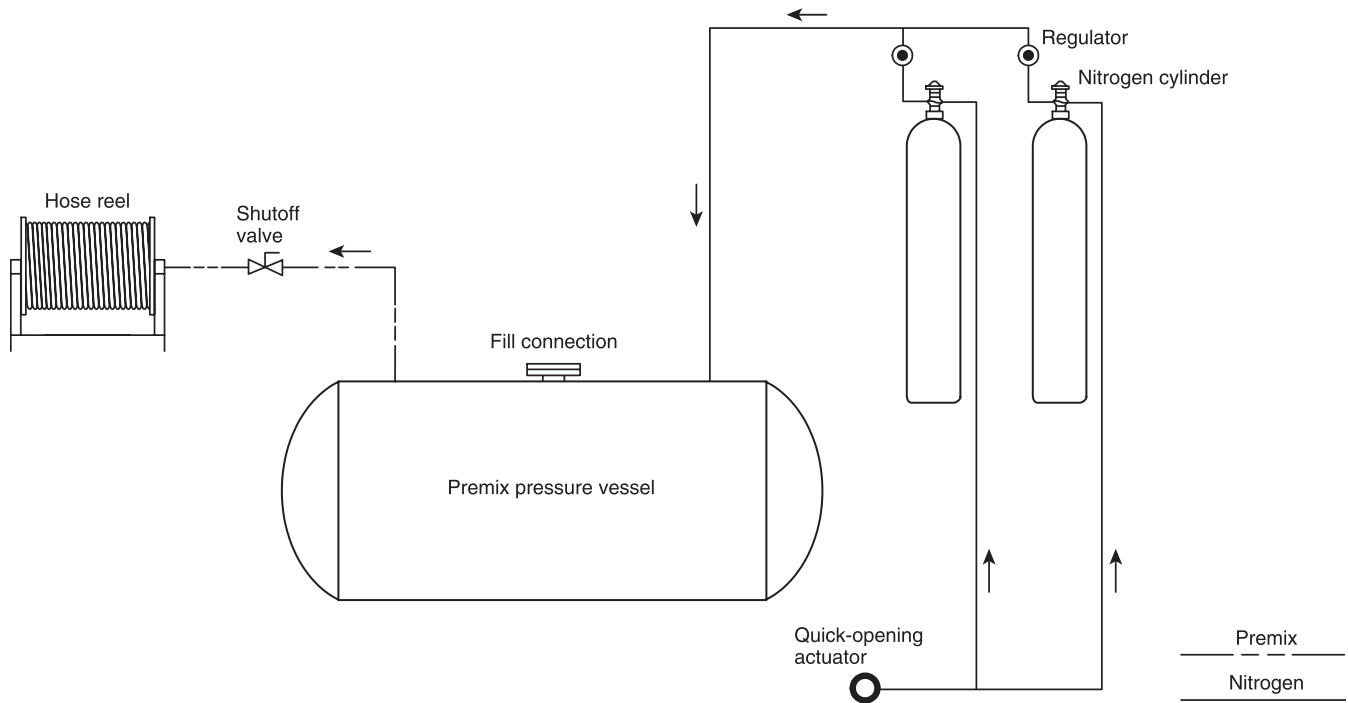


FIGURE A.4.18(c) Pressure-Type Premix System.

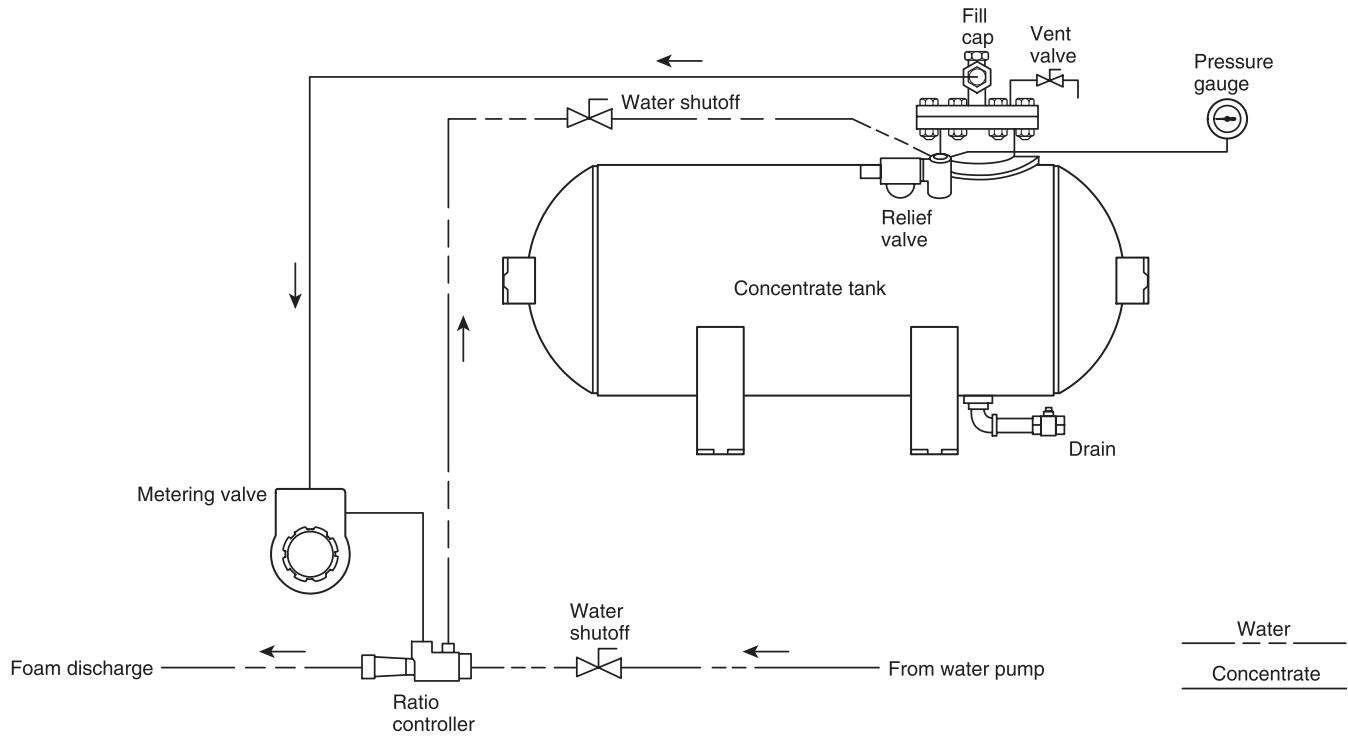


FIGURE A.4.18(d) Pressure Proportioning System.

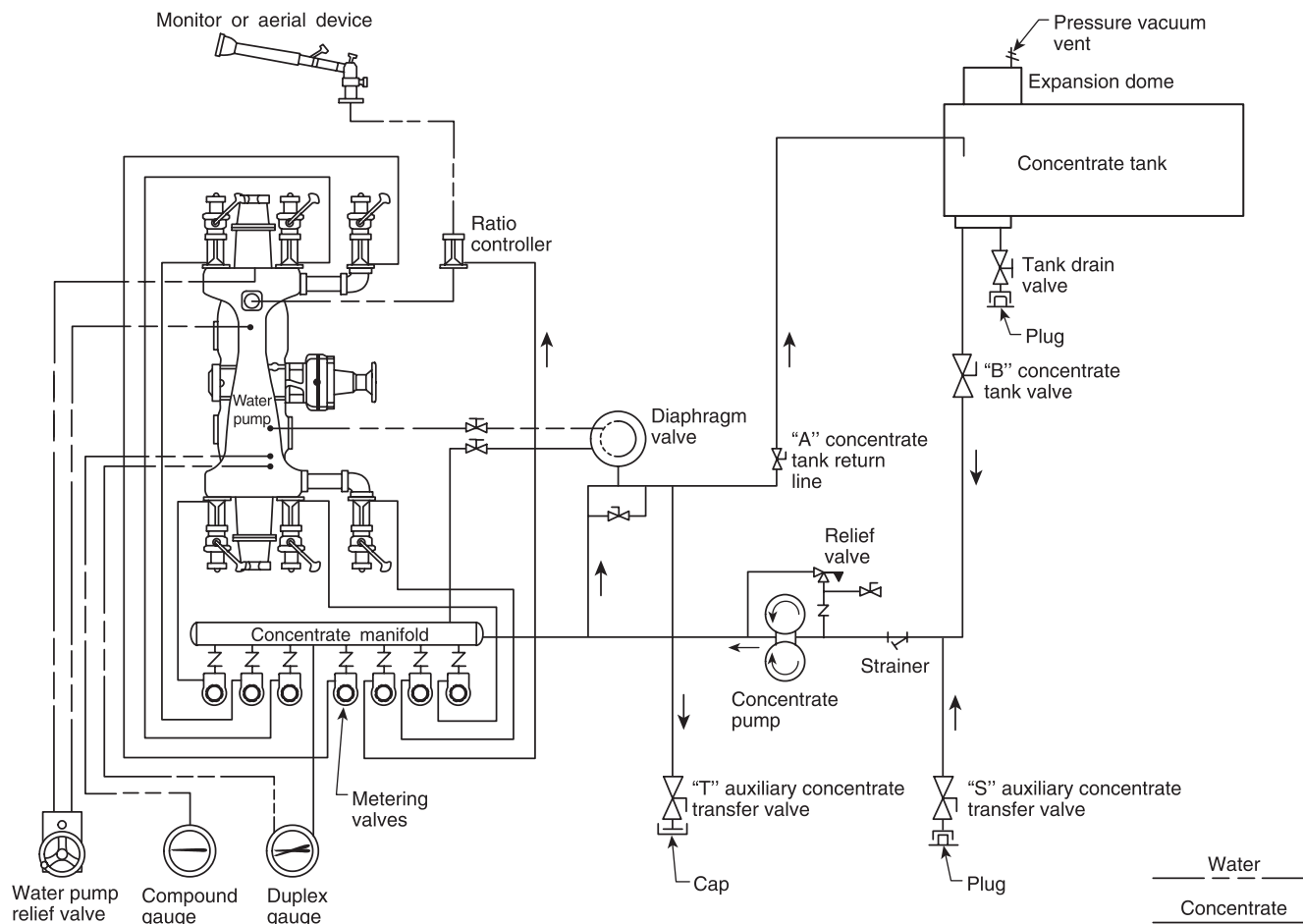


FIGURE A.4.18(e) Bypass Balanced Pressure Proportioning System.

A.4.26.1 The following are lighting options:

- (1) Where specified, a spotlight on both left and right sides of the windshield, hand-adjustable type, with controls for adjustment inside the truck cab
- (2) Where specified, a spotlight mounted on a turret with a control switch that is readily accessible to the operator
- (3) Where specified, two high-intensity floodlights mounted one on each side of the vehicle to provide illumination of the work area adjacent to the vehicle
- (4) Where specified, two high-intensity fog-type driving-type lights with a protective brush guard around each lamp and switch mounted on the dash in the cab
- (5) Where specified, in addition to the normal vehicle headlight system, two high-intensity driving-type lights with a protective brush guard around each lamp and a switch mounted on the dash in the cab
- (6) Where specified, two high-intensity floodlights mounted at the rear of the vehicle that are controlled by a switch in the cab
- (7) Where specified, map light(s)

A.4.26.2 If desired, the driver's siren control can be wired for selective control on the steering wheel horn button. If a combination public address-type siren is desired, an electronic type having an equivalent sound output should be substituted.

A.5.2.3(4) A new holder can be employed for each test.

A.5.4.1 Airports that accommodate second-level aircraft, such as the Boeing 747 and Airbus A380, operating on their airport should have a vehicle that can access the upper level aircraft door sills from ground level.

A.5.4.2 Other means than a ladder (e.g., ramp or stairway) are more easily traversed by ARFF personnel in full PPE carrying equipment and/or an incapacitated victim.

A.5.5.2 The docking platform should have protective railings that are designed to extend after the platform is docked to prevent the presence of voids between the railings and the aircraft fuselage. Other protective panels/intermediate rails paralleling the stairs/ramp and platform should be no more than 250 mm (10 in.) apart.

A.5.6.2 The required turning radius allows for maneuverability through a crash site debris field, in the vicinity of aircraft passenger gates, and if necessary a quick reposition of the vehicle. The driver of the vehicle should have full view of the contact portion of the docking platform(s). The vehicle control should be possible at speeds less than 1.6 kph (1 mph) without noticeable lurching.

A.5.6.4 If available, active suspension, self-leveling devices, and/or vehicle stabilizers can be used for this test.

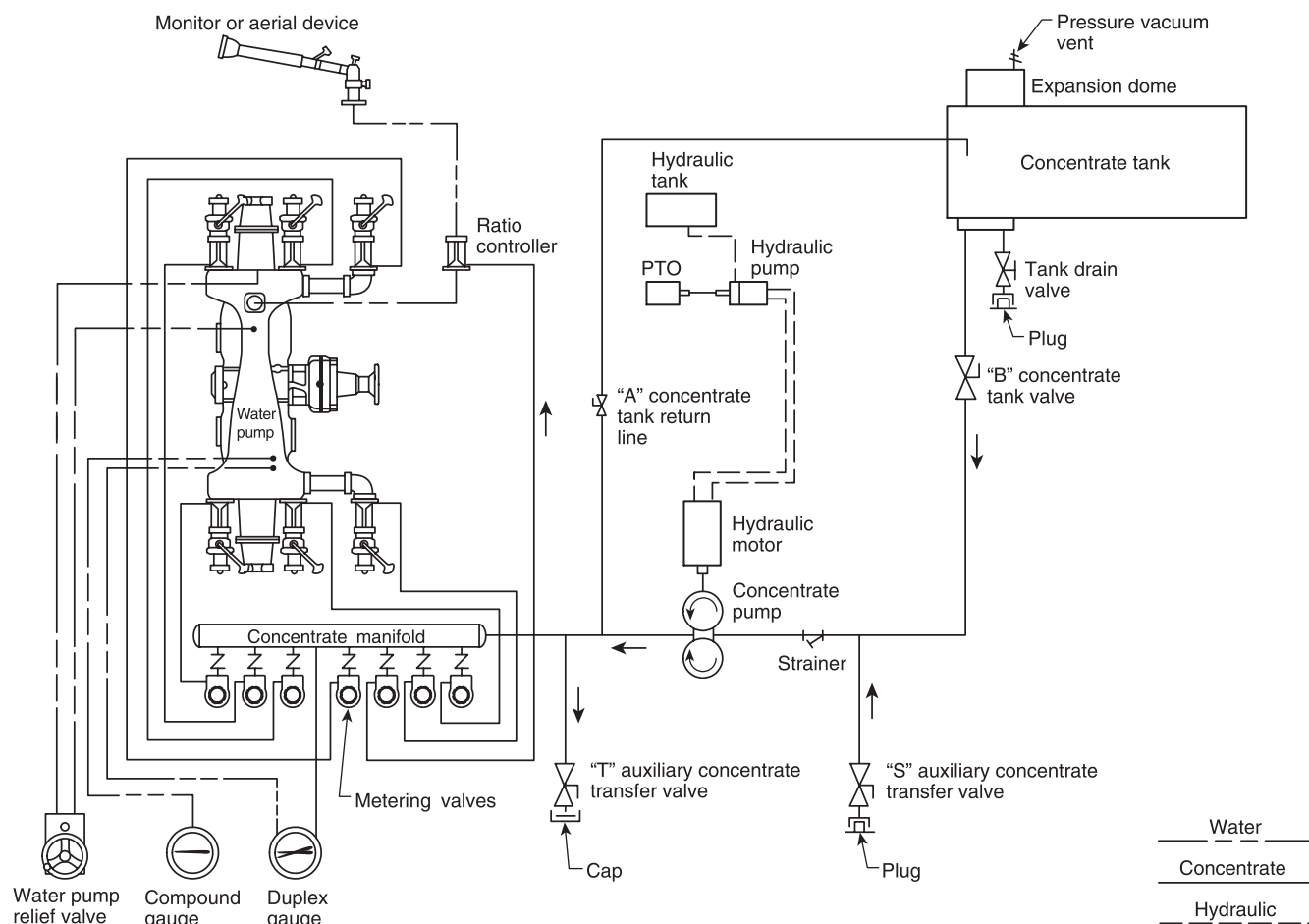


FIGURE A.4.18(f) Demand Balanced Pressure Proportioning System.

A.5.8.1 Refer to SAE ARP 1328C, *Aircraft Ground Support Equipment — Wind Stability Determination*.

A.6.1.7 Manufacturers have the option of conducting calibration in house or through outside contractors.

A.6.3.5 The maximum capacity configuration includes all agent tanks full of agent, and all compartments loaded with the maximum allowable weight.

A.6.3.6 Test facilities should consist of an open site suitable for discharging agent that includes both level ground and measured grades of at least 20 percent and 30 percent. Access to a refill water supply should be required.

A.6.3.7 Test facilities should consist of a level site having a dry, paved surface at least 76.2 m (250 ft) in diameter that is free from loose material upon which a circle with a radius of 30.5 m (100 ft) should be marked in a manner that can be followed easily by a driver.

A.6.3.8 Test facilities should consist of a flat measurement pad that is large enough to accommodate the entire vehicle.

A.6.3.9 Test facilities should consist of a level site at least 6.1 m (20 ft) longer than the vehicle.

A.6.3.10 Test facilities should consist of a site suitable for discharging the agent that includes a measured grade of

40 percent at least twice the vehicle's length or a level, paved test pad adequate for an extended drawbar pull.

A.6.3.11 Test facilities should consist of an area suitable for running the engine while the electric loads and charging rates are being measured.

A.6.3.11.3.3.1 The purchaser might wish to have the entire low voltage electrical system and warning device system certified by an independent third-party certification organization.

A.6.3.12 Test facilities should be in accordance with SAE J551/1 or the equivalent standard being used.

A.6.3.13 Test facilities should consist of a site that includes a measured grade of 50 percent at least equal to the vehicle in length or a level, paved test pad adequate for an extended drawbar pull.

A.6.3.14 Test facilities should consist of a flat test pad suitable for discharging agent and securing portable ramps under the vehicle.

A.6.3.15 Test facilities should consist of any dry, smooth, level, paved surface adequate in length to reach the respective test speeds and stop safely. The test area should be marked so that a lane equivalent in width to that of the vehicle plus 1.2 m (4 ft) is established.

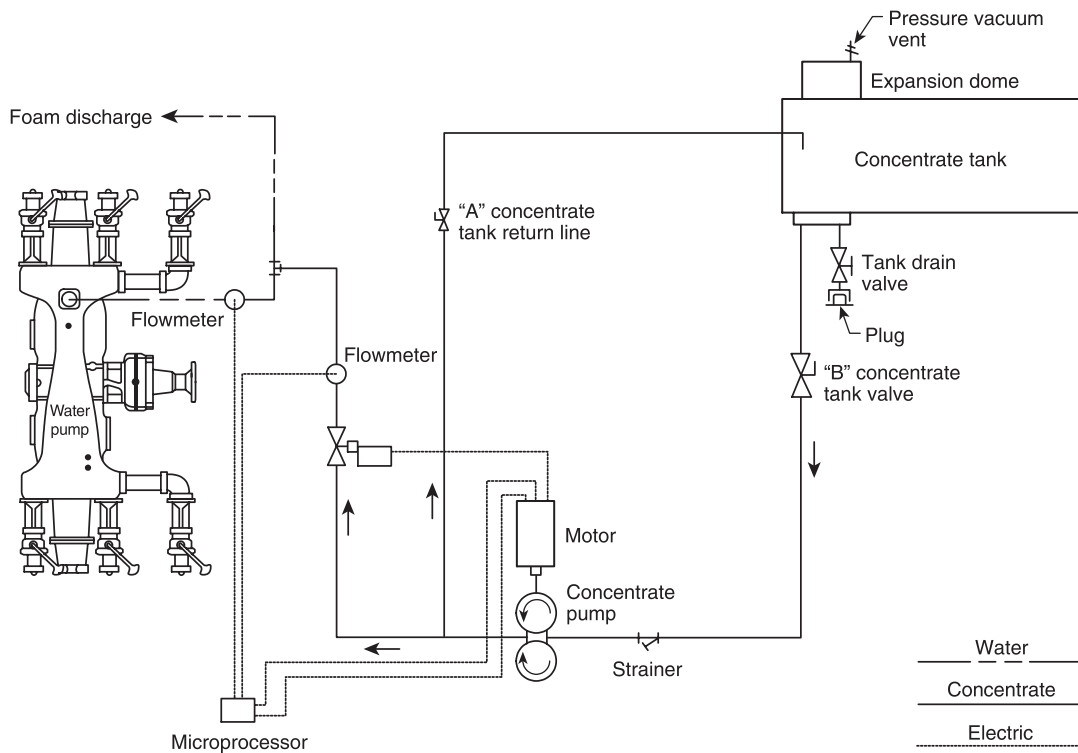


FIGURE A.4.18(g) Direct Injection Foam Proportioning System.

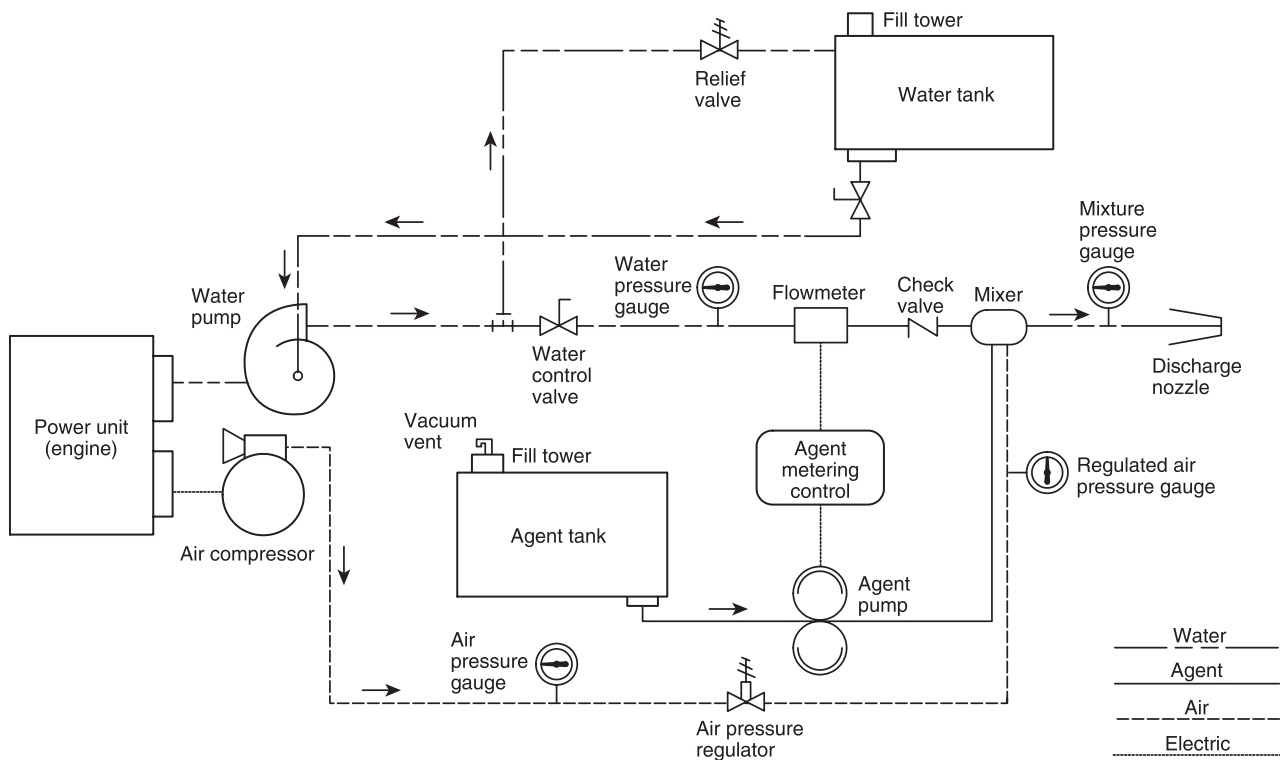


FIGURE A.4.18(h) Compressed Air-Foam System.

A.6.3.16 Test facilities should consist of dry, smooth, measured grades of 20 percent and 50 percent at least equal to the vehicle in length or a level, paved test pad adequate for an extended drawbar pull.

A.6.3.17 Test facilities should consist of any dry, level, paved surface that is free from loose material.

A.6.3.18 Test facilities should consist of a level site having a dry, paved surface greater than three times the vehicle's length in diameter and free from loose material.

A.6.3.19 Test facilities should consist of a level, open site suitable for discharging agent and with access to a refill water supply.

A.6.3.20 Test facilities should consist of a level site with pumping or hydrant capacity, or both, sufficient to provide the water delivery rate needed to fill the water tank in 2 minutes at an inlet pressure of 551.6 kPa (80 psi).

A.6.3.21 Test facilities should consist of an open site suitable for discharging agent and draining the vehicle and with access to a refill water supply.

A.6.3.22 Test facilities should consist of a level, open site suitable for discharging agent and with access to a refill water supply.

A.6.3.24 Test facilities should consist of a level, open site suitable for discharging agent and with access to a refill water supply.

A.6.3.25 Test facilities should consist of a level, open site suitable for discharging agent and with access to a refill water supply.

A.6.3.26 Test facilities should consist of a level, open site suitable for discharging agent and with access to a refill water supply.

A.6.3.28 Test facilities should consist of an open site suitable for discharging agent and with access to a refill water supply.

A.6.3.30 Test facilities should consist of an open site suitable for discharging agent.

A.6.3.31 Test facilities should consist of an open site suitable for discharging agent and with access to a refill water supply and a foam concentrate supply.

A.6.3.32 Test facilities should consist of a flat, open area that is free from large reflecting surfaces (such as other vehicles, signboards, or hills) within a 61 m (200 ft) radius of the vehicle.

A.6.3.33 Test facilities should consist of an open site suitable for discharging AFFF concentrate, dry chemical, or halogenated agent.

A.6.3.34 Test facilities should consist of an open site suitable for discharging the AFFF solution, dry chemical, or halogenated agent.

A.6.3.35 Test facilities should consist of a level, open site suitable for discharging the agent and measuring ranges.

A.6.3.36 Test facilities should consist of an open site suitable for discharging AFFF solution, dry chemical, or halogenated agent.

A.6.3.37 Test facilities should consist of a level, open site suitable for discharging the dry chemical or halogenated agent and measuring ranges. Wind conditions should be calm [less than 8 kph (5 mph)].

A.6.3.38 Test facilities should consist of a level, open site suitable for discharging the agent and measuring range. The test should be conducted in calm wind [less than 8 kph (5 mph)].

A.6.3.39 Test facilities should consist of a flat, open, paved area suitable for operating the vehicle at a constant speed of 80.5 kph (50 mph) and free from large reflecting surfaces (such as other vehicles, signboards, or hills) within a 15.2 m (50 ft) distance of the vehicle. The wind speed should not exceed 24.1 kph (15 mph) during the test.

A.6.4 Due to the high tilt-table angle that is required in this standard per SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, testing to 30 degree tilt angle, vehicle slipping on the table surface can occur. Research has shown that an "open grid deck" product specified as follows resists vehicle traction slippage without impacting the tilt-table angle achieved: IKG Greulich 5 in., 4-way, standard open steel grid with 4183# main bars @ 645 mm (7.5 in.) on center, 6.35 mm × 50.8 mm (¼ in. × 2 in.) crossbars @ 95.3 mm (3.75 in.) on center, on 6.35 mm × 25.4 mm (¼ in. × 1 in.) diagonal and supplemental bars.

This product is available from IKG Industries, Harsco Company, 1514 S. Sheldon Road, Channelview, TX 77530, United States; phone (281) 452-6637; fax (713) 378-3987.

A.6.4.1.1.4.1 SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, provides OEM's a detailed procedure on how to conduct a tilt-table test on heavy trucks. There are a few details in this document that end users should be aware of. First, the vehicle should be tested in a straight line parallel to the tilt axis such that no axle centerline is offline by more than 1 in. (25 mm). Being positioned off-axis could result in one axle being higher on the table than the other(s) and could affect how the vehicle reacts as it's being tilted. Second, a vertical constraining surface might be installed on the tilt table as a safety feature. The vertical constraining surface cannot exceed 2 in. (51 mm) in height. An initial clearance of 3 to 4 in. (75 to 100 mm) between the tires and the vertical constraining surface is generally adequate to prevent contact in the normal contact of a test. This will allow the tires to not come into contact with the surface during the tilting process and have an adverse effect on the tilt performance.

A.6.4.2 Test facilities should consist of an in-ground, certified weight scale large enough to accommodate the vehicle or a level test pad for positioning the truck on top of portable wheel scales.

A.6.4.3 Test facilities should consist of a dry, straight, level paved surface sufficient in length to accelerate the vehicle from rest to 80.5 kph (50 mph) and then bring it to a safe stop.

A.6.4.4 Test facilities should consist of a dry, paved, level surface suitable for achieving a vehicle speed of at least 104.6 kph (65 mph) and bringing the vehicle to a safe stop.

A.6.4.5 Test facilities should consist of a dry, smooth, paved surface adequate in length to reach the respective test speeds and stop safely. The test area should be marked so that a lane that equals the width of the vehicle plus 1.2 m (4 ft) is established. A runway or taxiway with a marked centerline should be permitted to be used.

A.6.4.7 Test facilities should consist of an open site suitable for discharging agent.

A.6.4.8 Test facilities should consist of an open site suitable for discharging agent.

A.6.4.9 Test facilities should consist of an open site suitable for discharging agent and operating the vehicle up to its maximum speed.

A.6.4.10 Test facilities should consist of an appropriate area in the vehicle manufacturer's plant.

A.6.4.11 Test facilities should consist of an open site suitable for discharging agent and with access to a refill water supply and foam concentrate supply.

A.6.4.12 Test facilities should consist of a level, open site suitable for discharging agent.

A.6.4.13.1 This demonstration need not have the piercing nozzle mounted to the finished boom system. This demonstration is a laboratory test to show that the manufacturer understands the requirements of the penetration task requirement.

A.6.4.13.2 This demonstration need not have the piercing nozzle mounted to the finished boom system. This demonstration is a laboratory test to show that the manufacturer understands the requirements of the penetration task requirement.

A.7.1.1 The term *new* as applied in this standard is intended to refer to the original construction of a fire apparatus using all new materials and parts.

A.7.1.3.1 The requirements of this standard apply to fire apparatus that have a GVWR of 10,001 lb (4,501 kg) or greater. While the standard was not written specifically to cover vehicles below that size, fire departments should consider using those portions of this standard that address safety issues with smaller emergency vehicles. This would apply particularly to the restraint of equipment in the driving and crew areas and to providing adequate optical warning devices and reflective striping to increase the visibility of the vehicle.

A.7.1.4 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 suggested that the apparatus be brought into line with this standard as closely as possible. NFPA 1910 covers the requirements for refurbishing a fire apparatus.

A.7.1.6.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter, a unit that is outside of but recognized by SI, is commonly used in international fire protection. Table A.7.1.6.1(a) and Table A.7.1.6.1(b) provide U.S.-to-SI conversion factors and SI-to-U.S. conversion factors as an aid to the user. Table A.7.1.6.1(c) provides other conversion factors that could be useful to the reader. Table A.7.1.6.1(d) provides a list of the abbreviations used in this standard and their meanings.

Table A.7.1.6.1(a) Conversion Factors: U.S. Units to SI Units

U.S. Units	SI Units
1 gallon per minute (gpm)	= 3.785 liters per minute (L/min)
1 imperial gallon per minute (igpm)	= 4.546 liters per minute (L/min)
1 pound per square inch (psi)	= 6.895 kilopascals (kPa)
1 inch of mercury (in. Hg) at 60°F (15.6°C)	= 3.377 kilopascals (kPa)
1 inch (in.)	= 25.40 millimeters (mm)
1 foot (ft)	= 0.305 meter (m)
1 cubic foot (ft ³)	= 0.0283 cubic meter (m ³)
1 square inch (in. ²)	= 645.2 square millimeters (mm ²)
1 mile per hour (mph)	= 1.609 kilometers per hour (km/hr)
1 pound (lb)	= 0.454 kilogram (kg)
1 horsepower (hp)	= 0.746 kilowatt (kW)
1 candlepower (cp)	= 12.566 lumens
1 pound per cubic foot (lb/ft ³)	= 16 kilograms per cubic meter (kg/m ³)
1 footcandle (fc)	= 10.764 lux (lx)
1 footlambert	= 3.427 candela/m ²

Table A.7.1.6.1(b) Conversion Factors: SI Units to U.S. Units

SI Units	U.S. Units
1 liter per minute (L/min)	= 0.264 gallon per minute (gpm)
1 liter per minute (L/min)	= 0.22 imperial gallon per minute (igpm)
1 kilopascal (kPa)	= 0.145 pound per square inch (psi)
1 kilopascal (kPa)	= 0.2962 in. Hg at 60°F (15.6°C)
1 millimeter (mm)	= 0.0394 inch (in.)
1 meter (m)	= 3.281 feet (ft)
1 cubic meter (m ³)	= 35.31 cubic feet (ft ³)
1 square millimeter (mm ²)	= 0.00155 square inch (in. ²)
1 kilometer per hour (km/hr)	= 0.6214 mile per hour (mph)
1 kilogram (kg)	= 2.2 pounds (lb)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 lumen	= 0.08 candlepower (cp)
1 kilogram per cubic meter (kg/m ³)	= 0.062 pound per cubic foot (lb/ft ³)
1 lux (lx)	= 0.092 footcandle (fc)
1 candela/m ²	= 0.292 footlambert

Table A.7.1.6.1(c) Other Useful Conversion Factors

1 gallon per minute (gpm)	= 0.833 imperial gallon per minute (igpm)
1 imperial gallon per minute (igpm)	= 1.2 gallons per minute (gpm)
1 foot (ft) of water	= 0.433 pound per square inch (psi)
1 pound per square inch (psi)	= 2.31 feet (ft) of water
1 metric ton (mton)	= 1000 kilograms (kg)
1 kilopascal (kPa)	= 0.01 bar
1 bar	= 100 kilopascals (kPa)

Table A.7.1.6.1(d) Abbreviations Used in This Standard

Abbreviation	Term
A	ampere(s)
ac	alternating current
C	Celsius
cd	candela(s)
dc	direct current
F	Fahrenheit
fc	footcandle(s)
ft	foot (feet)
gpm	gallon(s) per minute
hp	horsepower
in.	inch(es)
in. Hg	inch(es) of mercury
kg	kilogram(s)
km/hr	kilometer(s) per hour
kPa	kilopascal(s)
kW	kilowatts(s)
L	liter(s)
L/min	liter(s) per minute
lx	lux
m	meter(s)
mm	millimeter(s)
mph	mile(s) per hour
NH	National Hose
psi	pound(s) per square inch
rms	root mean square
V	volt(s)

A.7.4.1 Just specifying that an apparatus to be purchased must be compliant with NFPA 1900 is not enough information to purchase a specific vehicle. There are many items described in NFPA 1900 that must be specified by the purchaser. For example, does the purchaser want a pumper, an aerial ladder, a rescue, and so on. NFPA 1900 is a minimum standard and most purchasers want to include additional features.

Annex D contains detailed descriptions of considerations to include in the decision-making process for purchasing an apparatus. Figure D.2.12 can be used as a guide for collecting information. Many items in the figure are marked with an asterisk (*). These items should be specified for every apparatus. Those items without an asterisk should be specified if desired.

A.7.8.4 If the third-party certification of the pump test results uses verifiable automated data collection and image recording equipment, then the third-party organization should refuse to certify any test results for a system if all components of that system requiring testing do not pass the testing required by this standard. The process for acquiring test data should include the following:

- (1) The equipment for securing verifiable automated data collection and image recording should be designed to monitor, collect, and transmit test data from the test site to a microprocessor and compatible software.
- (2) Electronic components should record all pump test data.
- (3) Hardware, software, and data output should be configured into a tamper-free design and operation.
- (4) Date and time displays should be provided and recorded as part of the electronic data acquisition.

- (5) Cameras and data recorders should record all sequences of pump testing and video snapshot clips can be provided for specific test points.
- (6) The equipment should have provisions for manual entry to record information specific to the purchaser, chassis, OEM manufacturer, vertical suction lift distance, no-load governed speed, altitude, barometric pressure, and other required test documentation.
- (7) Data acquisition should record the following at intervals required by the appropriate sections of this standard:
 - (a) Master pump pressure
 - (b) Master vacuum (in. of Hg)
 - (c) Fire pump drive engine RPM — tachometer
 - (d) Pitot pressure and/or flowmeter display(s)
 - (e) Date and time (i.e., day, hour, minute, second)
 - (f) Flow measurement
 - (g) Water temperature of test pit and ambient temperature
 - (h) Coolant temperature from the fire pump drive engine radiator
 - (i) Oil pressure monitoring from the fire pump drive engine
 - (j) Low-voltage monitoring during entire test sequence in addition to alarm to operator
 - (k) If applicable, line voltage monitoring and recording (i.e., frequency, voltage, amps, and ambient temperature in the generator area)
- (8) Following the OEM apparatus test, the test data and video/photo segments should be transmitted to a third-party accredited organization in compliance with the requirements of this standard as it pertains to review and certification of test results.

A.7.8.6 Refer to typical forms, data sheets, and test protocols for pump and aerial testing in Section C.3 of NFPA 1910. Additional forms for testing foam, CAFS, air systems, and low and line voltage are provided if the authority having jurisdiction requires third-party testing of these systems.

A.7.9.4 Refer to typical forms, data sheets, and test protocols for pump and aerial testing in Section C.3 of NFPA 1910. Additional forms for testing foam, CAFS, air systems, and low and line voltage are provided if the authority having jurisdiction requires third-party testing of these systems.

A.7.10.1 The engine compartment and the underside of the vehicle are not considered areas of normal nonmaintenance operation.

A.7.10.4 Uniformity of safety signage is a desirable objective. Examples of common safety sign solutions are depicted in FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*, and should be considered where deemed applicable by the manufacturer.

A.7.10.4.3 Font size, scaling, and aspect ratio can be adjusted if required to fit the physical restrictions of the apparatus.

A.7.11.2 All required signs, instruction plates, and labels should be highly visible and placed on the vehicle where they are not subject to damage from wear and tear.

A.7.12.3 If equipment is going to be installed after delivery, such as radio or data communications equipment, it might be a good idea to consult with the future installer for what accommodations they would like to have the apparatus manufacturer provide to make their work easier.

A.7.12.5(4) If a vehicle data recorder (VDR) is provided, it should provide at least the following minimum capabilities:

- (1) The VDR should be capable of recording the data shown in Table A.7.12.5(4)(a) at least once per second.
- (2) Data should be stored at the sampling rate in a 48-hour loop.
- (3) Memory should be sufficient to record 100 engine hours' worth of minute-by-minute summary showing the data in Table A.7.12.5(4)(b).
- (4) When the memory capacity is reached, the system should erase the oldest data first.

All data stored in the VDR should be uploadable by the user to a computer or fire department management/engineering system via cable, Wi-Fi, data channel, cellular data, or other technology.

As a minimum, the user should have the capability to view the data as follows:

- (1) Raw second-by-second data over a specified data/time range
- (2) Daily log for the time the engine is running for a given date (minute-by-minute output of all values)
- (3) Weekly summary (i.e., maximum values each hour for each day of the week)
- (4) Monthly summary (i.e., maximum values each day for each day of the month)

A.7.12.5(5) V2X (vehicle to everything) communications provide information from a vehicle to other systems. This can include communications through dedicated short-range communications; cellular communications; WLAN; WiFi (in station); and, in the case of emergency vehicles, existing radio network data channels. Vehicles can communicate with other vehicles (V2V), infrastructure such as traffic signals and other fixed infrastructure (V2I), pedestrians (V2P), networks (V2N), devices such as smartphone apps or other portable devices (V2D), power grid (V2G), and other systems such as maintenance/engineering departments and other technologies. This is a rapidly growing and developing area of technology with almost unlimited possibilities to improve safety and efficiency. Purchasers need to research available equipment and capabilities, and then direct the contractor to provide the capabilities desired. There are many standards related to these communications, including NFPA 950.

Table A.7.12.5(4)(a) VDR Data

Data	Unit of Measure
Vehicle speed	mph
Acceleration (from speedometer)	mph/sec
Deceleration (from speedometer)	mph/sec
Engine speed	rpm
Engine speed control position	% of full speed control
Antilock braking system event	on/off
Seat occupied status	Occupied: Yes/No by position
Seat belt status	Buckled: Yes/No by position
Master optical warning device switch	on/off
Time	24-hour clock
Date	year/month/day

Table A.7.12.5(4)(b) VDR Summary Data

Data	Unit of Measure
Maximum vehicle speed	mph
Maximum acceleration (from speedometer)	mph/sec
Maximum deceleration (from speedometer)	mph/sec
Maximum engine speed	rpm
Maximum engine throttle position	% of full throttle
Antilock braking system event	on/off
Seat occupied with seat belt unbuckled	yes/no by position at 30 sec into minute
Master optical warning device switch	on/off at 30 sec into minute
Time	24-hour clock
Date	year/month/day

A.7.12.6 Departments might wish to consider a DAWS to help alert surrounding traffic to the presence of emergency vehicles. Refer to NFPA 950 for requirements on DAWS specifications.

A.7.13.1 The attachment of electric, air, hydraulic, and other control lines and hoses should be with removable mechanically attached fastening devices. The attachment of such equipment with adhesive or glue-on clamps or clips has been found to be inadequate for long-term performance on fire apparatus. The use of plastic ties to bundle wire harnesses and hose is permissible, but ties should not be used to attach such items to a cab, body, frame, or other major structure.

A.7.14.1 Several features and factors affect vehicle safety in a rollover.

Custom Fire Apparatus Cab. The nature of the custom fire apparatus cab makes it much stronger in rollover than typical conventional commercial chassis cabs. There is much anecdotal evidence to indicate that the crashworthiness of a typical custom fire apparatus cab is significantly greater than a typical commercial cab, and most custom chassis manufacturers can provide test data on cab integrity.

Lateral Acceleration Alert Device. There are both mechanical and electronic devices available that will measure the lateral acceleration of a vehicle. Although these devices will not prevent rollover, they can be used effectively as a driver training tool to indicate when the vehicle is approaching the roll threshold and as a reminder to the driver that excessive lateral acceleration can lead to a rollover event.

Side Roll Protection. Many custom fire apparatus manufacturers offer side air bags or curtains that inflate during a roll event and that are usually combined with seat belt pretensioning devices and suspension seat pull-down devices. This option can reduce injury during a rollover as long as the occupants are seated and belted.

Roll Stability Control. This technology electronically senses the lateral acceleration of the vehicle and takes action by depowering the engine and applying the brakes if the vehicle approaches a roll threshold. The effectiveness of this product is limited to events on relatively flat pavement, since it cannot do much to help the situation once a vehicle is off the road and leaning into a ditch.

Electronic Stability Control (ESC). ESC has been standard in passenger vehicles as of 2011. It helps drivers maintain control of their vehicle during extreme steering maneuvers by keeping the vehicle headed in the driver's intended direction, even when the vehicle nears or exceeds the limits of road traction. ESC has been added as a requirement to fire apparatus for those configurations where the technology is readily available. Before ESC can be offered on an apparatus, algorithms must be designed and the configuration must be tested to prove that it will work safely in all conditions. There are certain configurations in the fire service where the production volumes are so low that the major manufacturers of braking ESC systems cannot make a business case to develop it. In the case of tractor drawn aerials (TDAs), the algorithm would be so complex it is unlikely that ESC could ever be offered. The intent of the requirement in 7.14.1 is to require ESC on all apparatus where the technology is currently available. Configurations where the technology might not be commercially available include the following:

- (1) Apparatus with a driving front axle.
- (2) TDA apparatus
- (3) Apparatus with rear axle steering

Driver Skill and Experience. While the design and features of the vehicle are important to safe driving, the most important aspect of crash prevention is the skill and experience of the operator. The operator's attitude, training, experience, qualifications, and the application of those qualities are the most important elements in crash prevention. The operator must ensure that the physical limits of the vehicle are not exceeded. Driver skill is developed only through training and practice.

A.7.14.3.1(1) When a vehicle is on a tilt table, the point of instability is when the vehicle is "balanced" on the verge of rollover, and very little constraining force, if any, is required to restrain the vehicle. This can occur with the front wheels still in contact with the surface of the tilt table or with other wheels in contact with the surface of the tilt table.

A.7.14.4.1 The distribution of the weight between the front wheels and the rear wheels should be a major consideration, because improper design will seriously affect the handling characteristics of the fire apparatus. Too little weight on the front wheels can cause a front-end skid and, on bumpy roads, can cause the front of the fire apparatus to veer from side to side. At the very least, it would be difficult to keep the fire apparatus under control. Too much weight on the front wheels reduces the traction of the rear wheels and can result in a rear-end skid or difficulty in traveling over unpaved roads or in mud.

A.7.14.5.1 It is critical that the purchaser provide the manufacturer the equipment inventory and mounting locations for equipment on the apparatus. This information should include existing equipment and estimated future equipment to be carried. The projections of total equipment payload and mounting locations are essential for proper engineering of a new fire apparatus. It is the responsibility of the purchaser to properly load the fire apparatus and place equipment to comply with the GVWR, the front-to-rear weight distribution, and the right-to-left load balance requirements of this standard.

A.7.14.5.4 The projections of total equipment payload and mounting locations are essential for proper engineering of a new fire apparatus. The purchaser of the fire apparatus should

maintain the side-to-side loading requirement in 7.14.5.4 as equipment is loaded or installed on the apparatus.

The percentage difference in side-to-side tire load should be calculated as shown in the following formula:

[A.7.14.5.4]

$$\frac{(\text{heavier weight} - \text{lighter weight})}{\text{total weight}} \times 100 = \text{percent difference}$$

A.7.14.6 A frequent killer of firefighters is apparatus rollover. Proper tire inflation improves the handling characteristics and minimizes rollover.

A.7.15.1 The power generated by internal combustion engines can decrease with an increase in altitude. The loss varies with the type of engine, the fuel it uses, and the amount of air inlet supercharging. If the apparatus is going to be regularly used at elevations above 2000 ft (600 m), the manufacturer needs to know the operating elevation to provide an engine that will deliver proper performance. (See Section 7.4.)

A.7.15.2 Although the purchaser needs to specify grades in excess of 6 percent (see Section 7.4), the fire department should evaluate where the apparatus will be expected to operate in a stationary position on such grades. The occasional exposure to excessive grades while moving over roadways is different from prolonged stationary operations. Apparatus might require special lubrication systems for engines and other modifications to ensure the apparatus will not be damaged by operation on the increased grades.

A.7.15.3 The temperature conditions, either hot or cold, where the fire apparatus will be used or stored should be considered in the design of the vehicle. If the fire apparatus will be used in conditions that exceed 110°F (43°C), additional cooling of the engine, pump, and other components might be necessary. Likewise, if the apparatus is to be used or stored in subfreezing conditions, special system drains, engine heaters, pressure gauge protectors, or other components might be needed to prevent damage or to allow continued use.

A.7.16.1(2) Although this standard recognizes the need for the fire apparatus to be able to accelerate to a high speed while traveling on public roads, caution should be taken with regard to how fast the fire apparatus can travel.

Where fire apparatus has to operate off paved roads, all-wheel drive, a two-speed rear axle, an auxiliary transmission, an automatic transmission, or any combination of these might enhance the fire apparatus's off-road capability.

A.7.16.1(3) The purchaser should specify the performance required on grades in excess of 6 percent. The occasional exposure to excessive grades is different from an everyday occurrence. A combination of steep grades and narrow, winding roads might require consultation with manufacturers prior to finalizing the apparatus specifications and then the designation of special road tests. If the apparatus will be subjected to a class of service not normally encountered, a manufacturer cannot be expected to anticipate the need without sufficient specification details.

A.7.16.2 Special fire service tire ratings could apply that are different from the sidewall rating on the tire. The purchaser might want to consider requesting the tire manufacturer's

rating documentation. Fire service ratings are based on the assumption that the truck will never drive at this speed for more than 50 mi (80 km) (1 hour for some manufacturers) without stopping to cool the tires. If longer responses or trips are anticipated, the fire service ratings should not be used.

A.7.16.4 Where fire apparatus might have to operate off paved roads, all-wheel drive, a two-speed rear axle, an auxiliary transmission, an automatic transmission, or any combination thereof might enhance the fire apparatus's off-road capability.

A.7.17.1 Purchasers might want to specify that all routine lubricant and fluid level checks be performed from ground level to reduce the risks of injury from falling from apparatus.

A.7.18.5 The variations in the brake performance testing requirements reflect the differences between 49 CFR 571.105, "Hydraulic and Electric Brake Systems," and 49 CFR 571.121, "Air Brake Systems."

A.7.19.1 Where the point of delivery is over 2000 ft (600 m) of elevation, it is important to test the pump and pumping engine performance to ensure that the engine can develop adequate power at the point of delivery. This test can be performed with the pump supplied from a fire hydrant or at draft, with the discharge and net pressure maintained at rating for the pump. The net pressure (P) when the pump is supplied from a hydrant with positive intake pressure is the discharge gauge pressure (D) minus the intake gauge pressure (S).

A.7.19.2.1 Where the point of delivery is over 2000 ft (600 m) of elevation and a fire pump is provided, the pumping engine overload test described in 13.13.3 should be performed to ensure that the engine can develop adequate power at point of delivery. This test should be performed with the pump supplied from draft per Table 13.13.2.2.1.1, with the net pressure maintained at 165 psi (1100 kPa).

A.7.20 It is important for the purchaser and the contractor to agree on the format in which the documentation is to be delivered. It is also important that the purchaser consider the long-term ramifications of changing media technology if electronic format is used for delivery of the documentation. Software and hardware will need to be maintained over the years to utilize electronic documentation.

A.7.21.2.3(g) The equivalent circuit logic could be described in several ways. It might be shown as an equivalent schematic, a word-based description, or a table. In any case, it should define the relationship between input status and output status.

A.7.21.2.4 Suppliers of components and equipment installed or supplied by the contractor often supply operations and maintenance documents with those components or equipment. This standard requires that the contractor deliver these documents to the purchaser. The purchaser should specify if multiple copies of these documents are required.

A.7.21.2.9 The ability of an apparatus to ford water is dependent on a number of factors. One of these is the height of the engine air intake opening. This height can help the purchaser understand part of the apparatus's ability to operate in high water. Even this value must be considered carefully because the speed of travel as well as physical features around the opening will affect the fording ability. Other considerations include vents on axle differentials and engine crankcases as well as electrical equipment. If the purchaser intends to operate in high

water, it is recommended that they work with their apparatus manufacturer to ensure that other components that would be affected by water will be addressed, and that the apparatus can be manufactured to the desired water fording depth.

A.7.22 Specifications, standards, and vehicles have become more complex over time. Complexity, experience level, and lack of familiarity can make it difficult to know for certain if an apparatus, all its components, and the manufacturer of the component comply with all applicable NFPA standards. The fire department and/or purchasing agency might want to consider requiring the apparatus manufacturer to provide, from an independent third-party certification organization, a certification that the apparatus fully complies with all requirements of this standard or, alternatively, a statement of exceptions specifically describing each aspect of the completed apparatus that is not fully compliant with the requirements of this standard at the time of delivery.

A.8.1 Fire departments should carefully evaluate their water supply needs and the available water delivery systems when considering water tank size. The minimum tank size might not meet the needs of the department. Fire departments servicing areas with wide hydrant spacing or areas with no hydrants should strongly consider increasing the water tank size. The department should choose a water tank size that will best support efficient and effective fireground operations.

Additional compartmentation might be required to accommodate the size, shape, and weight of special equipment. Any special equipment to be carried on the apparatus should be identified in the specifications so the apparatus manufacturer can ensure the equipment will be properly accommodated within the design of the apparatus.

Hose storage areas are not required to be contiguous. The purchaser should consider arrangements for hose storage that will best support operational procedures. The purchaser should also consider specifying some type of cover for the hose compartment(s). Hinged or removable covers might be advantageous.

Departments should consider the addition of a sodium chloride fire extinguisher for use on combustible metal fires. Combustible metals, such as magnesium, can react violently with water and pose a hazard to personnel.

A.8.2 The fire department should study its needs for ground ladders, evaluating which ladders will be arriving at a fire scene with pumpers as well as aerial fire apparatus. Many communities have multiple three- and four-story buildings around which a power-operated aerial device cannot be positioned and that require longer or additional extension ladders to support fire-fighting operations. However, it should be recognized that as requirements for additional ground ladders are added, space for other equipment can become limited.

Where there are no ladder trucks in service, pumpers should normally be equipped with a 35 ft (10.7 m) extension ladder. It might be advantageous to standardize on the 35 ft (10.7 m) extension ladder, regardless of available ladder truck service. The purchaser should consider specifying an extension ladder length that will allow the ladder tip to extend a minimum of 2 ft (0.6 m) above or into a hazard area to be an accessible and visible emergency egress.

A.8.3 Apparatus of 500 gpm (2000 L/min) rated pump capacity or more normally require more than 300 ft (90 m) of

2½ in. (65 mm) hose to utilize their pumping capacity and their 2½ in. (65 mm) or larger discharge connections. For example, the 300 ft (90 m) load provides only 150 ft (45 m) lines from the two outlets of a 500 gpm (2000 L/min) apparatus. Experience has shown that, with large capacity pumps, 600 ft to 1000 ft (180 m to 300 m) of hose might be desirable to utilize the available pumping capacity. Additional hose capacity might also be desirable for pumps rated at less than 500 gpm (2000 L/min).

A.8.4 The recommended minimum equipment listed in this standard (e.g., nozzles, hose, ladders) might not meet the service needs of a community. It is recommended that the purchaser conduct a needs assessment to determine the appropriate level of equipment that should be carried on the apparatus. Additionally, the minimum level of equipment specified might not maximize a community's grading by the insurance rating authority. Individual fire departments should check with the insurance rating authority for their state or jurisdiction for information on what tools and equipment should be carried to maximize their community's grading.

FAMA TC018, *Fire Apparatus Equipment Weight and Cube Calculator*, is a free download available on the FAMA.org website. This is a spreadsheet tool listing hundreds of common pieces of equipment. The spreadsheet can be used to locate equipment in compartments and determine the final in-service axle weights. It is also a useful list of equipment the purchaser might wish to consider carrying on an apparatus.

Table A.8.4(a), Table A.8.4(b), and Table A.8.4(c) are lists of equipment by apparatus type for the purchaser to consider.

A.8.7 The purpose of a mobile water supply apparatus does not include attack firefighting. However, if a pump is provided, the provision of handlines will allow limited firefighting capability, particularly in protecting the apparatus if that becomes necessary.

A.8.8 If the aerial fire apparatus does not have a prepped waterway provided, the following equipment might be considered if water suppression from the aerial is desired:

- (1) Manual ladder pipe with 1½ in. (32 mm), 1⅝ in. (35 mm), and 1½ in. (38 mm) tips or electric ladder pipe with automatic nozzle that can be attached to the aerial ladder

- (2) Sufficient length(s) of 3 in. (75 mm) or larger attack hose complying with the requirements of NFPA 1961 to reach between the installed ladder pipe and the ground with at least 10 ft (3 m) of hose available on the ground with the ladder at full extension
- (3) One hose strap for each ladder section
- (4) Halyards to control the ladder pipe from ground level (for manual ladder pipe only)

A bracket for carrying the detachable ladder pipe should be both of the following:

- (1) Provided on the apparatus
- (2) Designed so that the ladder pipe clamps will not have to be readjusted to secure the pipe to the aerial ladder

The horizontal traverse of the detachable ladder pipe should not exceed the aerial ladder manufacturer's recommendations.

The ladder pipe should be capable of swiveling 135 degrees from a line parallel to the ladder and down.

If the purchaser wants extra length on the hose, a two- or three-inlet siamese, or a shutoff at the base of the ladder, these should be specified. The purchaser might also wish to specify a 500 gpm (2000 L/min) minimum spray nozzle.

The size of hose used to supply the ladder pipe will have been considered by the aerial ladder manufacturer in the design of the ladder. Use of larger size hose could overload the ladder with excessive weight and should be avoided until the aerial ladder manufacturer is consulted.

The hose should be fastened in a straight line up the middle of the aerial ladder. Hose straps not only secure the hose in place but take the strain off couplings and fittings that might otherwise fail and cause injury.

Where the purchaser wants pulleys and rope for vertical control of the stream from the turntable, the purchaser should specify these.

Table A.8.4(a) Equipment That Should Be Considered on Fire Apparatus

		Pumper	Initial Attack	Mobile Water Supply	Mobile Water Supply with Pump	Aerial	Quint	Special Service	Mobile Foam
Ground Ladders	Straight equipped with roof hooks	1	—	—	—	2	1	—	—
	Extension ladder	1	—	—	—	2	1	—	—
	Extension or combination ladder	—	1	—	—	—	—	—	—
	Folding ladder/stepladder/ multipurpose ladder	1	—	—	—	1	1	—	—
	Total ladder compliment — ft (m)	—	—	—	—	115 (35)	85 (26)	—	—
Hose	Suction hose — ft (m) or supply hose — ft (m)	20 (6)	20 (6)	—	20 (6)	—	20 (6)	—	20 (6)
		15 (4.5)	15 (4.5)	—	15 (4.5)	—	15 (4.5)	—	15 (4.5)
	Fire hose 2½ in. (65 mm) or larger — ft (m)	800 (240)	300 (90)	200 (60)	200 (60)	—	800 (240)	—	800 (240)
	Fire hose 1½ in. (38 mm), 1¾ in. (45 mm), or 2 in. (52 mm) — ft (m)	400 (120)	400 (120)	—	100 (30)	—	400 (120)	—	400 (120)
Nozzles	Handline nozzle, 200 gpm (750 L/min)	1	—	—	—	—	1	—	4
	Handline nozzle, 95 gpm (360 L/min)	2	2	—	1	—	2	—	2
	Smooth bore or combination nozzle with shutoff and with 2½ in. (65 mm) inlet that flows a minimum of 250 gpm (950 L/min)	1	—	—	—	—	—	—	—
	Playpipe with shutoff and 1 in. (25 mm), 1⅝ in. (29 mm), and 1¼ in. (32 mm) tips	—	—	—	—	—	1	—	—
	Monitor with nozzle preconnected and mounted on top of apparatus — gpm (L/min)	—	—	—	—	—	1	—	1000 (4000)
Demolition Tools	Flathead axe — 6 lb (2.7 kg)	1	—	—	—	2	1	—	—
	Pick head axe — 6 lb (2.7 kg)	1	1	—	—	3	1	—	1
	Pike pole or plaster hook — 6 ft (2 m) or larger	1	1	—	—	—	1	—	1
	Pike pole — 8 ft (2.4 m) or larger	1	—	—	—	4	1	—	—
	Plaster hooks with D handles — 3 ft to 4 ft (1 m to 1.2 m)	—	—	—	—	2	—	—	—
	Crowbar	—	—	—	—	2	—	—	—
	Claw tool	—	—	—	—	2	—	—	—
	Sledgehammer — 12 lb (5 kg)	—	—	—	—	2	—	—	—
Portable Lights	Hand lights	2	2	2	2	4	2	2	2
Fire Extinguisher	Dry chemical portable fire extinguisher 3A:40B:C rating	—	1	1	1	—	—	—	—
	Dry chemical portable fire extinguisher 4A:80B:C rating	1	—	—	—	1	1	1	1
	Water fire extinguisher — 2½ gal (9.5 L) or larger	1	1	—	—	1	1	1	—

(continues)

Table A.8.4(a) *Continued*

		Pumper	Initial Attack	Mobile Water Supply	Mobile Water Supply with Pump	Aerial	Quint	Special Service	Mobile Foam
SCBA	SCBA apparatus	4	2	—	—	4	4	2	4
	SCBA spare cylinder	4	2	—	—	4	4	2	4
Medical	First aid kit	1	1	1	1	1	1	1	1
	Automatic external defibrillator (AED)	1	1	1	1	1	1	1	1
Tools	Combination spanner wrench	4	2	2	2	4	4	—	4
	Hydrant wrench	2	1	1	1	—	2	—	2
	Double female 2½ in. (65 mm) adapter with national hose (NH) thread	1	1	1	1	—	1	—	1
	Double male 2½ in. (65 mm) adapter with national hose (NH) thread	1	1	1	1	—	1	—	1
	Rubber mallet, suitable for use on suction hose connections	1	1	—	1	—	1	—	1
	Scoop shovel	—	—	—	—	2	—	—	—
	Bolt cutter 24 in. (0.6 m)	—	—	—	—	1	—	—	—
Toolbox	Hacksaw with three blades	—	—	—	—	1	—	—	—
	Keyhole saw	—	—	—	—	1	—	—	—
	Pipe wrench — 12 in. (0.3 m)	—	—	—	—	1	—	—	—
	Pipe wrench — 24 in. (0.6 m)	—	—	—	—	1	—	—	—
	Ballpeen hammer	—	—	—	—	1	—	—	—
	Tin snips	—	—	—	—	1	—	—	—
	Pliers	—	—	—	—	1	—	—	—
	Lineman's pliers	—	—	—	—	1	—	—	—
	Screwdrivers — assorted types and sizes	—	—	—	—	1	—	—	—
	Adjustable wrenches — assorted	—	—	—	—	1	—	—	—
	Combination wrenches — assorted	—	—	—	—	1	—	—	—
Tarps	Salvage covers each a minimum size of 12 ft × 18 ft (3.7 m × 5.5 m)	2	—	—	—	6	4	—	—
Rope	Light — use life safety rope meeting the requirements of NFPA 2500 — ft (m)	—	—	—	—	150 (45)	150 (45)	—	—
	General — use life safety rope meeting the requirements of NFPA 2500 — ft (m)	—	—	—	—	150 (45)	150 (45)	—	—
	Utility rope having a breaking strength of at least 5000 lb (2300 kg) — ft (m)	—	—	—	—	150 (45)	—	—	—

Table A.8.4(b) Equipment that Should be Considered on Wildland Fire Apparatus

		Wildland Fire Suppression			Wildland Mobile Water Supply	Wildland Crew Carrier
		10,001–14,000 lb (4,501–6,350 kg)	14,001–26,000 lb (6,351–11,793 kg)	Over 26,000 lb (Over 11,793 kg)		
Fire Extinguisher	Dry chemical portable fire extinguisher 2A:10B:C rating	1	1	—	1	1
	Dry chemical portable fire extinguisher 3A:40B:C rating	—	—	1	—	—
Medical	First aid kit	1	1	1	1	1

A.8.10 Special service fire apparatus can be designed to provide a wide variety of support functions (e.g., rescue, command, hazardous material containment, air services, electrical generation and floodlighting, and transportation of support equipment and personnel). Because of this variety, the recommended list of equipment is minimal, and the purchaser needs to develop an appropriate equipment list based on a review of the functions and operations that the apparatus will be expected to support.

Equipment in the following list should be considered if the primary use of the apparatus is for hazardous material containment:

- (1) One copy of the current edition of the US DOT Emergency Response Guidebook
- (2) One copy of NFPA *Fire Protection Guide to Hazardous Materials* or equivalent reference guide
- (3) Two pairs of binoculars
- (4) One gas detection instrument that complies with OSHA standards
- (5) One radiation-monitoring instrument
- (6) One pH test kit
- (7) One colorimetric chemical detector tube kit with 20-chemical minimum detection capability
- (8) Six vapor-protective suits meeting the requirements of NFPA 1990
- (9) Twelve liquid-splash-protective suits meeting the requirements of NFPA 1990
- (10) Twenty-four pairs of disposable boot covers
- (11) Twenty-four pairs of disposable glove liners or inner gloves
- (12) Forty-eight pairs of disposable chemical protective gloves of three different materials as a minimum
- (13) Six additional SCBA complying with NFPA 1981
- (14) One spare SCBA cylinder for each SCBA
- (15) Ten traffic cones, 18 in. (0.5 m) minimum height
- (16) Four rolls 1000 ft × 3 in. (300 m × 76 mm) banner tape
- (17) Two rolls 6 mil (0.152 mm) minimum 10 ft × 100 ft (3 m × 30 m) plastic sheeting
- (18) Two rolls 2 in. (51 mm) wide duct tape
- (19) Two decontamination containment pools
- (20) One decontamination shower
- (21) Two 50 ft (15 m) lengths of heavy-duty garden hose with adapters for connection to a fire pump
- (22) Two spray nozzles with garden hose thread
- (23) Four 30 gal (100 L) open-top containers with sealed covers
- (24) Four long-handle scrub brushes
- (25) Twenty 50 gal (190 L) capacity heavy-duty garbage bags
- (26) One assortment decontamination solution
- (27) Four round-point shovels
- (28) Four portable explosionproof hand lights with mounting brackets
- (29) Four nonspark, plastic, square-point shovels
- (30) One 6 lb (2.7 kg) flathead axe or forcible entry tool
- (31) Two street brooms
- (32) Two floor squeegees with handles
- (33) One 6 lb (2.7 kg) sledgehammer
- (34) Two nonspark bung wrenches
- (35) One gas shutoff wrench
- (36) One pair 24 in. (0.6 m) bolt cutters
- (37) One drum upender
- (38) One nonspark 28 in. (0.7 m) crowbar
- (39) One plug and patch kit
- (40) One toolbox (wrenches, sockets, screwdrivers; minimum 100 units)
- (41) Six MC #306/DOT #406 dome clamps
- (42) 400 pads 18 in. × 18 in. × ⅜ in. (450 mm × 450 mm × 9.5 mm) hydrophobic polypropylene-type absorbents
- (43) 150 lb (68 kg) of dry granular or loose absorbent in ruptureproof 5 gal (19 L) containers that can be disposed of by approved methods
- (44) Four 10 ft (3 m) sorbent booms
- (45) 50 lb (22.7 kg) dry lime in ruptureproof 5 gal (19 L) containers
- (46) One manually operated product transfer pump with minimum 15 gpm (57 L/min) capacity and appropriate hose
- (47) One 55 gal (208 L) drum (UN—1A2)
- (48) One 85 gal (322 L) drum (UN—1A2)

Table A.8.4(c) Additional Equipment That Might Be Considered on Structural Fire Apparatus

		Pumper	Initial Attack	Mobile Water Supply	Aerial	Quint	Special Service
Cleaning Supplies	Brooms	—	—	—	4	4	—
	Deodorizer unit, power operated	—	—	—	1	1	—
	Mop wringers with buckets	—	—	—	2	2	—
	Mops	—	—	—	4	4	—
	Squeegees with handles	—	—	—	4	4	—
	Water pickup vacuum	—	—	—	1	1	—
Demolition Tools	Bale/mattress hooks	—	—	—	4	4	—
	Bolt cutter — insulated with $\frac{7}{16}$ in. (11 mm) minimum cut	1	1	1	1	1	1
	Crowbar	—	—	—	—	—	1
	Fire service claw tool	1	1	1	—	—	—
	Flathead axe — 6 lb (2.7 kg)	—	1	—	—	—	1
	Halligan-type tool	1	1	1	—	—	1
	Handsaws — assorted	—	—	—	4	4	4
	Log chain with hooks — 10 ft (3 m) and one 15 ft (4.5 m)	—	—	—	—	—	1
	Pick head axe — 6 lb (2.7 kg)	—	—	—	—	—	1
	Pike pole — 8 ft (2.4 m) or larger	—	1	—	—	—	—
	Pike pole or plaster hook — 6 ft (2 m) or larger	—	—	—	—	—	1
	Pike pole, nonconductive — 8 ft (2.4 m) or larger	—	—	—	—	—	1
	Power saw (chain or heavy-duty rotary type)	—	—	—	1	1	1
	Sledgehammer — 12 lb (5.4 kg)	—	—	—	—	—	2
	Thermal cutting unit designed for cutting metal	—	—	—	1	1	1
EMS	Blankets	—	—	—	2	2	2
	Resuscitator equipment with oxygen administration capability and spare cylinders, for cardiopulmonary resuscitation	—	—	—	—	—	1
	Stokes basket	—	—	—	1	1	1

(continues)

Table A.8.4(c) *Continued*

		Pumper	Initial Attack	Mobile Water Supply	Aerial	Quint	Special Service
Extrication	Air bags set for lifting	—	—	—	1	1	1
	Jack, hydraulic — 10 ton (9000 kg)	—	—	—	2	2	2
	Jack, hydraulic — 20 ton (18,000 kg)	—	—	—	2	2	2
	Pneumatic rescue cushion	—	—	—	1	1	—
	Portapower kit — 4-ton (3500 kg)	—	—	—	—	—	1
	Rescue-type tool with extension rams and assorted lengths of chain	—	—	—	1	1	1
	Shoring of various sizes and lengths	—	—	—	—	—	1
Fans	Smoke ejector	1	—	—	1	1	1
Foam	Foam delivery equipment compatible with onboard foam system, if any	1	1	—	—	—	—
Ground Ladders	Combination ladder a minimum of 14 ft (4.3 m) in length	—	—	—	1	1	—
	Extension ladder a minimum of 24 ft (7.3 m) in length	—	—	—	1	1	—
	Extension ladder a minimum of 35 ft (10.7 m) in length	—	—	—	1	1	—
	Folding ladder	—	1	—	—	—	—
	Folding ladder a minimum of 10 ft (3 m) in length	—	—	—	1	1	—
	Roof ladders (with folding roof hooks) a minimum of 16 ft (4.9 m) in length	—	—	—	2	2	—
Hose	Hose adapters for water supply connections in neighboring communities	1	1	—	—	—	—
	Hose clamp	1	1	—	—	—	—
	Hose straps	4	2	4	—	—	—
Plumbing Tools	Sprinkler head wrenches for the type of heads carried	—	—	—	1	1	—
	Water shutoff wrench	—	—	—	1	1	—
Portable Lights	Light, portable — 10,000 lumen	2	1	—	3	3	2
Power	2-wire to 3-wire adapters	—	—	—	3	3	—
	Cord reels or means to store and deploy the stated length of power cord — ft (m)	400 (120)	100 (30)	—	400 (120)	400 (120)	400 (120)
	Generator —portable 3000 W or larger (if the apparatus does not have a fixed line voltage power source)	1	1	—	1	1	1

(continues)

Table A.8.4(c) *Continued*

		Pumper	Initial Attack	Mobile Water Supply	Aerial	Quint	Special Service
PPE	Class I life safety harnesses meeting the requirements of NFPA 2500	—	—	—	—	—	2
	Lineman's gloves with leather glove protectors, pair	—	—	—	2	2	1
	Safety goggles	—	—	—	2	2	1
Pump	Low level strainer for use with portable pumps	—	—	1	—	—	—
	Portable pump	1	—	1	—	—	—
	Submersible-type pump	—	—	—	1	1	—
Roadside Safety	Illuminated traffic warning devices	—	—	—	—	—	12
	Road flares	—	—	—	—	—	48
Rope	Block and tackle	—	—	—	1	1	1
	General-use life safety rope meeting the requirements of NFPA 2500 — ft (m)	—	—	—	—	—	150 (45)
	Light-use life safety rope meeting the requirements of NFPA 2500 — ft (m)	—	—	—	—	—	150 (45)
	Line gun with ammunition	—	—	—	1	1	—
	Utility rope having a breaking strength of at least 5000 lb (2300 kg) — ft (m)	125 (38)	125 (38)	125 (38)	—	—	150 (45)
Supplies	Assorted rolls of tape (duct tape, electrical tape, cellophane tape, etc.)	—	—	—	1	1	1
	Plastic “emergency scene” or equivalent crowd control tape	—	—	—	—	—	500
	Sprinkler stops or wedges	—	—	—	6	6	—
	Standard sprinkler heads (assorted temperatures and types)	—	—	—	12	12	—
Tank	Portable tank — 1500 gal (6000 L) (minimum) collapsible	—	—	1	—	—	—
	Water transfer device to be used between portable tanks	—	—	1	—	—	—

(continues)

Table A.8.4(c) *Continued*

		Pumper	Initial Attack	Mobile Water Supply	Aerial	Quint	Special Service
Tarps	Floor runners, at least 3 ft × 18 ft (1 m × 5.5 m)	—	—	—	2	2	—
	Roll 15 lb (6.8 kg) tar paper or plastic sheeting at least 8 mil thick	—	—	—	1	1	1
	Salvage covers each a minimum size of 12 ft × 18 ft (3.7 m × 5.5 m)	—	—	—	4	4	—
	Salvage covers each a minimum size of 12 ft × 14 ft (3.7 m × 4.3 m)	—	—	—	—	—	2
Toolbox	Adjustable wrenches — assorted	—	—	—	—	—	1
	Ballpeen hammer	—	—	—	—	—	1
	Combination wrenches — assorted	—	—	—	—	—	1
	Hacksaw with three blades	—	—	—	—	—	1
	Keyhole saw	—	—	—	—	—	1
	Lineman's pliers	—	—	—	—	—	1
	Pipe wrench — 12 in. (0.3 m)	—	—	—	—	—	1
	Pipe wrench — 24 in. (0.6 m)	—	—	—	—	—	1
	Pliers	—	—	—	—	—	1
	Screwdrivers — assorted types and sizes	—	—	—	—	—	1
	Tin snips	—	—	—	—	—	1
Tools	Claw hammers, each with assorted nails	—	—	—	2	2	—
	Crowbar — 36 in. (1 m) or larger	1	1	1	—	—	—
	Four-tine forks	—	—	—	2	2	—
	Gas shutoff wrench	—	—	—	1	1	1
	Shovel — pointed blade	1	1	1	2	2	1
	Shovel — scoop blade	1	1	1	—	—	1
	Stapler, heavy-duty	—	—	—	1	1	—
	Toolbox with hammers, wrenches, screwdrivers, and other assorted tools	1	1	1	—	—	—
Valves	Hydrant valve with screw-type gate 2½ in. (65 mm)	1	1	1	—	—	—
	Master stream appliance, 1000 gpm (4000 L/min) minimum	1	—	—	—	—	—
	Wye — double-gated reducing leader type, sized to fit hose used in department	1	—	—	—	—	—

A.8.13 Mobile water supply fire apparatus are known as “tankers” in the eastern part of the U.S. and as “water tenders” in the western part of the U.S.

In wildland firefighting, two types of mobile water supply fire apparatus are used, “support” and “wildland.” Wildland mobile water supply fire apparatus are used for fire suppression activities. Support mobile water supply fire apparatus are typically contractor-owned construction equipment and are not used for fire suppression.

This standard covers the wildland mobile water supply fire apparatus.

A.8.15 Parking brakes on FMVSS-certified apparatus are only designed to hold on a 20 percent grade. If departments intend to park on grades greater than 20 percent, they should consider specifying wheel chocks with higher performance. Chock performance criteria are not meant to encourage parking on a grade greater than 20 percent. The practice of parking on a grade greater than 20 percent should be performed by a two-person crew, with the driver staying in the cab with a foot on the service brake pedal and the second crew member setting or removing the chocks.

A.9.1 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 a GVWR, which should not be exceeded by the apparatus manufacturer or by the purchaser after the vehicle has been placed in service. For tractor-drawn vehicles, the in-service weight of the apparatus should not exceed the GCWR. There are many factors that make up the GVWR, including the design of the springs or suspension system, the rated axle capacity, the rated tire and wheel loading, and the distribution of the weight between the front and rear wheels.

Water Tank. One of the most critical factors is the size of the water tank. Water weighs approximately 8.3 lb/gal (1 kg/L). A value of 10 lb/gal (1.2 kg/L) can be used when estimating the weight of the tank and its water, making a 500 gal (2000 L) tank and its water about 5000 lb (2400 kg).

Miscellaneous Equipment. If the finished apparatus is not to be overloaded, the purchaser should provide the contractor with the weight of equipment to be carried if it is in excess of the allowance specified in this standard.

Large Compartment Capacity. The manufacturer is obligated by this standard to provide only a miscellaneous equipment allowance in compliance with the minimum allowance listed in Table 9.1.2. Purchasers who specify vehicles with large compartment capacity should work closely with the vehicle manufacturer to ensure that the GVWR is sufficient to carry the intended equipment. A vehicle with average compartment loading will have a miscellaneous equipment weight of about 8 lb/ft³ (125 kg/m³) of compartment space available for miscellaneous equipment. A lightly loaded vehicle could have as little as 4 lb/ft³ (65 kg/m³). A heavily loaded vehicle can reach 12 lb/ft³ (200 kg/m³). This volume does not include space occupied by generators, reels, air systems, ladders, hose, and so forth, that are not in the miscellaneous equipment allowance. Total equipment weight varies significantly depending on the density of the equipment and how tightly the fire department chooses to pack it.

Overloading. Overloading of the vehicle by the manufacturer through design or by the purchaser adding a great deal of

equipment after the vehicle is in service will materially reduce the life of the vehicle and will undoubtedly result in increased maintenance costs, particularly with respect to the springs, tires, axles, transmissions, clutches, and brakes. Overloading can also seriously affect handling characteristics, making steering particularly difficult.

Underloading. Brake equipment on heavy vehicles can be sensitive to the weight distribution of the vehicle. Specifying a GVWR significantly greater than the estimated in-service weight can lead to poor brake performance, chatter, and squeal. Purchasers who specify configurations with limited compartment volume on a high capacity chassis should consult the manufacturer to ensure that a vehicle with an underloaded condition will not result.

Purchaser Responsibility. The purchaser should specify the weight of the equipment to be carried if it is in excess of the allowance for miscellaneous equipment. This weight specification allows a chassis with an adequate GAWR and GVWR to be supplied. Specific additional equipment is often necessary to meet the operational requirements of the department. For example, on a wildland fire suppression apparatus this might include additional hose, chain saws, rations, tow chains, drinking water containers, ice chests, additional hand tools, and additional containers of foam concentrate.

Severe Service. Fire apparatus have to be able to perform their intended service under adverse conditions that might require operation off paved streets or roads. Chassis components should be selected with the rigors of service in mind.

Off Road Use. If the apparatus is designed for off-road use, it is recommended that the apparatus, when loaded to its estimated in-service weight, should not exceed 80 percent of the chassis GVWR. In addition, the axle loads should not exceed 80 percent of the appropriate GAWR. If the vehicle chassis manufacturer certifies the GVWR and GAWR for 50 percent minimum off-road use, the full weight ratings can be utilized.

A.9.1.2(4) The 250 lb (114 kg) per person used here does not include the weight of SCBA and tools carried by a firefighter, because the weight of this equipment is accounted for elsewhere.

Agencies might want to also consider the weight of personal gear when the apparatus could be used for responses of anticipated long duration, such as wildland fire responses, where the crew must take their personal gear with them.

A.9.1.2(5) If the purchaser or dealer will be installing generators, reels, air systems, or other fixed equipment, the purchaser should notify the manufacturer, and allowance for this weight should be provided by the manufacturer in addition to the miscellaneous equipment allowance.

A.9.1.2(7) The miscellaneous equipment allowances for wildland fire apparatus are minimum values based on the minimum compartment volume requirements. These values should be adequate for many volunteer departments responding to individual incidents that are suppressed in less than a 12-hour period. Those departments or agencies that send crews out for days or weeks at a time will likely need more carrying capacity both by weight and by volume. Apparatus that will be used in this manner should be specified accordingly. The ratio of 100 lb (45 kg) of weight capacity for each 10 ft³ (0.28 m³) of compartment volume can be used as a conservative approach when configuring individual apparatus.

A.9.1.2(8) Wildland fire apparatus are not required to carry SCBA units. However, if the purchaser intends to carry SCBA units, accommodations need to be made for them and their weight included in the miscellaneous equipment allowance. The purchaser needs to work with the manufacturer on where the units will be carried, whether in seat backs or in compartments, and how they will be mounted.

A.9.1.4 Final-stage manufacturers of motor vehicles are required to affix certification labels or tags to all motor vehicles sold in the U.S., stating that the vehicle meets all applicable Federal Motor Vehicle Safety Standards (49 CFR 571) and Federal Theft Prevention Standards (49 CFR 541). The location for affixing the certification label on the motor vehicle is a requirement of the federal standard requiring this label. See 49 CFR 567, "Certification," for more information.

A.9.1.5.1 It is important for fire apparatus drivers to understand the height, length, and weight of the vehicle compared to their personally owned vehicles. It is also important that this information be accurate. Because the height of the apparatus could change after delivery, depending on what equipment might be added, the fire department should note such changes on the label. Suggested wording for the label is shown in Figure A.9.1.5.1.

A.9.2.1.2.1 An increase in engine speed provides increased alternator output, increased engine cooling, increased air conditioner output, and increased output or performance from other devices that derive their power from the chassis engine.

The purpose of the interlock is to ensure that the chassis engine speed cannot be advanced without disengaging the driving wheels of the apparatus either at the transmission (having it in park or neutral) or by having a split shaft PTO fully engaged in the correct position to drive the component.

A.9.2.3(5) Tire cold pressure should be based on the tire manufacturer's load and inflation tables for the load to be carried and the rim pressure rating, not necessarily the maximum load at maximum pressure listed on the tire sidewall.

A.9.2.3(6) Tire cold pressure should be based on the tire manufacturer's load and inflation tables for the load to be carried and the rim pressure rating, not necessarily the maximum load at maximum pressure listed on the tire sidewall.

A.9.2.4 On a diesel engine, a manual emergency engine shutdown might be provided in addition to the normal engine shutdown switch. It could be of the type that will close off either the air supply or the exhaust gas flow of the engine. The activation mechanism should be provided with a guard and marked with a sign that reads "Emergency Shutdown." Provisions to prevent restarting of the engine without a special reset procedure should be included.

When manufactured, this vehicle was: XX ft YY in. high XX ft YY in. long ZZZZ tons GVWR Changes in height since the apparatus was manufactured shall be noted on this label by the fire department.
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FIGURE A.9.1.5.1 Suggested Label Showing Dimensions of Fire Apparatus.

A.9.2.4.1 The extent to which air inlet protection is required could depend on specific fire department operations. Departments operating in ember-rich environments, such as wildland fires, should consider specifying a multiscreen ember separator capable of meeting the test requirements defined in FAMA TC079, *Ember Separator Test*. Purchasers of apparatus utilizing commercial chassis should be aware that ember separators capable of meeting these test requirements might have a screen and housing externally mounted on or around the commercial chassis hood or bumper extension.

A.9.2.6.5.3 The purchaser might wish to specify a means of instruction available to the driver on how to perform a manual regeneration and to temporarily inhibit active regeneration. The purchaser might wish to specify a separate lighting cluster other than the universal symbol dashboard indicator lights to help the operator determine the DPF issue or reason for the alarm concerning the following:

- (1) Regeneration required
- (2) High exhaust system temperature (HEST)
- (3) Low diesel exhaust fluid (DEF)

The DPF regeneration inhibit switch allows the operator to keep the DPF from regenerating during times when the apparatus is operating in an environment where extremely hot exhaust gas would be a hazard.

The inhibit function must be used carefully. Repeated use of the inhibit function can lead to soot buildup. Excessive buildup of soot can produce an uncontrolled burn inside the DPF, causing significant vehicle damage and dangerous exhaust temperatures. Watch the DPF indicator and provide opportunity to regenerate the DPF soon after using the inhibit function.

A.9.2.6.5.4 Exhaust temperature while the DPF is actively regenerating can reach 900°F to 1300°F (480°C to 704°C). The purchaser should be aware that these temperatures are much higher than normal engine idle exhaust temperatures. Those fire departments that employ in-station exhaust venting equipment while performing DPF regeneration should consult their vent supplier to ensure that the vent system will handle any potential DPF active regeneration event or perform the regeneration outside while not connected to exhaust venting equipment.

Exhaust system temperature mitigation devices might be required to meet the temperature requirement. Exhaust temperature mitigation devices might be affected by the addition of adapters commonly used to hook up to exhaust extraction equipment. The purchaser should ensure that this adaptation is certified by the manufacturer/installer of the adapter that it will not adversely affect the performance of the device.

Exhaust gas temperatures that meet this standard can ignite fine fuels, especially if a stationary DPF regeneration process is used. Exhaust system surface temperatures will exceed this requirement during a DPF regeneration and can ignite fuels that are under the apparatus or caught on the underside of the apparatus. A site away from potential fuel sources should be selected for a stationary DPF regeneration.

A.9.3.1.3.3 If an onboard automatic electric compressor is provided, it might be low-voltage driven or line-voltage driven. If it is low-voltage driven, it is important that the required battery conditioner or charger be utilized. The shoreline recep-

tacle might be a manual-disconnect-type receptacle or an automatic-ejection-type receptacle.

A.9.3.1.4 Purchasers of fire apparatus with a GVWR less than 36,000 lb (16,300 kg) should also consider equipping the apparatus with an auxiliary braking system. Fire apparatus commonly make repeated stops from high speeds that cause rapid brake lining wear and brake fade, sometimes leading to accidents.

Auxiliary braking systems are recommended on apparatus that are exposed regularly to steep or long grades, operate in congested areas where repeated stops are normal, or respond to a high number of emergencies.

Examples of auxiliary braking systems include engine retarders, transmission retarders, exhaust retarders, and driveline retarders. These devices have various levels of effectiveness on braking. In addition, the systems can be activated by various means and settings, both automatic and manual in operation. The purchaser should carefully evaluate all auxiliary braking systems based on vehicle weight, terrain, duty cycle, and many other factors.

Some auxiliary braking devices should be disconnected when the apparatus is operated on slippery surfaces. Follow the auxiliary braking device manufacturer's recommendations for proper instructions.

A.9.3.2.1 Fire departments with vehicles that could be subject to continuous long-distance driving need to specify tire rating for continuous operation in place of intermittent operation.

A.9.3.2.2 Special fire service tire ratings could apply that are different from the sidewall rating on the tire. The purchaser might want to consider requesting the tire manufacturer's rating documentation. Fire service ratings are based on the assumption that the truck will never drive at this speed for more than 50 mi (80 km) (or 1 hour for some manufacturers) without stopping to cool the tires. If longer responses or trips are anticipated, the fire service ratings should not be used.

A.9.3.2.4 The angle of approach or departure affects the road clearance of the vehicle going over short steep grades such as would be found in a driveway entrance, crossing a high crowned road at a right angle, or off-road service. Too low an angle of approach or departure will result in the apparatus scraping the ground. Figure A.9.3.2.4 shows the method of determining the angle of departure. The angle of approach (front of vehicle) is measured in the same fashion.

In Figure A.9.3.2.4, the line AT represents the circumstance in which the tailboard is the determining lowest point. The line BT represents a circumstance in which the tailboard is not the lowest point (in this case, the lowest point is a fuel tank). The angle of departure is shown as XA or XB . To determine the angle of departure, place a thin steel strip against the rear of the tires where they touch the ground or stretch a string tight from one rear tire to the other at the rear of where they touch the ground. Determine the lowest point (the tailboard, fuel tank, or other equipment or component) that would make the smallest angle of departure. Hang a plumb bob from the lowest point and mark the point on the ground where the point of the plumb bob touches. Measure the vertical distance from the ground to the point where the plumb bob was hung (distance V). Measure the horizontal distance from the plumb bob point to the front of the steel strip or to the string running from rear tire to rear tire (distance H). Divide the vertical distance (V) by

the horizontal distance (H). The ratio of V/H is the tangent of the angle of departure. If this ratio is known, the angle of departure can be determined from a table of trigonometric functions of angles or from a math calculator. The standard requires a minimum angle of departure of 8 degrees; since the tangent of 8 degrees is 0.1405, if V divided by H is 0.1405 or larger, the angle of departure is 8 degrees or greater.

A.9.3.3.3 The purchaser can consider adding a device that will shift the transfer case from all-wheel drive back to standard 4×2 or 6×4 drive when the vehicle speed exceeds the manufacturer's recommended maximum speed for all-wheel drive operations.

A.9.3.4.1 Fire apparatus range, either for pumping, or for driving, should be determined based on the expected duty cycle. Consult run logs for the apparatus being replaced or for apparatus in a similar response area to determine the desired range. Where a large-capacity fuel tank is desired, as in the case of apparatus designed for rural service, the capacity should be specified by the purchaser.

A.9.3.5 If the purchaser wants the hooks or rings to be accessible without compartment doors having to be opened, the specifications should state that fact.

A.10.1 This chapter defines the requirements for alternators, batteries, load management, and instrumentation to detect incipient electrical system failure. The intent is to require an electrical system that will operate the apparatus using power supplied by the alternator, shed nonessential electrical loads where necessary, and provide early warning of electrical failure in time to permit corrective action.

A.10.2.1 The 125 percent requirement for wiring and circuits is intended to provide reduced voltage drop over wire rated based on ampacity due to heating. In low voltage wiring, voltage drop becomes a problem before the thermal limit of current carrying capacity of a wire is reached. This requirement also ensures that the circuit protection will prevent damage to the wire in the event of a short or an overload. It is not the intent of this requirement to have the final-stage manufacturer replace the chassis manufacturer's original equipment wiring to meet the 125 percent requirement. It is also not the intent of this requirement to have electrical accessories purchased by the apparatus manufacturer rewired to meet the 125 percent requirement. Electrical device manufacturer-supplied wiring

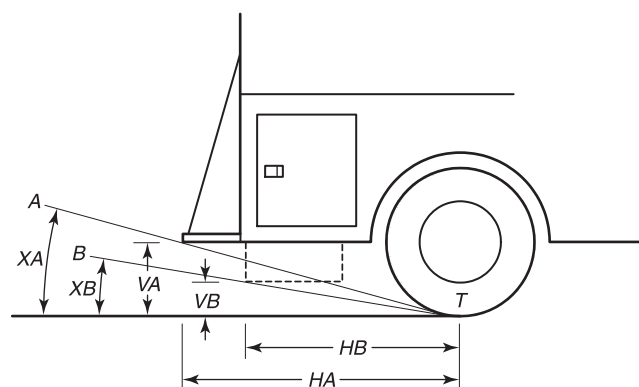


FIGURE A.9.3.2.4 Dimensions for Determining Angle of Departure.

can be used to the point where it connects to the apparatus manufacturer's installed wiring.

A.10.2.4.2 If the terminals are accessed only during normal maintenance operations, they are considered protected.

Good engineering practices should be followed to ensure that electrical connections and components are protected from physical and environmental damage.

A.10.2.6 It is the intent of 10.2.6 to provide a unique means of identifying a wire or circuit to prevent confusing it with another wire or circuit if electrical system repairs become necessary. If a color coding scheme is used instead of some other unique identification, that color should not be reused for a wire in any unrelated circuits within the same harness. However, 10.2.6 covers low voltage wiring only and does not apply to shielded cables commonly used for communication purposes or wiring used in line voltage circuits.

A.10.3.1 A diesel/electric hybrid power plant typically does not have an alternator. The low-voltage electrical system is charged with a dc-to-dc converter from the high-voltage battery system. This provides the same functionality as an alternator driven by a diesel prime mover. The diesel engine is not always running, but the high-voltage battery system and dc-to-dc converter are always available to keep the low-voltage electrical system charged.

A.10.3.2 When that load is exceeded and larger means of charging are not available, the purchaser and the manufacturer need to work together to determine how to reduce the minimum continuous electrical load to one that can be sustained under the conditions defined in 10.3.2.

The minimum charging system size is developed using the loads required to meet the minimum continuous electrical load. Most apparatus will actually have loads exceeding the minimum requirements of this standard. The purchaser should review the maximum current output of the alternator versus the load study supplied for the apparatus from the manufacturer for on-scene and responding modes.

A.10.3.3.1(8) The purchaser should analyze the electrical loads that need to be maintained to fulfill the mission of the apparatus and define those loads for the manufacturer of the apparatus. The purchaser needs to understand, however, that there is a limit to the output capacity of an alternator system on the apparatus's engine and that this standard requires that the apparatus be capable of maintaining the minimum continuous electrical load under the conditions defined in 10.3.2.

A.10.3.4 The unexpected shutdown of a fire apparatus at a fire can place firefighters in mortal danger and seriously affect the fire attack. With computer-controlled engines and transmissions as well as electric valves and other controls, an electrical system failure could result in an immediate and total shutdown of the apparatus. The low voltage monitoring system is intended to provide an early warning of an impending electrical failure and provide enough time to permit operator intervention.

A.10.3.6.1 Reduced crew sizes have forced the apparatus operator to assume many new fireground tasks in addition to that of operating an apparatus. Even if the operator is at the apparatus, he or she is too busy with higher priority tasks to pay much attention to monitoring the condition of the electrical system.

Electrical loads on modern fire apparatus frequently exceed the alternator capacity and can be supplied only by the deep

discharge of the apparatus batteries. The high-cycle batteries that are designed to provide the large amount of amperage to crank modern diesel engines are severely damaged when deeply discharged. The automatic load management is intended to protect the electrical system from needless damage while maintaining the operation of essential devices.

It is important that the priority of all managed loads be specified by the purchaser so that, as electrical loads are disconnected from the apparatus's electrical systems, they are shed in an order least likely to affect emergency operations. The optical warning devices in excess of the minimum required in this standard can and should be load managed.

A.10.4 Low voltage batteries on fire apparatus should be larger than those used on commercial vehicles because, in addition to starting the vehicle, they need to provide the supplemental energy to power high-amperage, intermittent operation devices such as mechanical sirens and electric rewind hose reels.

Low voltage batteries usually have two ratings: "cold cranking amperes," which determine the size engine that can be started, and "reserve capacity," which provides a measure of the total power that can be provided at a much lower constant rate of discharge. Fire apparatus batteries should be sized to have enough cold cranking amperage and reserve capacity to restart the engine after being substantially discharged.

The apparatus will include a major-load disconnect switch to allow the operator to disconnect many of the low voltage apparatus loads when the apparatus is not in use. This is useful to avoid the risk of draining the low voltage batteries if the apparatus develops an electrical short circuit or other device failure. The major load disconnect switch will likely not disconnect all the electrical loads since many electronic devices on the apparatus require constant power to maintain data, or to allow fast start-up from a sleep mode when they are required. Some apparatus could also include a sequential switching device(s) used to minimize the load placed on the electrical system during apparatus startup.

It is normally obvious that the major load disconnect switch is ON because there will often be lights, buzzers, or other clues that the apparatus is energized. If department policy does not keep the apparatus plugged into a charger, consider specifying an indicator light(s) visible to the driver inside the cab, or on the outside of the apparatus, or both to warn that the master disconnect is ON when the apparatus is parked in the fire station.

A.10.4.4.4 Overheating of a low voltage battery will cause rapid deterioration and early failure; evaporation of the water in the battery electrolyte can also be expected.

A.10.4.5 The power cord from the onboard low voltage charger or battery conditioner should be plugged only into a receptacle protected by a ground-fault circuit interrupter (GFCI) at the shoreline origination point.

A.10.6 SAE J551/1 provides test procedures and recommended levels to assist engineers in the control of broadband electromagnetic radiation and in the control of radio interference resulting from equipment installed on the apparatus. Adherence to the recommended levels will minimize the degradation effects of potential interference sources on fireground communication equipment or other devices susceptible to electromagnetic interference.

Procedures are included to measure the radiation from a single device or the entire apparatus. Compliance could be determined through actual tests on the completed apparatus or predictions based on tests previously conducted on similarly equipped apparatus. If compliance certification is required, it should be so indicated in the apparatus specifications.

A.10.7.2 The upper-level optical warning devices provide warning at a distance from the apparatus, and the lower-level optical warning devices provide warning in close proximity to the apparatus. (See Figure A.10.7.2.)

A.10.7.4.2 Figure 10.7.4.2, and the warning zone descriptions, refer to the direction of the projection of light from lighting devices for measuring optical performance. They do not refer to the physical mounting locations of optical warning devices. A physical light source, no matter where it is mounted, can contribute light in one or more zones if not blocked by the apparatus or equipment. A single light can even provide light in all four zones, particularly on small apparatus.

A.10.7.4.4 System compliance is achieved when each individual zone is documented as compliant. Compliance for all eight zones can be established from one lighting manufacturer or multiple lighting manufacturers. When the optical warning devices for all zones are from one manufacturer, system compliance documentation should be provided by that manufacturer. When the optical warning devices are from more than one manufacturer, system compliance documentation should be provided by the manufacturer specific to that zone. The following are examples:

- (1) All lights could be from one lighting manufacturer.
- (2) All upper lights could be from one lighting manufacturer and all lower lights could be from another lighting manufacturer.
- (3) All front lights (upper and lower) could be from one lighting manufacturer, all side lights (upper and lower) could be from a second lighting manufacturer, and all rear lights (upper and lower) could be from a third lighting manufacturer.

A.10.7.6 The operator should be able to quickly activate all the emergency warning lights with a single switch. This should not prevent other means in activating or deactivating individual warning lights, based on a specific situation or function.

Under typical conditions, the specified optical warning system provides effective, balanced warning. In some situations, however, the safety of the apparatus can be increased by turning off some warning devices. For example, if other vehicles need to pass within close proximity to the parked apparatus, the possibility of distracting other drivers can be reduced if the

headlights and lower-level warning lights are turned off. In snow or fog, it might be desirable to turn off forward-facing warning lights to reduce visual disorientation of the apparatus driver.

The intent of the warning light system is to provide full coverage signal through the operation of a single master switch when the apparatus is either responding or blocking the right-of-way. There is no intent to prevent the reduction of optical power of the warning devices when the apparatus driver believes such reductions are appropriate, given the vehicle's mission, the weather, or other operational factors. Additional switches downstream of the master switch can be specified by the purchaser to control individual devices or groups of devices.

Purchasers might want to specify traffic-flow-type lighting such as amber directional indicators for use in alerting approaching motorists of blocked or partially blocked highways.

A.10.7.7 The purchaser might want to consider additional mode(s), through manual or automatic means, adjusting the optical signaling characteristics to create greater conspicuity.

The introduction of LED warning lights has created brighter and more dynamic emergency warning signals with greater functionality than traditional halogen and strobe lighting. These brighter warning lights also have increased the concern for potential optical distraction.

Lighting manufacturers are increasingly offering new methods and technology that can alter optical signaling characteristics in various modes of operation to reduce potential optical obstruction and alert surrounding drivers of the actions being performed by the emergency apparatus.

The following are some examples of different modes and optical characteristic changes:

- (1) Mode changes:
 - (a) Braking or slowing down
 - (b) Daytime and nighttime operations
 - (c) Specific function of apparatus such as pumping or aerial use
 - (d) Speed increase of the apparatus
- (2) Optical characteristic changes:
 - (a) Slowing the flash rates
 - (b) Using complex flash patterns through the combination of multiple flash patterns or non-flashing optical devices
 - (c) Single flash rather than a train of flashes
 - (d) Synchronizing the lights
 - (e) Outlining the vehicle by marking corners with simultaneous flashes on both sides
 - (f) Reducing the light intensity at night to reduce potential optical distraction
 - (g) Altering the colors to more amber from red/blue to convey more of a caution message rather than an emergency message

A.10.7.10 Warning lights mounted close to headlights are less visible to other drivers because of glare from the headlights. Warning lights mounted close to turn signals, clearance lights, and brake lights can make those lights less visible for the same reason. The purchaser and apparatus designer should consider

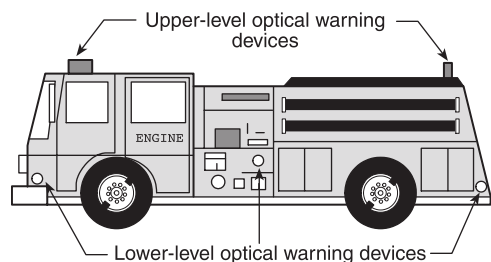


FIGURE A.10.7.2 Upper- and Lower-Level Optical Warning Devices.

these factors in determining the locations for emergency warning lights.

A.10.7.11 When a component such as a flasher or power supply is used to operate more than one optical source, the optical sources should be connected so that the failure of this component does not create a zone without a warning signal either from the upper or lower level. Although a single optical source can be used to provide warning signals into more than one zone, the possibility of a total signal failure at a measurement point is increased when the same flasher or power supply is used to operate multiple optical sources, each providing signals into more than one zone.

A.10.7.14 The minimum optical warning system should require no more than an average of 40 A for the operation of the upper-level and lower-level devices in the blocking mode. On apparatus whose length requires midship lights, no more than 5 A of additional current should be required for the operation of each set of midship lights. Optical warning systems drawing more than 40 A might necessitate modification of the electrical system specified in Section 10.3 to supply the additional power required.

See Figure A.10.7.14(a) and Figure A.10.7.14(b) for illustrations of an optical warning system on a large fire apparatus.

A.10.7.14.5 The zone totals reflect the combined performance of the individual optical warning devices oriented as intended on the apparatus when viewed along the perimeter of

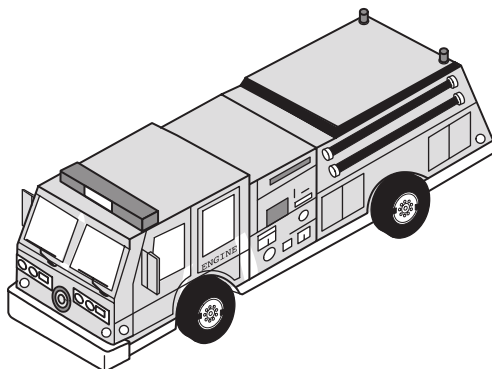


FIGURE A.10.7.14(a) Front and Left Side of an Apparatus with an Optical Warning System.

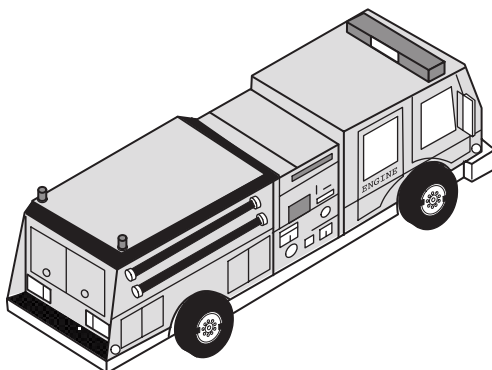


FIGURE A.10.7.14(b) Rear and Right Side of an Apparatus with an Optical Warning System.

a circle of 100 ft (30.5 m) radius from the geometric center of the apparatus.

The zone total is the sum of the optical power of all optical sources projecting signals of permissible color into the zone as measured at 5 degree increments along the horizontal plane passing through the optical center H throughout the 90 degrees included in the zone (19 data points). The calculation of zone totals assumes that all optical sources are mounted at the geometric center of the apparatus. With the optical center of each optical source oriented as installed, the optical power contributed by every optical source at a given point is taken from the test report, and they are added together to determine the total optical power at that point. The zone total is the sum of the optical power at the 19 measurement points in the zone. The upper- and lower-level optical sources are calculated independently.

The engineering basis of Section 13.6 permits both the design and the certification of an optical warning system by mathematical combination of the individual test reports for any number of optical warning devices of different color, flash rate, optical source, and manufacturer.

Using the test reports provided by the device manufacturer, the contribution of optical energy from each optical source is determined for every data point. The total candela-seconds per minute of optical energy is determined at each point, and then the zone totals are calculated and compared to Table 10.7.14.5.

A.10.7.15 The minimum optical warning system should require no more than an average of 35 A for the operation of the devices in the blocking mode.

A.10.7.15.2.2 Small vehicles configurations come in many body configurations. Some allow for convenient mounting of independent upper rear beacons, and some do not. An example would be a pick-up truck with a slide in skid unit. Given the size and geometric mounting parameters of a small vehicle, a single lightbar with 360 degrees of conspicuity will have comparable optical characteristics as a lightbar with front and side signal only in combination with rear beacons.

A.10.7.17 In the certification of lighting systems, either generic or specific configurations, the optical power in each zone is calculated assuming all optical warning devices are mounted at the geometric center of the apparatus and oriented as they will be mounted on the apparatus. No adjustments are made for variable distances and angles due to displacements from the geometric center to the actual mounting location.

The standard defines performance requirements for a complete optical warning system consisting of multiple lights and the associated control components. Measuring this performance for the assembled and installed system is not practicable. As a result, the certification is based on a mathematical model assuming all lights are mounted at the geometric center of the vehicle. If all the components are from a single manufacturer, typically the optical warning system manufacturer certifies that the system will meet the requirements. If components come from multiple manufacturers, typically the apparatus manufacturer uses data from the lighting manufacturer to combine the data from each device to produce a mathematical combination representing the entire system, and then certifies that these totals meet the requirements for the complete system as specified. In either case, the apparatus manufacturer

certifies that the devices are installed within the parameters specified by the device manufacturer.

Each optical warning device used should be certified by its manufacturer as conforming to all the requirements of this standard pertaining to mechanical and environmental testing. Photometric testing of the components of the system should be performed by qualified personnel in a laboratory for such optical measurements.

The system total optical power for any optical measurement point is the sum of the values for each device contributing optical power to that point based on how the device is oriented. The zone total is the sum of the optical power at the 19 measurement points in the zone. The endpoints of the 19 are counted twice in adjacent zones.

A.10.8.1.2 If the purchaser wishes to have the siren controls within convenient reach of persons riding in both the right and left front seat positions, that should be specified. In some apparatus, multiple control switches might be necessary to achieve convenient reach from the two positions. If other signal devices, such as an additional siren, bell, air horn(s), or buzzer are desired, the type of device and its control location also should be specified.

A.10.9 Wildland fire apparatus have minimal requirements for work lighting in the standard. Depending on how the fire apparatus will be used, the purchaser might want to call for ground lighting, hose bed lighting, work surface and step lighting, interior lighting, or compartment lighting. The purchaser should specify where lights are desired and what level of performance is desired. For many of these lights, there is a problem with mounting them in a way that they will not be damaged by brush, equipment, or vibration.

A.10.9.1.1 The purchaser might want to specify work area (scene) lighting along the side of the vehicle. This can be provided by low voltage or line voltage lighting.

A.10.9.2 The hose bed lighting can be line voltage lighting provided by mounted line voltage lights that can be directed to provide the required light. The intent of the standard is to provide lighting for personnel unloading or packing hose in the hose bed. Each department requests varying configurations of hose bed divider, and many are adjustable and/or removable. It would be impracticable to provide lighting that would illuminate every corner of the hose bed with dividers installed.

A.10.9.3 Lighting should be directed at working surfaces, steps, and walkways. Backlighting can create shadow areas and glare to the user in low ambient light conditions and does not meet the requirement of the standard.

A.10.9.4 The user may want to consider a map light or additional task lighting in the cab. For the purposes of illumination, interior driving or crew compartment seating are those designated seating positions provided with seat belts. Other seating areas that would be used with the vehicle stationary will typically have work lighting specified by the purchaser depending on the work being performed. Minimum lighting levels in these cases will be subject to the purchaser's specification.

A.10.9.9 LED lights tend to lose light output as they heat up. Proper design and mounting can minimize this effect. The drop will generally be uniform across the light field, so testing light output at a single point from initial turn-on with the light

at room temperature to thermal steady-state, which takes about one hour, is sufficient to determine the drop.

A.10.9.10 Scene lights should generally be mounted as high as possible, both for better coverage and to avoid producing glare toward firefighters and nearby vehicle drivers. Lights should be spaced away from warning lights to avoid drowning out warning lights.

A.10.9.10.2 Wildland fire apparatus have minimal requirements for work lighting in the standard. Depending on how the fire apparatus will be used, the purchaser might want to call for ground lighting, hose bed lighting, work surface and step lighting, interior lighting, or compartment lighting. The purchaser should specify where lights are desired and what level of performance is desired. For many of these lights, there is a problem with mounting them in a way that they will not be damaged by brush, equipment, or vibration.

A.10.9.10.2.1 The handle might be on the base of a push-up pole or an electric remote control.

A.10.10.3 Manually operated floodlights on telescoping poles are not required to be tied into the hazard light in the driving compartment. If the purchaser wishes that these devices be tied into the hazard light or otherwise equipped with an indicator to warn the operator the floodlights are in the up position, that should be specified in the purchase specification.

A.10.11 The purchaser might wish to add camera(s) at the sides or rear of a vehicle with cab monitoring screens or automatic vehicle-stopping devices that sense an obstruction at the rear of the vehicle. In addition, angled backup lights mounted in the wheel well areas will provide additional scene lighting for personnel who might be at the side of the vehicle or lighting of folding tanks or other obstacles on the side of the apparatus. Any such devices will improve safety while vehicles are backing.

A.10.13.1 The purchaser might wish to have the entire low voltage electrical system and warning device system certified by an independent third-party certification organization.

A.10.13.3.4 This test can be run concurrently with the pump test.

A.10.13.5.1(2) If there are multiple outputs to support multiple battery systems or a separate output for loads like rechargeable equipment and a dc clamp-on ammeter is used, the same meter can be moved from output to output to make multiple measurements.

A.10.13.5.1(5) If the output rating is for the sum of multiple outputs, the load should be split between the outputs and the readings from multiple outputs added to determine the output current to compare to the total rating.

A.11.1 Fire departments might wish to establish procedures to minimize the fireground contamination that is introduced into any occupant compartments, and to specify features that will facilitate periodic cleaning. These features can include the following:

- (1) Dedicated body compartments to store SCBA and cylinders after fireground operations
- (2) Dedicated body compartments to store contaminated PPE
- (3) Dedicated clean compartments to store replacement PPE
- (4) Dedicated storage for gross decontamination equipment

- (5) Seat upholstery that is easy to clean, or seat covers that can be removed for cleaning
- (6) Methods of providing hose-down soap streams and rinse streams for gross decontamination prior to reentering the occupant compartments
- (7) Interior surfaces that are easy to clean and that will minimize contaminant absorption

A.11.1.1 Typically, while engaged in firefighting operations on structural fires, apparatus are positioned in a safe location, and hose is extended as necessary to discharge water or suppressants on the combustible material.

In wildland fire suppression, mobile attack is often utilized in addition to stationary pumping. In mobile attack, sometimes referred to as “pump-and-roll,” water is discharged from the apparatus while the vehicle is in motion. Pump-and-roll operations are inherently more dangerous than stationary pumping because the apparatus and personnel are in close proximity to the fire combined with the additional exposure to hazards caused by a vehicle in motion, often on uneven ground. The personnel and/or apparatus could thus be more easily subject to injury or damage due to accidental impact, rollover, and/or environmental hazards, including burn over.

To potentially mitigate against the increased risk inherent with pump-and-roll operations, the following alternatives are provided for consideration:

- (1) Driver and firefighter(s) are located inside the apparatus in a seated, belted position within the enclosed cab, and water is discharged via a monitor or turret that is controlled from within the apparatus.
- (2) Driver and firefighter(s) are located inside the apparatus in a seated, belted position within the enclosed cab, but water is discharged with a short hose line or hard line out an open cab window.
- (3) Driver is located inside the apparatus in a seated, belted position within the enclosed cab with one or more firefighters seated and belted in the on-board pump-and-roll firefighting position as described in a following section.
- (4) Driver is located inside the apparatus in a seated, belted position within the enclosed cab. Firefighter(s) is located outside the cab, walking alongside the apparatus, in clear view of the driver, discharging water with a short hose line.

Under no circumstances is it ever considered a safe practice to ride standing or seated on the exterior of the apparatus for mobile attack other than seated and belted in an on-board pump-and-roll firefighting position.

The on-board pump-and-roll firefighting position should only be used when the following conditions are met:

- (1) The apparatus is actively engaged in mobile attack on the fire line.
- (2) The fuel model is characterized as fine fuels.
- (3) The ground is level, flat, and free of obstacles.
- (4) Driver visibility is unobstructed.
- (5) Vehicle speeds are no greater than 10 mph.
- (6) The firefighter is wearing full protective NFPA 1977-compliant personal protective equipment and is equipped with a fire shelter.

On-Board Pump-and-Roll Firefighting Position. If an on-board pump-and-roll firefighting position as described as follows is

provided, it should only be on a wildland fire apparatus with a GVWR of no more than 19,500 lb.

If an on-board pump-and-roll firefighting position is provided, it should, at minimum, include the following safety-related attributes:

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

If the seating position is located outside the cab, it should also meet the following requirements:

- (1) The seating position should be located behind the cab and ahead of the rear axle.
- (2) A protective structure should be provided in compliance with the side impact and crush criteria from SAE J1194, *Rollover Protective Structures (ROPS) for Wheeled Agricultural Tractors*.
- (3) The protective structure should be designed to allow exit from either side of the vehicle.
- (4) The protective structure should include a perforated plate or mesh with openings no larger than 1.5 in. (3.8 cm) × 1.5 in. (3.8 cm) or other solid guard to protect from brush hazards at the front, the back, and the roof. This is to protect against objects such as limbs entering the seating enclosure. Woven wire cloth with ¼ in. (0.6 cm) diameter wire spaced at 1 ¾ in. (4.4 cm) on centers is commonly used in the forestry industry to provide this protection.
- (5) A door or gate with a latching mechanism should be provided on each side of the vehicle designed to allow exit out of either side of the vehicle.
 - (a) The door or gate should be designed to prevent outward swing even in the event of failure of the latching mechanism.
 - (b) The door or gate should be at least 48 in. (1200 mm) high from the walking surface below the firefighter's feet.
 - (c) The door or gate should be constructed so there are no horizontal or vertical openings below the 48 in. (1200 mm) minimum height greater than 24 in. (610 mm) in either direction.

Equipment located within the seating enclosure position protective structure should meet the requirements of 11.1.11.

Development of this Design. Firefighting is an inherently dangerous operation. This is especially true of fighting a moving wildland fire in fine fuels. There are many techniques used and a great deal of discussion about the safest way to fight these fires. Over the years, many fire companies and apparatus manufacturers have developed techniques and equipment for fighting wildland fine-fuel fires. These have included fighting fire from seats mounted to front bumpers, sitting on hoods or

hose reels, standing on flat beds, standing in step wells on the side of apparatus, standing on running boards, or walking alongside a moving apparatus. All of these approaches are extremely dangerous. The Fire Department Apparatus Committee did extensive work to try to come up with a safer solution. We looked at the available apparatus and techniques that have been historically used in the industry. The preceding suggestions are safer than any of these ad-hoc techniques. The Fire Service Occupational Safety and Health Committee (NFPA 1500) does not approve of any fireground operations that permit the firefighter to ride outside the fully enclosed cab of a moving apparatus.

A.11.1.3.1 The minimum effective belt length dimensions were determined from a survey of 300 firefighters wearing bunker gear. For a lap belt only, the 95th percentile male firefighter required 48 in. (1220 mm) of belt length, and the largest subject in the survey required 54 in. (1370 mm). The 60 in. (1525 mm) minimum will accommodate the largest subject and provide 12 in. (305 mm) spare for the 95th percentile subject.

A.11.1.3.2 For a lap and shoulder belt assembly, the 95th percentile firefighter required 98 in. (2490 mm) of effective belt length, and the largest subject in the survey required 109 in. The 110 in. (2800 mm) minimum will accommodate the largest subject and provide 12 in. (305 mm) spare for the 95th percentile subject.

A.11.1.3.2.3 If the H-point of the seat is unknown, it can be estimated by the method outlined in A.11.1.8.1.

A.11.1.3.3 The seat belt color is intended to aid the driver or officer in determining if all occupants are seated and belted in apparatus where the size of the cab or the number of occupants might make an assessment difficult. For small vehicles with small cabs and fewer occupants, a bright seat belt color is less necessary because the observer is closer to the occupants. Purchasers might wish to specify web color on smaller apparatus if they desire.

Some models of commercial vehicles of Class 5 or less do not have bright red or bright orange seat belts available. However, if seat belts meeting these requirements are commercially available on the required cab model, purchasers should consider specifying the bright red or bright orange color. Alternatively, a patch or slipcover might be available to make the seat belts more visible.

A.11.1.3.8 The seat belt warning system is intended to aid the driver or officer in determining if all occupants are seated and belted in apparatus where the size of the cab or the number of occupants might make an assessment difficult. For small vehicles with small cabs and fewer occupants, this check can be accomplished visually or verbally without the need for a complicated electronic system.

A.11.1.8.1 The H point is the mechanically hinged hip point of the torso and thigh on the devices used in defining and measuring vehicle seating accommodation in SAE J826, *Devices for Use in Defining and Measuring Vehicle Seating Accommodation*. It is an imaginary point located in two-dimensional space above the seat cushion. The H point is measured using a tool that simulates human hips and torso of a specific size and weight. The H point will vary with the size, shape, and material of the seat back, seat frame, and seat cushion. If the H point measurement is not available, it can be approximated by measuring

5 in. (130 mm) ahead of the seat back and 3 in. (75 mm) up from the nondepressed seat cushion surface.

Suspension-style seats have been developed for long-haul truck operations where the operator is driving for many hours at a time. Acceleration and braking are controlled, with an eye to fuel economy. The suspension-style seat in this duty profile provides a smoother ride and reduces fatigue from long hours in the seats. In contrast, the operator of a fire apparatus typically is making short runs with fast acceleration, quick maneuvers, and sudden braking. The bouncing motion of the suspension seat could hinder the driver's ability to maintain precise control of the throttle, brake, steering wheel, and other driving controls.

Selection of seating options should be made with consideration to the frequency of time that the driver will spend in the vehicle each day, and whether the fire department strictly enforces not wearing head gear during travel. In wildland fire apparatus, selection could also depend on whether the standard operating procedure (SOP) requires or encourages the occupant of the seat to be equipped with headgear during firefighting operations. The use of headgear reduces headroom and increases the chance of injury should the vehicle encounter unexpected road undulation or speed bumps. The effect of such road conditions during high-speed operation might be intensified by the action of a seat suspension. Potential for injury is greatly increased by failure to use or properly adjust the seat belt.

Proper seat adjustment is another issue that should be addressed by the fire department SOPs if apparatus are equipped with suspension seats. Too much pressure in a suspension seat air bag will reduce static headroom height and will negate the potential benefits of the suspension. Too little pressure will cause the seat to bounce excessively. The proper amount of pressure is dependent on the weight of the occupant. Departments where multiple drivers share an apparatus should recognize that adjustments need to be made between each shift. Seat adjustment should not be postponed until the driver is exiting the station on the way to a call.

A.11.1.8.4 The minimum seat head height values in this standard assume that the occupants are not wearing fire helmets. The use of a helmet puts the occupant at greater risk of neck or back injury during a rollover or a severe road event.

A.11.1.9 The ability of a firefighter to enter the driving or crew riding area, get seated, and properly buckle the seat belt is critical. NIOSH studies of firefighter size have shown that it is not possible to seat four of the largest firefighters (95th percentile males) wearing their protective clothing side by side across the crew riding area of a custom cab without rubbing shoulders. Departments with populations of larger-than-average firefighters and whose policy is to ride fully equipped with bunker gear and equipment should consider a seating configuration where all occupants will be able to be buckled into a seating position effectively and efficiently before the apparatus is moving. Alternative seating configurations that can be considered include three seats across the back wall of a custom cab or two seats across the back wall of a commercial cab.

A.11.1.10 SCBA units and other equipment stored in the crew compartment can cause injuries to occupants of the compartment if they fly around the compartment as the result of an accident or other impact. Departments should check their pack

and bottle weight to ensure that it does not exceed the published rating of the SCBA holder to be provided.

A.11.1.10(4) A new holder can be employed for each test.

A.11.3.1 With the requirements for fully enclosed driving and crew compartments, the potential for heat buildup in these areas is greater. The purchaser should be aware of this condition and might wish to specify ventilation fans or air conditioning to keep the ambient temperature in the driving and crew compartment(s) lower.

A.11.3.2 The U.S. standards developed by SAE and the United Nations ECE regulation mirror each other except that SAE J2422, *Cab Roof Strength Evaluation — Quasi-Static Loading Heavy Trucks*, requires a roof preload impact prior to the roof crush. The ECE standard was established in 1958, while the SAE standards did not add performance criteria until 2003. Both the SAE and ECE standards are viable minimum measures of cab integrity. Manufacturers can test in excess of the standards.

A.11.3.4 The location and mounting of the mirrors should not be placed where door pillars or other obstructions block the driver's view. The location and mounting should be placed so warning lights do not reflect in the mirror to blind the driver's view. The location and mounting should not be placed so that the driver must look through the windshield area that is not wiped by the windshield wiper when viewing the passenger side mirror. Convex and other secondary mirrors should be considered to eliminate blind spots not covered by primary mirrors. Where necessary, heated mirrors should also be considered.

A.11.3.6.1 The ignition switch on structural fire apparatus traditionally does not require a key. If a keyed ignition switch is all that is offered on the selected chassis, then the key can be tethered to the vehicle. This ensures that any firefighter that needs to can start and operate the apparatus without searching for a key. This works well in structural departments where apparatus are always secured inside a station. Wildland apparatus have a different situation because these vehicles are often parked in remote unsecured locations. Consider the location and level of security in which your apparatus will be kept to determine if you need to specify a keyed ignition, or if a key is provided, whether it needs to be tethered in the driver's location.

A.11.4.2 The purchaser might wish to specify a Type 1 lap belt rather than a Type 2 lap-and-shoulder belt to allow the tiller operator to lean from side to side as required to have a better view around the ladder and to each side of the apparatus.

A.11.4.3 Past practice was to use a temporary seat mounted to the outside of the tiller cab to allow a supervisor to ride near the tiller operator for training purposes. Modern communication methods, including wireless headsets, are available that allow the supervisor to remain off the apparatus and still communicate with the student, either standing safely away on the training ground, or following in a chase vehicle. Driving simulators can also be used to train tiller operators.

A.12.1 Compartmentation that is designed to meet the size, shape, and weight requirements of special equipment might be required. Any special equipment to be carried on the apparatus should be identified in the specifications.

A.12.1.1 A water tank can condense water on the outside. Ventilation and drainage should be provided in compartments sharing a common wall with a water tank.

A.12.2.1 Firefighter injuries resulting from climbing on apparatus to retrieve, store, and operate equipment can be minimized if specifications require that equipment be accessible from ground level. Examples of ways to reduce the need to climb on the apparatus include, but are not limited to, using powered equipment racks, using remote control deck guns, lowering of storage areas for preconnected attack lines and using pull-out trays, using slide-out or pull-down storage trays, and providing for the checking of fluid levels from ground level.

A.12.2.2 Where equipment other than that originally mounted on the apparatus is to be carried, the fire department should ensure that the equipment is securely attached to the vehicle with appropriate holders.

A.12.4 SCBA units are typically stored in crew seats, behind bench seats, and on walls, doors, or shelves of storage compartments.

The area where the complete SCBA unit is to be mounted should be arranged to prevent damage to hose, straps, belts, facepiece, regulator, and other attachments. This arrangement should include prevention of wear and tear on the delicate facepiece due to vehicle movement. The facepiece should be stored in a nylon or plastic bag to prevent such abrasion.

Storage of spare hose assemblies, facepieces, regulators, and other SCBA pack accessories should be in a clean and dry area, away from heat-producing devices or mechanical damage. Preferably, the equipment should be stored individually in plastic or noncorrosive bins with dust-free covers. The contents of each bin should be noted on a label on the bin exterior.

A.12.4.5 SCBA cylinders should always be stored with the valve assemblies at the top.

A.12.4.6 SCBA cylinders should be stored with valve assemblies exposed to the compartment opening or storage area to permit inspection of valves or gauges.

A.12.5.1.5 The purchaser should consider specifying additional doors or removable panels for service, maintenance, or replacement of components in the fire pump installation.

The pump compartment needs at least one quick-opening access panel so that the pump and plumbing area can, at a minimum, be viewed through it. This panel should be at least 18 in. × 18 in. (46 cm × 46 cm) if rectangular, or 18 in. (46 cm) in diameter if circular. This panel can be located anywhere on the pump module, even if you need to raise the cab to get to it, so long as it can be opened without the use of tools.

Removable panels should be provided so that all the pump and plumbing components can be serviced or replaced. These panels can require standard tools to remove, and might require components such as outlet caps, valves, or adapters to be removed so long as they can be removed with standard tools.

A.12.6.1 Ascending into and descending from certain types of driving and crew compartments is ergonomically difficult and sometimes results in falls and subsequent firefighter injuries. When designing and specifying apparatus, it is strongly suggested that chassis and apparatus manufacturers be consulted concerning available alternatives to make driving and crew

compartment access as ergonomically convenient and as safe as possible.

A.12.6.1.2 The intent of step size and placement requirements is to ensure that the firefighter's foot is supported 7 in. to 8 in. (175 mm to 200 mm) from the toe when the foot is placed on the step in the normal climbing position. The leading edge is not necessarily the side opposite the fastening location.

A.12.6.4 Apparatus are constructed with surface areas that are not intended to be used as stepping, standing, and walking areas. These include cosmetic and protective coverings on horizontal surfaces. During the design stage of the vehicle, purchasers should designate which areas are stepping, standing, or walking areas. It is important that proper materials are selected for the application and local conditions.

When selecting stepping, standing, and walking surfaces, the purchaser should take into consideration the long-term use of the vehicle. The slip resistance of certain surfaces might deteriorate over time. It is also important for the fire department to properly maintain or replace slip-resistant materials as they deteriorate.

A.12.7.4 Exterior access handrails should be mounted in a way so as to minimize the chances of damage or removal by brushing objects such as trees.

A.12.7.6 The intent is that the apparatus manufacturer does not need to remove and replace those grab handles designed and built into the chassis by a commercial chassis manufacturer. Grab handles inside the door are acceptable.

A.12.8.2 Corrosion protection, commonly known as undercoating, might be advantageous in areas where climate conditions or road treatment will corrode vehicle components. The material, its application method, and the areas to be protected should be carefully specified so the corrosion protection will adequately protect the vehicle's cab and body sheet metal components subject to corrosive conditions that might be encountered in the fire department's response area.

A.12.8.2.1 The purchaser should give consideration to the choice of paint color(s) as it relates to the total vehicle conspicuousness. In addition, the purchaser needs to specify whether nonferrous body components are to be painted and whether any lettering, numbering, or decorative striping is to be furnished.

A.12.8.3 The purchaser should specify whether the striping required under this standard will be provided by the manufacturer on delivery of the apparatus or will be installed by the purchaser or its designee following delivery. In any event, the required striping must be installed before the unit is placed in emergency service.

A.12.8.3.1 If the purchaser specifies roll-up doors, consideration should be given to affixing a strip of reflective material to the rail area below the door. If the purchaser specifies vertically hinged compartment doors, consideration should be given to affixing 4 in. (100 mm) minimum width reflective stripes or chevron-type reflective stripes on the inside of the doors.

A.12.8.3.2 Purchasers of wildland fire apparatus might wish to consider adding the chevron requirement if there is sufficient vertical surface at the rear of the apparatus.

A.12.9 The purchaser should specify whether a single or split hose bed is desired and any special arrangements desired for preconnected hose lines.

It is also recommended that the purchaser consider specifying some type of cover for the hose compartment. Hinged or removable covers might be advantageous.

Many departments now find it useful to use large diameter supply hose [4 in. (100 mm) or 5 in. (125 mm)] to effectively move water from its source to the fire scene. Fire departments serving areas with wide hydrant spacing or areas with no hydrants often find it desirable to carry additional hose.

It is recommended that the department carry at least 200 ft (60 m) of 2 ½ in. (65 mm) hose for handline operation. If the operations of the department are geared to using multiple large handlines from single apparatus, the department should consider carrying more 2 ½ in. (65 mm) hose and additional nozzles. Likewise, the amount and size of hose used to supply large stream devices should be considered in planning the amount and size of hose to be carried.

The department should evaluate its needs and choose the size and amount of hose that will best support its operation and then discuss those hose storage needs with the contractor to ensure the fire apparatus hose storage space will be properly laid out and of sufficient size to accommodate the department's needs.

A.12.9.6 Many fire departments have experienced fire hose inadvertently coming off apparatus traveling to and from incidents. Several incidents have resulted in injuries, damage to property, and death. Fire departments and manufacturers have developed various methods of preventing inadvertent deployment, including fully enclosed hose bed covers, buckled straps, hook-and-loop straps, fabric covers, webbing mesh, wind deflectors, and other material restraints or combination of restraints. It is also important that fire departments develop methods of storing hose and appliances in a manner that does not promote the inadvertent deployment of the hose and appliances.

A.12.9.8 Apparatus provided with booster hose and reel assemblies should have power rewind capability. However, if a manual rewind is provided, attention should be paid to the location of the hand crank. It should be placed in a location that allows the operator to rewind the hose onto the reel without having to climb onto the apparatus.

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

A.12.11 Trailer hitch-type receivers are commonly used as anchor points for both removable winches and rope operations. Removable winches are intended for equipment recovery operations only. Rope operations could involve personnel rescue, which requires the receiver and its anchorage to be designed using higher safety factors.

A.12.12.4.4 If the unit is going to be moved onto and off a chassis periodically, the purchaser might wish to specify lifting eyes or forklift slots to facilitate the unit's movement. Provisions

to prevent accidental breakaway from the chassis should be provided.

A.13.2.2 If the apparatus is equipped with an automatic transmission, it is acceptable to lightly apply throttle and brakes for short periods of time to maintain this requirement.

If the vehicle is to be used for simultaneous pump-and-roll and firefighting while the vehicle is moving, remote controlled nozzle(s) or turret(s) should be considered. See also A.6.3.1 of NFPA 1500.

A.13.2.3.2 Pumps of 3000 gpm (12,000 L/min) or greater capacity are used for specialized industrial firefighting applications, where the apparatus is typically supplied by a high-pressure feed system.

A.13.2.3.3 High points in the suction plumbing should be avoided. If there are high points in the intake plumbing, a prime or suction should also be taken at the top of the high point as well as at the top of the pump suction inlet.

A.13.2.3.3.5 Parallel operation can be referred to as “volume,” and series operation can be referred to as “pressure.”

A.13.2.4.1 At an altitude of 2000 ft (600 m), the actual (uncorrected) atmospheric pressure equivalent to the sea level reading of 29.9 in. Hg (101 kPa) is 27.8 in. Hg (94.1 kPa).

The values given in Table 13.2.4.1(b) and Table 13.2.4.1(c) are representative values of pressure losses due to flow entrance, velocity, and friction sources through 20 ft (6 m) of suction hose (including strainer) of the diameter indicated.

The basis of the tables on friction loss is tabular data from 1953 testing and other accumulated data and testing. In 1976, the data were reviewed and incorporated in Table 13.2.4.1(b). The data include a velocity head component, and the values account for bending, because the actual values were derived from suction hose bent from the suction intake into the test pit.

A.13.2.4.2 Where the community to which the apparatus is to be delivered is at a considerably higher altitude than the factory or other test location, sufficient excess power should be provided to compensate for the fact that the power of a naturally aspirated internal combustion engine decreases with elevation above sea level. The performance of a fire pump can be adversely affected by the design of the suction piping or the addition of valves to the suction side of the pump. Losses due to additional piping or valves that are added to the fire pump suction reduce pump performance.

A.13.3.1 The purchaser might want to consider a supplementary heat exchanger cooling system for the pump drive engine. If utilized, valving should be installed to permit water from the discharge side of the pump to cool the coolant circulating through the engine cooling system without intermixing. The heat exchanger should maintain the temperature of the coolant in the pump drive engine not in excess of the engine manufacturer's temperature rating under all pumping conditions. A drain(s) should be provided to allow draining of the heat exchanger to prevent damage from freezing.

A.13.3.4 A separate pumping engine could use the vehicle chassis battery system, or it could have a separate set of dedicated batteries. Whichever system is used, the battery charging and electrical supply should be designed to meet this standard.

A.13.4.3 Each component in the driveline has a continuous duty torque rating. At this level of usage, each component also has a design life expressed as hours of use at rated torque. The design life of some components can be substantially less than the remaining drive system components. An hour meter activated by the pumping system and marked with a label should be provided to log the number of hours of drive system usage.

Programming the engine to use an alternate torque curve or sizing the pump and pump gear ratio to limit the torque required is an acceptable means of limiting the net engine output torque.

A.13.5.1 Pumps and piping that are frequently used to pump saltwater, water with additives, or other corrosive waters should be made of bronze or other corrosion-resistant materials. For occasional pumping of such water, pumps made of other materials are satisfactory if properly flushed out with freshwater after such use. Where corrosive water is being pumped and the pump and piping are not made of corrosion-resistant materials, the placement of anodes in the pump might minimize the corrosive effects.

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

Corrosion effects are proportional to the mass relationship of bronze to iron. It is, therefore, preferable to use similar materials for the pump and piping. Where both iron and bronze are used, it is preferable to keep the mass of the iron larger than that of the bronze.

A.13.6.1 Intakes can be larger than the size of the suction hose specified in Table 13.2.4.1(a). The sizing of suction hose in Table 13.2.4.1(a) is for the pump manufacturer's certification of the pump's capability only. It is recommended that a fire department standardize suction hose size regardless of fire pump size on its apparatus, which will allow extra suction hose to be available if a long horizontal reach is needed to get to the water source. Regional standardization of suction hose sizes will improve interoperability within the region in the event of a major disaster.

It is also advantageous to have valves on more than one of the intakes. The purchaser should specify if larger intakes are to be provided and if more than one of the intakes are to be equipped with valves.

Intakes at the front or rear of the apparatus or otherwise specially situated might not allow drafting rated capacity at rated pressure. The purchaser should specify the flow rates required from auxiliary intakes, especially front and rear intakes or other intakes located 10 ft (3 m) or more away from the pump. If auxiliary intakes are provided, the purchaser should also consider requiring the manufacturer to certify the actual flow rates from auxiliary intakes.

It is recommended that permanently gated intakes 4 in. (102 mm) or larger be controlled from the pump operator's position.

A.13.6.1.1 Apparatus used outside the United States can have intake connections other than NH if specified by the authority having jurisdiction.

A.13.6.1.3 Pressurizing a suction inlet could create a dynamic water hammer that might cause a hose or fitting failure, resulting in injury or death to anyone in the immediate vicinity. Valves should be opened and closed slowly, and lines should be charged slowly.

A.13.6.2.2 Sizing of the openings of the strainer(s) is intended for debris of generally uniform dimensions. It is recognized that debris of nonuniform dimensions — that is, long in relation to cross section — might be able to pass through the strainer(s) while not being able to pass through the pump.

A.13.6.3.1 The valve might also be controlled from another location. For valves located on the opposite side from the pump operator's position (or front or rear), the purchaser might want to consider a second control at the valve location.

A.13.6.5 The bleeder valve should be used prior to the removal of a hose, a cap, or other closure connected to an intake. The bleeder valve should also be used while filling a hose connected to an intake with water. Failure to use the bleeder valve in these situations might result in serious injury or death.

A.13.7 Consideration should be given to providing an additional pump cooling/recirculation line or thermal relief valve that is automatic in operation. Pumps on fire apparatus are often left unattended, and a cooling/recirculation line or thermal relief valve that is automatic in operation will help ensure that the pump does not overheat.

A.13.7.1 The flows listed for each outlet size are minimum and are for rating purposes only. If piping and valving are sufficient, much higher flows for a given outlet size might be achievable. The purpose of 13.7.1 is to provide sufficient discharge outlet connections to allow the apparatus to relay-supply the rated capacity of the pump for a distance of 1200 ft (366 m) or greater. If a 1500 gpm pump (6000 L/min) is chosen, six 2.5 in. (65 mm) lines, or two 2.5 in. (65 mm) lines and one 5 in. (125 mm) line, or one 6 in. (150 mm) line will be needed.

Subsection 13.7.1 allows the customer the option of using LDH hose instead of many 2.5 in. (65 mm) lines. A 1500 gpm (6000 L/min) pump could be supplied with a 5 in. (125 mm) connection and two 2.5 in. (65 mm) connections and be totally compliant and functional, because the LDH connection equals four 2.5 in. (65 mm) connections.

This section is based on discharge outlet connections, not valve sizes or piping. The valve size friction loss is not normally as great as the hose loss attached to the outlet connection. A 3 in. (75 mm) valve can easily supply a 5 in. (125 mm) connection at 1000 gpm (4000 L/min), with little noticeable loss through the valve and the pipe. (See Table A.13.7.1.)

A.13.7.2.1 Apparatus intended for use outside the United States can have outlet connections other than NH if specified by the authority having jurisdiction.

A.13.7.2.2 For interoperability among fire departments at major incidents, National Hose threads are required. Adapters can then be used to adapt to locally used hose connections.

A.13.7.3 If flows greater than 200 gpm (750 L/min) through preconnected lines are needed, piping from the pump to preconnected hose lines should be larger than 2 in. (52 mm) in order to keep the friction loss to a reasonable level. If addi-

Table A.13.7.1 Common Valve/Pipe Size by Connection Size

Connection Size	Required Flow	Common Valve/ Pipe Size to Meet the Requirement
2.5 in	250	2.5 in. or 3 in.
3 in.	375	2.5 in. or 3 in.
4 in.	635	3 in.
5 in.	1000	3 in. or 4 in.
6 in.	1500	4 in.

tional preconnected lines are wanted, the location and hose size should be specified.

A.13.7.5.3 Control of discharges on apparatus is available as pull-type actuators, trunnion or swing valves, flexible push/pull controls, gear-operated hand wheel controls, and hydraulic, air, and electric operators. These controls are available with either quick-operating or slow-operating valve mechanisms. The nozzle and hose reaction and “operational effort” for high flow or high-pressure discharges are critically important to many fire departments. Because of the variations in types of individuals and characteristics of operators involved with pump operations, a purchaser should carefully evaluate valve controls.

A.13.7.9 Where possible, discharge outlets should be positioned in an area away from the pump operator's position.

If a deck gun or monitor is to be mounted on the top of the apparatus, consideration should be given to designing the system so it can be operated without the need for a person to climb to the top of the apparatus. This can be accomplished by using a remotely operated monitor or by positioning the device so it is operable from the pump operator's position.

A.13.9.1 Ideally, having no intake or discharge connections at the operator's position would simplify and improve safety for the operator. If complete removal of these connections is impracticable, the reduction and careful placement of these connections, with operator safety in mind, would improve the situation considerably.

Operation of pump and discharge controls should not compromise the clearances of the operator's space on a top-mount pump panel or provide sharp edges, projections, or barriers to movement. The purchaser might want to state the clear walkway minimum space that is required.

Many fire departments have found it useful to color code the labels that identify the various discharge and intake controls. While this process can simplify pump operations, it can also create confusion if a pattern is not followed on all apparatus in the department. For standardization, the color-coding scheme in Table A.13.9.1 is recommended for all new apparatus labels.

A.13.10 The indicator lights and interlocks specified in this section are minimums. Some manufacturers or users might choose to add additional indicator lights or interlocks.

A.13.10.1.2 Pumps are operated from the side, top, front, or rear of the vehicle, and stationary pumping requires that no power is applied to the wheels during pumping. Therefore, it is essential that any controls that could apply power to the wheels while pumping be equipped with a means to prevent dislocation of the control from its set position in the pumping mode.

Table A.13.9.1 Color Scheme for Labels on Discharge and Intake Controls

Discharge	Color
Preconnect #1 or front bumper jump line	Orange*
Preconnect #2	Red*
Preconnect #3 or discharge #1	Yellow*
Preconnect #4 or discharge #2	White*
Discharge #3	Blue
Discharge #4	Black
Discharge #5	Green
Deluge/deck gun	Silver
Water tower	Purple
Large-diameter hose	Yellow with white border
Foam line(s)	Red with white border
Booster reel(s)	Gray
Inlets	Burgundy

*Because the vast majority of fires are extinguished using preconnected lines, a fire department should give consideration to matching the hose jacket color to the color of the labels. Fire departments using this system have reported an improvement in fireground operations.

A.13.10.2 There are several ways to drive a pump from the chassis engine through a PTO. Each of them can be used with either an automatic or a manual transmission, but the interlocks and indicators with a manual transmission do not sense or depend on the gear selected. Generally, a driveshaft connects the PTO to the pump, except in the case of a split shaft PTO with a midship pump. In some cases, the PTO drives a hydraulic pump which drives a hydraulic motor driving the pump. The following are common PTO types:

- (1) *Pump driven through a split shaft PTO.* The driveline goes through a gearbox that either powers the rear driveline (road position) or the pump (pump position). This PTO can transmit the full power of the vehicle engine but cannot provide pump-and-roll functionality.
- (2) *Pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel (rear engine) PTO.* Each of these PTOs can be designed for stationary pumping only or for stationary pumping and pump-and-roll. Generally, there is a limit on the power available, but in some cases pumps as large as 1500 gpm (6000 lpm) can be driven. Each type of PTO has its advantages and disadvantages. Front-of-engine crankshaft PTOs are used for front-mount pumps. These drive choices are usually the only options if pump-and-roll capability is required from the chassis engine.
- (3) *Pump driven through a transfer case PTO or auxiliary transmission PTO.* The transfer case is part of the 4-wheel-drive system and can provide a PTO output for driving the pump. An auxiliary transmission PTO-driven pump functions much like a transfer case PTO-driven pump for 2-wheel-drive apparatus. These PTOs are suitable only for stationary pumping. These have been largely replaced by transmission-mounted or engine flywheel PTOs.

The following are descriptions of the interlocks and indicators for each type of chassis transmission and pump drive arrangement:

Stationary pump driven through split shaft PTO — automatic chassis transmission. Where the apparatus is equipped with an auto-

matic chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pumping system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided in the driving compartment to indicate that the pump shift process has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in pump gear. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on.

Stationary pump driven through split shaft PTO — manual chassis transmission. Where the apparatus is equipped with a manual chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pumping system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

Stationary pump driven through transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO — automatic chassis transmission. Where the apparatus is equipped with an automatic chassis transmission; the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO; and the apparatus is to be used for stationary pumping only with the chassis transmission in neutral; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pump system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided both in the driving compartment and on the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in neutral. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on.

Stationary pump driven through transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO — manual chassis transmissions. Where the apparatus is equipped with a manual chassis transmission; the water pump is driven by a

transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO; and the apparatus is to be used for stationary pumping only with the chassis transmission in neutral; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pump system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided both in the driving compartment and on the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

Stationary and "pump-and-roll" pump — automatic chassis transmissions. Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, and the apparatus is designed to be used in both stationary pumping mode with the automatic chassis transmission in neutral and "pump-and-roll" pumping mode in a road gear, an interlock system is provided to ensure that the pump drive system components are properly engaged so that the apparatus can be operated in either stationary or pump-and-roll pumping mode. A "Pump Engaged" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in neutral. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on. An "OK to Pump and Roll" indicator is provided in the driving compartment and is energized when the pump is engaged, the chassis transmission is in road gear, and the parking brake is released. When the "OK to Pump and Roll" indicator is energized, the "OK to Pump" indicator is not energized.

Stationary and "pump-and-roll" pumps — manual chassis transmissions. Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, and the apparatus is designed to be used in both stationary pumping mode with the chassis transmission in neutral and "pump-and-roll" pumping mode in a road gear; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the apparatus can be operated in either stationary or pump-and-roll pumping mode. A "Pump Engaged" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided in both the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

tor's panel when the parking brake is on. An "OK to Pump and Roll" indicator is provided in the driving compartment and is energized when the pump is engaged and the parking brake is released. When the "OK to Pump and Roll" indicator is energized, the "OK to Pump" indicator is not energized.

Stationary pumps driven through transfer case PTOs or auxiliary transmission — automatic chassis transmissions. Where the apparatus is equipped with an automatic chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline and through a transfer case, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the pumping system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged, the chassis transmission is in pump gear, and the transfer case drive to the chassis wheels is in neutral. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on.

Stationary pumps driven through transfer case PTOs or auxiliary transmission PTO — manual chassis transmissions. Where the apparatus is equipped with a manual chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline and through a transfer case, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the pumping system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided in both the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged, and the transfer case drive to the chassis wheels is in neutral. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

A.13.10.2.1.2 If the apparatus is equipped with an automatic chassis transmission and is not configured to provide engine speed control at the pump operator's panel when the parking brake is engaged and the chassis transmission is in neutral, both the "Throttle Ready" and the "OK to Pump" indicators will indicate at the same time when the apparatus is successfully placed in the "OK to Pump" configuration for stationary pumping mode. If the apparatus is configured to provide engine speed control at the pump operator's panel when the parking brake is engaged and the chassis transmission is in neutral, then only the "Throttle Ready" indicator will indicate when the apparatus is placed in this configuration. (See A.13.10.2.5.3)

A.13.10.2.2 Completion of the pump shift might require that the chassis transmission be shifted into pump gear.

A.13.10.2.4 When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized.

A.13.10.2.5.3 The purchaser should specify if they want throttle control at the pump panel when not in “OK to Pump” mode. Engine speed advancement control at the operator’s panel might be required for apparatus with the need to control the engine speed during operation of a generator, aerial device, alternator, or other chassis engine-driven device. The indicating device for this “Throttle Ready” condition is the same indicating device as in 13.10.2.5.2.

Other apparatus might not have equipment for which it is necessary to control engine speed from the pump operator’s panel. Engine speed control at the pump operator’s panel for these apparatus might not be desirable because, on many chassis engines, activating remote throttle operation automatically disables the in-cab accelerator pedal. For such apparatus, engine speed advancement control at the pump operator’s panel is not required when the chassis transmission is in neutral and the parking brake is engaged, so a “Throttle Ready” indication is not required.

A.13.10.4 The purpose of a pressure control system is to control the discharge pressures in order to protect firefighters who are operating hose streams as well as to protect discharge hose from damage in the event attack hose streams are shut off or other valves are closed, reducing flow rates.

The system could consist of a discharge relief valve, a pressure regulator that controls the speed of the pump, an intake relief valve, or any combination of these devices. Pressure control systems will relieve excess pressure when valves are closed in a normal manner, but some water hammer conditions could occur due to valves being closed so quickly that the system cannot respond fast enough to eliminate damage to equipment. Proper fireground procedures are still required.

A.13.10.4.1 Pressure control systems can be supplied in the following forms:

- (1) Integral with the pump and supplied by the pump manufacturer
- (2) As an external system of components supplied by the apparatus manufacturer
- (3) As an external control system provided by a pressure control manufacturer
- (4) Properly selected pump, PTO ratio, and discharge sizes to limit pressure rise to less than 30 psi (207 kPa)

Pressure governors control the engine speed, which relates directly to the net pump pressure: If the speed is raised, the pressure goes up; if the speed is lowered, the pressure goes down.

Discharge relief valves control pressure by passing water from the discharge side of the pump back into the intake side of the pump. This type of system works in a pressure differential of at least 70 psi to 90 psi (500 kPa to 600 kPa) between the intake and discharge sides of the pump. If the pressure differential is not present, the discharge relief valve might not control a pressure rise completely.

If either a discharge relief valve or a pressure governor is used with high incoming inlet pressures, an intake relief valve or total control system should be added.

In the case where an intake relief valve is selected, it should be of sufficient size and response time to handle the pump performance range. It should also be easily controlled by the pump operator so that this incoming pressure can be adjusted for each incident. For best results, the operator should set the intake relief valve to operate at 90 psi (600 kPa) below the desired discharge operating pressure.

The pressure control system should be certified by the appropriate manufacturer or an independent third-party certification organization. Because of the importance of these systems, the purchaser might wish to have performance tests conducted on the installed system.

A.13.10.5 Departments that need to attain a draft while conducting operations off tank water will find that adding a primer selector valve or second priming control valve to allow attaining a draft on the outboard side of the gated pump suction valve will reduce the potential loss of continuous water flow while supplying attack lines. A vacuum line is run to the outboard side of the valve and connected through a selector valve to the primer. Side, front, and rear selector settings can be arranged to allow priming off any side of the unit with one primer. Automatic priming is available from several manufacturers and offers added convenience to the pump operator.

A.13.11.1 The electronic throttle control systems that are currently available will provide greater flexibility for the operator because they can be set like a traditional throttle or a pressure governor.

A.13.12.1.1 A pumping engine fuel level indicator or red warning light indicating when the fuel level falls below one-fourth of the capacity of the tank(s) should be provided on the pump operator’s panel.

A.13.12.3.2 Because the rated operating pressure of large-diameter supply hose is substantially less than that of attack fire hose, an individual pressure gauge is required to allow the operator to control the discharge pressure even where a flowmeter is provided.

A.13.13.1.2.4 The purchaser might wish to have an independent third-party certification organization certify the test results, particularly where the pump is required to meet extended continuous duty pumping applications.

A.13.13.2.1.2 Where tests are performed inside a structure or elsewhere that has 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.13.13.2.1.2(4) The suction lift capability of a fire pump is certified by the pump manufacturer for specific conditions of altitude above sea level, atmospheric pressure, water temperature, and friction and entrance loss caused by the flow of water through the intake strainers and hose as stated in 13.2.4.1. As the temperature of the water increases and barometric pressures decrease, the suction lift capability of the fire pump is reduced. While the minimum lift of the test site for the pumping test is 3 ft, the test site configuration must not provide a vertical lift that exceeds the suction lift capability of the pump as a result of elevated water temperatures and reduced barometric pressure. See Table A.13.13.2.1.2(4).

Table A.13.13.2.1.2(4) Effect of Water Temperature and Barometric Pressure on Suction Lift Capability

Water Temperature		Effect on Lift		Barometric Pressure		Effect on Lift	
°F	°C	ft	m	in. Hg	kPa	ft	m
60	16	0	0	29.9	101.3	0	0
90	32	-1	-0.3	29.0	98.2	-1	-0.3
110	43	-2.3	-0.7				
120	49	-3.3	-1.0				

A.13.13.2.2.6 If a counter speed shaft is not provided, the engine speed can be read with a photo tachometer or strobe light off a rotating element.

A.13.13.2.3.1 Figure C.3(c) of NFPA 1910 shows a test data form for recording the test readings and other necessary data.

A.13.13.2.3.2 Where an engine is operating at or near full power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that, when touched, could cause extreme discomfort or injury. However, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

The suction lift can be determined either by measuring the negative pressure (vacuum) in the pump intake manifold with a test gauge that measures vacuum accurately or by adding the vertical lift and the value of friction and entrance loss from Table 13.2.4.1(b) or Table 13.2.4.1(c). 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 is not a significant amount and could be ignored. Thus, the net pump pressure can be calculated by using the following formulas.

For inch-pound units:

[A.13.13.2.3.2a]

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

or

[A.13.13.2.3.2b]

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

where:

P = net pump pressure (psi)

D = discharge pressure (psi gauge)

H = vacuum gauge reading (in. Hg)

L = vertical lift (ft)

F = friction and entrance loss (ft of water)

For SI units:

[A.13.13.2.3.2c]

$$P_m = D_m + H_m$$

or

[A.13.13.2.3.2d]

$$P_m = D_m + F_m + 9.8L_m$$

where:

P_m = net pump pressure (kPa)

D_m = discharge pressure (kPa)

H_m = vacuum gauge reading (kPa)

F_m = friction and entrance loss (kPa)

L_m = vertical lift (m)

A.13.13.2.3.3 Multistage fire pumps can include two-stage pumps with parallel/series capability in which the stages operate in parallel (i.e., volume) or with one stage feeding the second stage in series (i.e., pressure). The discharge outlets of these pumps typically experience a common discharge pressure whether in parallel or series mode. Other multistage pumps might not have parallel/series capability but might have provisions for discharging from specific stages at different discharge pressures to provide performance according to customer specifications. Other multistage pumps have the capability to provide flows at nominal NFPA rating pressures while selectively able to provide specific discharge outlets at elevated discharge pressure according to customer specifications.

A.13.13.6.5 When the test is done with intake valves open and intakes capped, the apparatus could have a bad intake valve that would not be detected. By conducting a second test with the intake valves closed and intakes not capped, a leaking intake valve would be detected.

A.13.13.8 The engine speed advancement interlock system test verifies the proper functioning of the throttle controls and indicator for various conditions of chassis transmission(s), parking brake, and pump shift control action status. Testing should be performed with a qualified person positioned in the driving compartment and a qualified person verifying indicators and engine speed control status at the pump operator's panel. Shifting of the pump transmission/PTO should be done in accordance with the manufacturer's instructions.

A.13.13.10 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might wish to specify that these tests also be certified by the independent third-party certification organization.

A.14.1 Auxiliary pumps come in a variety of different styles: gear, piston, and centrifugal designs. Where centrifugal designs are specified, the purchaser also has to select if it is to be a single-stage, series-only multistage, or series/parallel multistage-type pump.

The purchaser should indicate the type of operation and performance required from the auxiliary pump. Auxiliary pumps are predominantly for fighting grass, brush, and other small outside fires. Low capacity with high pressure through $\frac{3}{4}$ in. (19 mm) or 1 in. (25 mm) booster hose is commonly used for these fires. Pump-and-roll capability is often specified.

A.14.4 Various types of pump drive systems are available. These pumps are often driven by power takeoff units attached to SAE PTO openings on the chassis transmission. There are also front-of-engine PTO systems, flywheel PTO systems, split driveline PTO systems, and separate engine drive systems.

A.14.4.1 The volume and pressure that can be obtained safely depend on the torque capacity of the apparatus's transmission or transfer case, power takeoff, and pump driveline. In most cases, the torque rating of the PTO will determine the maximum pump performance. Power takeoff manufacturers assign a torque rating to their products. This torque rating is based on intermittent service, as in operating the PTO at the full torque limit for a period of 5 minutes or less. For continuous duty, the intermittent torque rating is devalued 30 percent.

A.14.4.2 Sustained operations at either high volume, high pressure, or both high volume and high pressure could cause excessive heating of the transmission lubricant. To maintain lubricant temperatures below the component manufacturer's published limits, it might be necessary to employ oil-to-oil or oil-to-water heat exchangers. The latter should be of a type that will not trap water, which would cause serious damage if the water subsequently freezes.

A.14.6.1 The purchaser should indicate the number, size, and location of the pump intake connections or combination of connections desired. The types of pump intake connections are as follows:

- (1) External intake
- (2) Direct supply line from the water tank
- (3) Supply line from the discharge side of the fire pump

A.14.7 The purchaser should indicate the size, number, and location of the pump discharge connections desired. The types of pump discharge connections are as follows:

- (1) Discharge line(s) for non-preconnected hose lines
- (2) Discharge line(s) to preconnected hose lines
- (3) Discharge line(s) to booster reel(s) (if provided)

A.14.7.3.1 For interoperability among fire departments at major incidents, National Hose threads are required. Adapters can then be used to adapt to locally used hose connections.

A.14.10.3 A separate pumping engine could use the vehicle chassis battery system, or it could have a separate set of dedicated batteries. Whichever system is used, battery charging and electrical supply should be designed to meet this standard.

A.15.2.1 Some of the pump performance requirements listed in Table 15.2.1 are the same as the pump requirements of certain U.S. fire and insurance organizations. Table A.15.2.1 ties the performances required by Table 15.2.1 to those required by the National Wildfire Coordinating Group (NWCG), the Insurance Services Office (ISO), and the U.S. Forest Service for agency engines.

A.15.2.2.1 If the apparatus is equipped with an automatic transmission, it is acceptable to lightly apply throttle and brakes for short periods of time to maintain a maximum speed of 2 mph (3.2 km/hr). If the vehicle is to be used for simultaneous pump-and-roll and firefighting while the vehicle is moving, remote controlled nozzle(s) or turret(s) should be considered. See also A.6.3.1 of NFPA 1500.

Heavy braking in combination with moderate to heavy throttle can create a large amount of heat in the automatic transmission converter and brakes that could lead to damage.

A.15.2.3.3 High points in the suction plumbing should be avoided. If there are high points in the intake plumbing, a prime or suction should also be taken at the top of the high point as well as at the top of the pump suction inlet.

Table A.15.2.1 Water Pump Performance When Installed in Wildland Apparatus Engine

psi	kPa	gpm	L/min
100	700	50 ^a 150	200 600
150	1000	50 ^b 250 ^c	200 1000
250	1700	50 ^d 150 ^e	200 600
300 400	2000 2800	200 ^f 30	800 120

^a NWCG rating for type 4, 5, and 6 engines [50 gpm @ 100 psi (200 L/min @ 700 kPa)]

^b ISO9 rating [50 gpm @ 150 psi (200 L/min @ 1000 kPa)]

^c ISO8 rating [250 gpm @ 150 psi (1000 L/min @ 1000 kPa)] and also NWCG Tactical Water Tender T2

^d U.S. Forest Service type 4, 5, and 6 engine [50 gpm @ 250 psi (200 L/min @ 1700 kPa)]

^e NWCG rating for type 3 engine [150 gpm @ 250 psi (600 L/min @ 1700 kPa)]

^f U.S. Forest Service type 3 agency engines [200 gpm @ 300 psi (800 L/min @ 2000 kPa)]

A.15.2.4.2 If the pump is expected to operate above 2000 ft (600 m) or at lifts of more than 10 ft (3 m) or through more than 20 ft (6 m) of suction hose, the apparatus manufacturer needs to be made aware of this fact in order to compensate for the fact that the power of a naturally aspirated internal combustion engine decreases with elevation above sea level or that additional head loss will be encountered on the intake side of the pump. At an altitude of 2000 ft (600 m), the actual (uncorrected) atmospheric pressure equivalent to the sea level reading of 29.9 in. Hg (101 kPa) is 27.8 in. Hg (94.1 kPa). The purchaser should seek certification from the pump manufacturer that the pump meets the necessary performance requirements under these more strenuous conditions.

Under some conditions, the engine-pump combination is not able to perform at higher elevations. When this occurs, it is necessary to either increase the engine horsepower or de-rate the pump.

The suction hose size shown in Table 15.2.4.1(a) is for pump rating purposes only, and other sizes of suction hose can be carried on the fire apparatus for use in the field. The performance of a fire pump can be adversely affected by the design of the suction piping or the addition of valves to the suction side of the pump. Losses due to additional piping or valves that are added to the fire pump suction reduce pump performance.

A.15.3.7.1 The maximum governed speed is established by the engine manufacturer as a safe limit of engine speed. The governor prevents the engine from exceeding the safe speed. Most engine manufacturers allow a plus tolerance of 2 percent for maximum governed speed.

A.15.3.7.2 A shutdown not controlled by the pump operator during the firefighting operations can result in loss of water-flow from the pump, which could severely endanger personnel.

A.15.3.8.3.2 It is important to have drain valves on the plumbing. The drain valve(s) should be located at low points in the

system to completely drain the system. The design of the valve should be such that the valve will not inadvertently open from vibration. It is also critical, especially on wildland vehicles or other vehicles subject to go off-road, that the drain valves are located out of the angle of approach or angle of departure or other areas where the valve could be subjected to damage or contact with brush or other objects. Accidental opening of or damage to the drain valve could impact the operation of the system.

A.15.3.10.1.1.1 Caution needs to be used because air intake filters might affect the engine manufacturer's air restriction requirements. See A.9.2.4.1.

A.15.3.11.2 Emissions from exhaust discharge pipes should be directed away from any firefighting tools, since such emissions contain an oily substance that could make the tools difficult to handle and possibly dangerous to use.

A.15.3.12.1 If a switch to stop the engine is provided in the driving compartment, it should be a momentary switch and should be within convenient reach of the driver. A pumping engine running light might be desired in the driving compartment.

A.15.3.13.3 If the vehicle batteries are used, the electrical requirements of the pump engine need to be considered when sizing the vehicle's charging system. (See 10.3.1 and 10.3.2.)

A.15.3.15 The fuel tank(s) and systems that meet 49 CFR 393.65, "All Fuel Systems"; 49 CFR 393.67, "Liquid Fuel Tanks"; or 49 CFR 393.69, "Liquefied Petroleum Gas System," should be used when available. Among other requirements, these regulations do not allow gravity or siphon feeds for other than diesel fuel tanks. Fuel withdrawal fittings have to be above normal levels of fuel in the tank when the tank is full.

A.15.3.15.2 It is recommended that the pump engine use the same type of fuel as the chassis engine.

A.15.4.3 Each component in the driveline has a continuous-duty torque rating. At this level of usage, each component also has a design life expressed as hours of use at rated torque. The design life of some components can be substantially less than the remaining drive system components. An hour meter activated by the pumping system and marked with a label should be provided to log the number of hours of drive system usage.

Programming the engine to use an alternate torque curve or sizing the pump and pump gear ratio to limit the torque required is an acceptable means of limiting the net engine output torque.

A.15.5 Figure A.15.5 shows a typical plumbing schematic for an apparatus with a centrifugal pump. The valves on the schematic are identified by numbers corresponding to a valve numbering system that is used by a number of federal wildland firefighting agencies. This numbering system is detailed in the schematic in Figure A.15.5.

A.15.5.1 When fire apparatus plumbing is being designed, galvanic corrosion protection for dissimilar metals should be provided. Pumps and piping frequently required to pump salt-water, water with additives, or other corrosive waters should be built of bronze or other corrosion-resistant materials. For occasional pumping of such water, pumps built of other materials are satisfactory if properly flushed out with freshwater after such use. Where corrosive water is being pumped and the pump and piping are not made of corrosion-resistant materials,

the placement of anodes in the pump might minimize the corrosive effects.

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

Corrosion effects are proportional to the mass relationship of bronze to iron. It is, therefore, preferable to use similar materials for the pump and piping. Where both iron and bronze are used, it is preferable to keep the mass of the iron larger than that of the bronze.

A.15.6 The bleeder valve, if available, should be used prior to the removal of a hose, a cap, or other closure connected to an intake. The bleeder valve should also be used while filling a hose connected to an intake with water. Failure to use the bleeder valve in these situations might result in serious injury or death.

A.15.6.1 Intakes can be larger than the size of the suction hose specified in Table 15.2.4.1(a). It is also advantageous to have valves on one or more of the intakes. On wildland fire apparatus the intake is usually a male thread fitting. The purchaser should specify if larger intakes are to be provided, if the intakes are to be male or female thread fittings, and if any of the intakes are to be equipped with valves.

Intakes at the front or rear of the apparatus or otherwise specially situated might not allow drafting-rated capacity at rated pressure. The purchaser should specify the flow rates required from auxiliary intakes, especially front and rear intakes or other intakes located 10 ft (3 m) or more away from the pump. When provided, the purchaser should also consider requiring the manufacturer to certify the actual flow rates from auxiliary intakes.

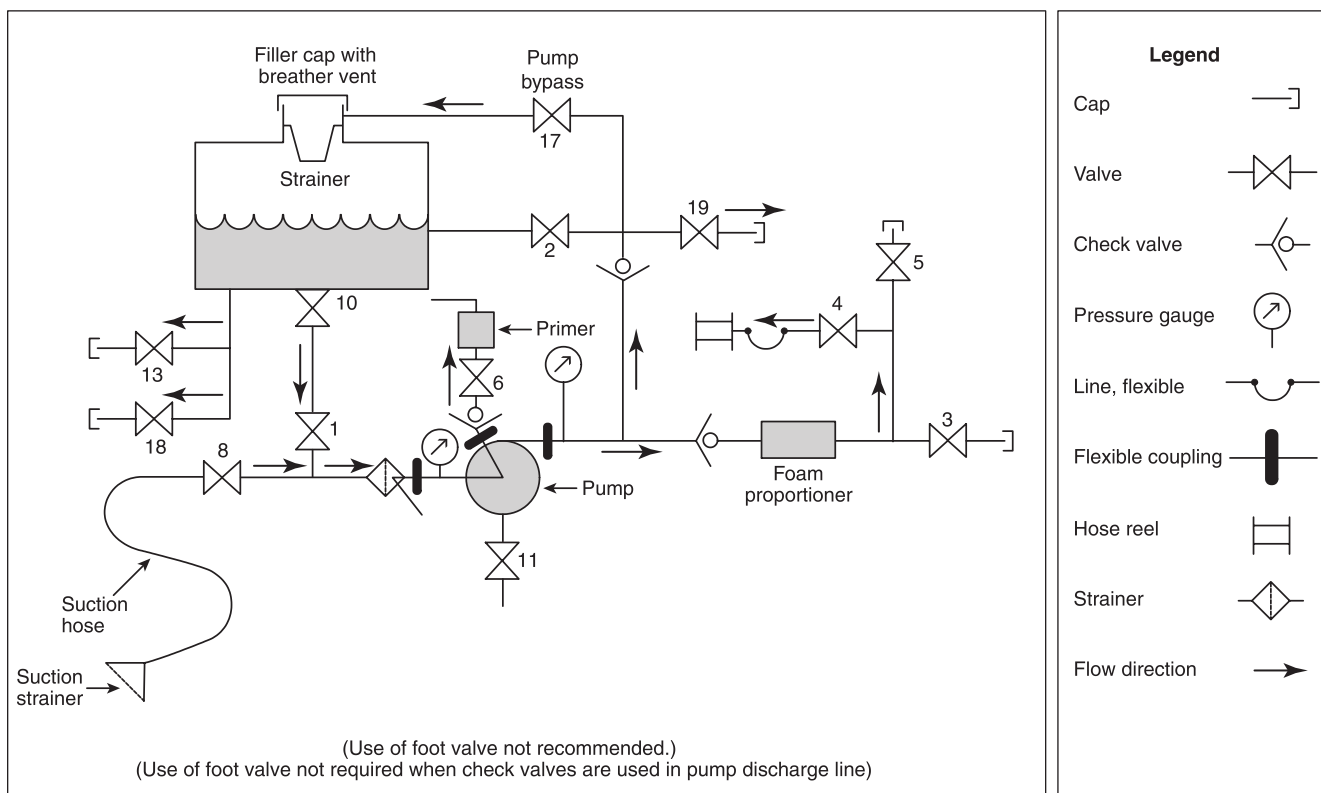
A.15.6.1.1 The purchaser should specify if there are any state regulations requiring backflow devices for hydrant operation. Backflow devices might restrict pump performance from draft.

A.15.6.1.3 Pressurizing a suction inlet could create a dynamic water hammer that might cause a hose or fitting failure, resulting in injury or death to anyone in the immediate vicinity. Valves should be opened and closed slowly, and lines should be charged slowly.

A.15.6.2.2 Sizing of the openings of the strainer(s) is intended for debris of generally uniform dimensions. It is recognized that debris of nonuniform dimensions — that is, long in relation to cross section — might be able to pass through the strainer(s) while not being able to pass through the pump.

A.15.6.10 If the purchaser plans to carry a valve, siamese, or adapter on a suction inlet while the apparatus is in motion, the manufacturer needs to know the details of the valve, siamese, or adapter so the manufacturer can accommodate the size of that valve, siamese, or adapter without it extending beyond the running board.

A.15.7.1 The flows listed for each outlet size are minimum and are for rating purposes only. If piping and valving are sufficient, much higher flows for a given outlet size might be achievable.



Valve Numbering System

The numbering system below has been adopted by the USDA Forest Service (other systems might also be available).

- | | |
|---|--|
| No. 1 from tank to pump | No. 12 pump coolant clean-out**† |
| No. 2 from pump to tank | No. 13 gravity tank drain |
| No. 3 from pump to overboard discharge | No. 14 foam-differential-valve shunt**† |
| No. 4 from pump to hose reel | No. 15 pump transfer valve* |
| No. 5 engine protection | No. 16 engine cooler line (heat exchanger)*† |
| No. 6 from pump to primer | No. 17 pump bypass |
| No. 7 adjustable pressure relief valve* | No. 18 low volume gravity (back pack fill) |
| No. 8 from overboard suction intake to pump | No. 19 water-only valve |
| No. 9 reserve supply from tank to pump**† | No. 20 feed #2 and/or #19* |
| No. 10 tank to plumbing shutoff valve | No. 21 discharge plumbing isolation valve* |
| No. 11 pump or plumbing drain valve | No. 22 tank fill with air gap* |

*Valves not shown in diagram.

†Valves not commonly used.

FIGURE A.15.5 Typical Plumbing Schematic for Centrifugal Pump.

A wildland fire apparatus might need a check valve in the plumbing, and the discharge side of the pump is the best location for the check valve, for the following reasons:

- (1) With a check valve in the discharge line of the pump, the suction plumbing and suction hose will not be subject to high pressures when the pump is shut down when pumping a high vertical distance [such as 600 ft (180 m) or more]. [Suction hose is generally not rated for high pressure; it is usually rated for about 100 psi (690 kPa).]
- (2) With the check valve located in the discharge line of the pump, the pump can be primed with a discharge valve open.
- (3) A check valve located in the discharge line of the pump will prevent foam solution from flowing back into the fire apparatus water tank or other water source.

- (4) With a check valve in the plumbing of a wildland fire apparatus, the water in a long hose lay will not be lost when the pump is shut down due to running out of water.
- (5) Higher suction flow rates and higher suction lifts can be obtained when the check valve is in the discharge line of the pump, as opposed to the use of a foot valve.
- (6) With a check valve in the discharge line of the pump or the use of a foot valve, the pump will hold prime when the pump is shut down.

If a check valve is used in the discharge plumbing or other location, it should be properly sized to reduce pressure drop. It should have a drain downstream of the checking device to permit water that might freeze and cause damage to be drained.

A.15.7.2.1 If flows greater than 100 gpm (400 L/min) through preconnected lines are needed, piping from the pump to the

preconnected hose lines should be larger than 1½ in. (38 mm) in order to keep the friction loss to a reasonable level.

A.15.7.2.2 For interoperability among fire departments at major incidents, National Hose threads are required. Adapters can then be used to adapt to locally used hose connections.

A.15.7.5 This standard does not specify where the valves should be located on discharge lines. Based on local operations, the purchaser should specify whether discharge valves are to be centralized at the pump operator's position or installed at the hose connection point. If the apparatus is designed for pump and roll, additional control might be desired inside the driving compartment.

A.15.7.5.3 Control of discharges on apparatus are now available in pull-type actuators, trunnion or swing valves, flexible push/pull controls, gear-operated hand wheel controls, and hydraulic, air, and electric operators. These are available with either quick-operating or slow-operating valve mechanisms. The nozzle and hose reaction and operational effort for high-flow or high-pressure discharges are critically important to many fire departments. Because of the variations in types of individuals and characteristics of operators involved with pump operations, a purchaser should carefully evaluate valve controls.

A.15.7.8.3 The flow should be no greater than 1 percent and no less than 0.5 percent of the pump's rated flow at the pump classification pressure or 150 psi (1000 kPa). If the recirculation valve is automatic, a check valve should be provided and an override shutoff should be considered if a foam system is provided.

A.15.7.8.3.1 For wildland apparatus that can be used in a relay pumping operation, the installation of an override shutoff in the pump cooling/recirculation line that returns to the water tank should be considered to avoid overflowing the water tank during extended operation. If equipped with an override shutoff, a warning label should be affixed near the override shutoff that states "Close valve only when relay pumping. During normal operation, serious bodily injury or pump damage can occur if valve is closed."

A.15.7.9 Where possible, discharge outlets should be positioned in an area away from the pump operator's position.

If a deck gun or monitor is to be mounted on the top of the apparatus, consideration should be given to designing the system so it can be operated without the need for a person to climb to the top of the apparatus. This can be accomplished by using a remotely operated monitor or by positioning the device so it is operable from the pump operator's position.

A.15.9.1 Ideally, having no intake or discharge connections at the operator's position would simplify and improve safety for the operator. If complete removal of these connections is impracticable, the reduction and careful placement of these connections, with operator safety in mind, would improve the situation considerably.

Operation of pump and discharge controls should not compromise the clearances of the operator's space on a top-mount pump panel or provide sharp edges, projections, or barriers to movement. The purchaser might want to state the clear walkway minimum space that is required.

Many fire departments have found it useful to color code the labels used to identify the various discharge and intake

controls. While this process can simplify pump operations, it can also create confusion if a pattern is not followed on all apparatus in the department. For standardization, the color-coding scheme in Table A.15.9.1 is recommended for all new apparatus labels.

A.15.10 The indicator lights and interlocks specified in this section are minimums. Some manufacturers or users might choose to add additional indicator lights or interlocks.

A.15.10.1.2 Pumps are operated from the side, top, front, or rear of the vehicle, and stationary pumping requires that no power is applied to the wheels during pumping. Therefore, it is essential that any controls that could apply power to the wheels while pumping be equipped with a means to prevent dislocation of the control from its set position in the pumping mode.

A.15.10.2 There are several ways to drive a pump from the chassis engine through a PTO. Each of them can be used with either an automatic or a manual transmission, but the interlocks and indicators with a manual transmission do not sense or depend on the gear selected. Generally, a driveshaft connects the PTO to the pump, except in the case of a split shaft PTO with a midship pump. In some cases, the PTO drives a hydraulic pump which drives a hydraulic motor driving the pump. The following are common PTO types:

- (1) *Pump driven through a split shaft PTO.* The driveline goes through a gearbox that either powers the rear driveline (road position) or the pump (pump position). This PTO can transmit the full power of the vehicle engine but cannot provide pump-and-roll functionality.
- (2) *Pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel (rear engine) PTO.*

Table A.15.9.1 Color Scheme for Labels on Discharge and Intake Controls

Discharge	Color
Preconnect #1 or front bumper jump line	Orange*
Preconnect #2	Red*
Preconnect #3 or discharge #1	Yellow*
Preconnect #4 or discharge #2	White*
Discharge #3	Blue
Discharge #4	Black
Discharge #5	Green
Deluge/deck gun	Silver
Water tower	Purple
Large-diameter hose	Yellow with white border
Foam line(s)	Red with white border
Booster reel(s)	Gray
Inlets	Burgundy

*Because the vast majority of fires are extinguished using preconnected lines, a fire department should give consideration to matching the hose jacket color to the color of these labels. Fire departments using this system have reported an improvement in fireground operations.

Each of these PTOs can be designed for stationary pumping only or for stationary pumping and pump-and-roll. Generally, there is a limit on the power available, but in some cases pumps as large as 1500 gpm (6000 lpm) can be driven. Each type of PTO has its advantages and disadvantages. Front-of-engine crankshaft PTOs are used for front-mount pumps. These drive choices are usually the only options if pump-and-roll capability is required from the chassis engine.

- (3) *Pump driven through a transfer case PTO or auxiliary transmission PTO.* The transfer case is part of the 4-wheel-drive system and can provide a PTO output for driving the pump. An auxiliary transmission PTO-driven pump functions much like a transfer case PTO-driven pump for 2-wheel-drive apparatus. These PTOs are suitable only for stationary pumping. These have been largely replaced by transmission-mounted or engine flywheel PTOs.

The following are descriptions of the interlocks and indicators for each type of chassis transmission and pump drive arrangement:

Stationary pump driven through split shaft PTO — automatic chassis transmission. Where the apparatus is equipped with an automatic chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pumping system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided in the driving compartment to indicate that the pump shift process has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in pump gear. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on.

Stationary pump driven through split shaft PTO — manual chassis transmission. Where the apparatus is equipped with a manual chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pumping system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

Stationary pump driven through transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO — automatic chassis transmission. Where the apparatus is equipped with an automatic chassis transmission; the water pump is driven by a

transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO; and the apparatus is to be used for stationary pumping only with the chassis transmission in neutral; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pump system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided both in the driving compartment and on the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in neutral. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on.

Stationary pump driven through transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO — manual chassis transmissions. Where the apparatus is equipped with a manual chassis transmission; the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO; and the apparatus is to be used for stationary pumping only with the chassis transmission in neutral; an interlock system is provided to ensure that the pump drive system components are engaged in pumping mode so that the pump system can be operated from the pump operator's position. A "Pump Engaged" indicator is provided both in the driving compartment and on the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

Stationary and "pump-and-roll" pump — automatic chassis transmissions. Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, and the apparatus is designed to be used in both stationary pumping mode with the automatic chassis transmission in neutral and "pump-and-roll" pumping mode in a road gear, an interlock system is provided to ensure that the pump drive system components are properly engaged so that the apparatus can be operated in either stationary or pump-and-roll pumping mode. A "Pump Engaged" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump shift has successfully completed. An "OK to Pump" indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged and the chassis transmission is in neutral. A "Throttle Ready" indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the "OK to Pump" indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on. An "OK to Pump-and-Roll" indicator is provided in the driving compartment and is energized when

the pump is engaged, the chassis transmission is in road gear, and the parking brake is released. When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized.

Stationary and “pump-and-roll” pumps — manual chassis transmissions. Where the water pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, and the apparatus is designed to be used in both stationary pumping mode with the chassis transmission in neutral and “pump-and-roll” pumping mode in a road gear; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the apparatus can be operated in either stationary or pump-and-roll pumping mode. A “Pump Engaged” indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided in both the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged. A “Throttle Ready” indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on. An “OK to Pump-and-Roll” indicator is provided in the driving compartment and is energized when the pump is engaged and the parking brake is released. When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized.

Stationary pumps driven through transfer case PTOs or auxiliary transmission — automatic chassis transmissions. Where the apparatus is equipped with an automatic chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline and through a transfer case, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the pumping system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided both in the driving compartment and at the pump operator's panel to indicate that the pump and parking brake are engaged, the chassis transmission is in pump gear, and the transfer case drive to the chassis wheels is in neutral. A “Throttle Ready” indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the chassis transmission is in neutral and the parking brake is on.

Stationary pumps driven through transfer case PTOs or auxiliary transmission PTO — manual chassis transmissions. Where the apparatus is equipped with a manual chassis transmission, the water pump is driven by the chassis engine through the transmission's main driveline and through a transfer case, and the apparatus is to be used for stationary pumping only; an interlock system is provided to ensure that the pump drive system components are properly engaged so that the pumping system can be operated from the pump operator's position. A “Pump Engaged” indicator is provided in the driving compartment to indicate that the pump shift has successfully completed. An “OK to Pump” indicator is provided in both the driving compartment and at the pump operator's panel to indicate

that the pump and parking brake are engaged, and the transfer case drive to the chassis wheels is in neutral. A “Throttle Ready” indicator is provided at the pump operator's panel to indicate throttle control at the pump operator's panel when either the “OK to Pump” indicator is on or if the apparatus is designed so that the chassis engine speed control is available at the pump operator's panel when the parking brake is on.

A.15.10.2.1.2 If the apparatus is equipped with an automatic chassis transmission and is not configured to provide engine speed control at the pump operator's panel when the parking brake is engaged and the chassis transmission is in neutral, both the “Throttle Ready” and the “OK to Pump” indicators will indicate at the same time when the apparatus is successfully placed in the “OK to Pump” configuration for stationary pumping mode. If the apparatus is configured to provide engine speed control at the pump operator's panel when the parking brake is engaged and the chassis transmission is in neutral, then only the “Throttle Ready” indicator will indicate when the apparatus is placed in this configuration. (See A.15.10.2.5.3.)

A.15.10.2.2 Completion of the pump shift might require that the chassis transmission be shifted into pump gear.

A.15.10.2.4 When the “OK to Pump-and-Roll” indicator is energized, the “OK to Pump” indicator is not energized.

A.15.10.2.5.3 The purchaser should specify if they want throttle control at the pump panel when not in “OK to Pump” mode. Engine speed advancement control at the operator's panel might be required for apparatus with the need to control the engine speed during operation of a generator, aerial device, alternator, or other chassis-engine-driven device. The indicating device for this “Throttle Ready” condition is the same indicating device as in 15.10.2.5.2.

Other apparatus might not have equipment for which it is necessary to control engine speed from the pump operator's panel. Engine speed control at the pump operator's panel for these apparatus might not be desirable because, on many chassis engines, activating remote throttle operation automatically disables the in-cab accelerator pedal. For such apparatus, engine speed advancement control at the pump operator's panel is not required when the chassis transmission is in neutral and the parking brake is engaged, so a “Throttle Ready” indication is not required.

A.15.10.4 The purpose of a pressure control system is to control the discharge pressures in order to protect firefighters who are operating hose streams as well as to protect discharge hose from damage in the event attack hose streams are shut off or other valves are closed, reducing flow rates.

The system could consist of a discharge relief valve, a pressure regulator that controls the speed of the pump, an intake relief valve, or any combination of these devices. Pressure control systems will relieve excess pressure when valves are closed in a normal manner, but some water hammer conditions could occur due to valves being closed so quickly that the system cannot respond fast enough to eliminate damage to equipment. Proper fireground procedures are still required.

A.15.10.4.1 Pressure control systems can be supplied in the following forms:

- (1) Integral with the pump and supplied by the pump manufacturer

- (2) As an external system of components supplied by the apparatus manufacturer
- (3) As an external control system provided by a pressure control manufacturer
- (4) Properly selected pump, PTO ratio, and discharge sizes to limit pressure rise to less than 30 psi (207 kPa)

Pressure governors control the engine speed, which relates directly to the net pump pressure. If the speed is raised, the pressure goes up; if the speed is lowered, the pressure goes down.

Discharge relief valves control pressure by passing water from the discharge side of the pump back into the intake side of the pump. This type of system works in a pressure differential of at least 70 psi to 90 psi (500 kPa to 600 kPa) between the intake and discharge sides of the pump. If the pressure differential is not present, the discharge relief valve might not control a pressure rise completely.

If either a discharge relief valve or a pressure governor is used with high incoming inlet pressures, an intake relief valve or total control system should be added.

In the case where an intake relief valve is selected, it should be of sufficient size and response time to handle the pump performance range. It should also be easily controlled by the pump operator so that this incoming pressure can be adjusted for each incident. For best results, the operator should set the intake relief valve to operate at 90 psi (600 kPa) below the desired discharge operating pressure.

The pressure control system should be certified by the appropriate manufacturer or an independent third-party certification organization. Because of the importance of these systems, the purchaser might wish to have performance tests conducted on the installed system.

A.15.10.5 Departments that need to attain a draft while conducting operations off tank water will find that adding a primer selector valve or second priming control valve to allow attaining a draft on the outboard side of the gated pump suction valve will reduce the potential loss of continuous water flow while supplying attack lines. A vacuum line is run to the outboard side of the valve and connected through a selector valve to the primer. Side, front, and rear selector settings can be arranged to allow priming off any side of the unit with one primer.

A.15.10.5.3 For best priming and pump performance when priming from the suction with the pump running, the following should be adhered to:

- (1) A check valve should be used at the discharge of the pump.
- (2) The prime should be taken at the eye of the impeller or at the top of the intake to the pump.
- (3) A smooth bell-shaped strainer inlet should be used on the end of the suction hose. A foot valve should not be used.
- (4) Suction hose should only be as long as necessary.
- (5) There should be no humps in the suction hose.

A.15.11.1 The electronic throttle control systems that are currently available will provide greater flexibility for the operator because they can be set like a traditional throttle or a pressure governor.

A.15.12.1.1 A pumping engine fuel level indicator or red warning light indicating when the fuel level falls below one-

fourth of the capacity of the tank(s) should be provided on the pump operator's panel.

A.15.12.2 The purchaser may wish to require a ¼ NPT test port at the pump output and the pump intake to improve the efficiency of the annual pump test process.

A.15.12.2.1.5 A drain should be installed at the connection of the pressure line to the gauges (back of the gauge or bottom, both intake and discharge gauges).

A.15.12.2.2 A drain can be installed at the connection of the pressure line to the gauges (back or bottom of the gauge, both intake and discharge gauges).

A.15.12.2.4 It might also be desirable to have a pressure gauge in the cab in view of the driver when the pump that is being used in a pump-and-roll operation is driven by a separate engine.

A.15.12.3.2 Because the rated operating pressure of large-diameter supply hose is substantially less than that of attack fire hose, an individual pressure gauge is required to allow the operator to control the discharge pressure even where a flowmeter is provided.

A.15.13.1.3 The purchaser might want to consider an instruction plate mounted at the pump operator's position giving basic instructions on valve positions for standard firefighting operations, possibly including the following:

- (1) Pumping fighting fire from tank
- (2) Fighting fire from external water source
- (3) Refilling tank from external water source

A.15.13.2.1.2 Where tests are performed inside a structure or other location having limited air circulation, carbon monoxide monitoring equipment should be used. Such equipment should be checked and calibrated regularly and should include a warning device.

A.15.13.2.1.2(4) The suction lift capability of a fire pump is certified by the pump manufacturer for specific conditions of altitude above sea level, atmospheric pressure, water temperature, and friction and entrance loss caused by the flow of water through the intake strainers and hose as stated in 15.2.4.1. As the temperature of the water increases and barometric pressures decreases, the suction lift capability of the fire pump is reduced. While the minimum lift of the test site for the pumping test is 3 ft (1 m), the test site configuration must not provide a vertical lift that exceeds the suction lift capability of the pump as a result of elevated water temperatures and reduced barometric pressure. See Table A.15.13.2.1.2(4).

Table A.15.13.2.1.2(4) Effect of Water Temperature and Barometric Pressure on Suction Lift Capability

Water Temperature		Effect on Lift		Barometric Pressure		Effect on Lift	
°F	°C	ft	m	in. Hg	kPa	ft	m
60	16	0	0	29.9	101.3	0	0
90	32	-1	-0.3	29.0	98.2	-1	-0.3
110	43	-2.3	-0.7				
120	49	-3.3	-1.0				

A.15.13.2.2.3 Square-edged circular orifice and pressure gauge is an accurate method of measuring low pump flows found on wildland fire apparatus. Flow through a square-edge circular orifice can be determined using the following formula:

[A.15.13.2.2.3]

$$Q = 29.8 \times C \times d^2 \times \sqrt{P}$$

where:

Q = flow (gpm)

C = orifice discharge coefficient (0.62 recommended)

d = orifice diameter (in.)

P = pressure (psi)

For best accuracy, the water supply line to the square-edge circular orifice should be a minimum of two times the diameter of the orifice.

A.15.13.2.3.2 Where an engine is operating at or near full power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that, when touched, can cause extreme discomfort or injury. However, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

The suction lift can be determined either by measuring the negative pressure (vacuum) in the pump intake manifold with a test gauge that measures vacuum accurately or by adding the vertical lift and the value of friction and entrance loss from Table 15.2.4.1(b) or Table 15.2.4.1(c). To be accurate, the vacuum gauge should be at the same level as the intake of the pump with no gauge line or a very short gauge line. If a long gauge line is used, a purge valve at the gauge connection to the gauge line should be installed and opened and closed when running to purge the gauge line of any water. If the vacuum gauge and the pump intake are at different levels with water in the gauge line, an incorrect reading will result. Opening and closing the purge valve at the vacuum gauge when operating will purge the gauge line. Every foot of water in the vacuum gauge line will result in almost an inch of mercury error of vacuum.

The net pump pressure can be calculated by using the following formula:

U.S. units:

[A.15.13.2.3.2a]

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

or

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

where:

P = net pump pressure (psi)

D = discharge gauge pressure (psi gauge)

H = vacuum gauge reading (in. Hg)

L = vertical lift (ft)

F = friction and entrance loss (ft of water)

SI units:

[A.15.13.2.3.2b]

$$P_m = D_m + H_m$$

or

$$P_m = D_m + F_m + 9.8 L_m$$

where:

P_m = net pump pressure (kPa)

D_m = discharge gauge pressure (kPa gauge)

H_m = vacuum gauge reading (kPa)

F_m = friction and entrance loss (kPa)

L_m = vertical lift (m)

A.15.13.6.5 When the test is done with intake valves open and intakes capped, the apparatus could have a bad intake valve that would not be detected. By conducting a second test with the intake valves closed and intakes not capped, a leaking intake valve would be detected.

A.15.13.8 The engine speed advancement interlock system test verifies the proper functioning of the throttle controls and indicator for various conditions of chassis transmission(s), parking brake, and pump shift control action status. Testing should be performed with a qualified person positioned in the driving compartment and a qualified person verifying indicators and engine speed control status at the pump operator's panel. Shifting of the pump transmission/PTO should be done in accordance with the manufacturer's instructions.

A.15.13.10 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might wish to specify that these tests also be certified by the independent third-party certification organization.

A.16.2.4 For apparatus with the rating for the ultra-high pressure fire pump based on the pump taking water from the apparatus water tank, the supply of water from the water tank through the plumbing to the pump should provide adequate pressure at the pump intake to avoid cavitation while pumping. By the pump manufacturer certifying the Net Positive Suction Head Required (NPSHR) value for the rated capacity and discharge pressure, the apparatus manufacturer can design water tank-to-pump plumbing to ensure that the performance as installed on the finished apparatus will meet requirements.

A.16.5.2 The arrangement of ultra-high pressure fire pumps and associated equipment, including the apparatus water tank and associated intake piping and valves, might require controls at more than one pump operator's position.

A.16.5.3 Apparatus used outside of the United States can have intake connections other than NH if specified by the authority having jurisdiction.

A.16.6.1 The arrangement of ultra-high pressure fire pumps and associated equipment, including the discharges, might require controls at more than one pump operator's position. Discharges designed to be operated while the apparatus is moving can be controlled only from the cab pump operator's position.

A.16.6.7 On UHP systems on which a tank fill line is included, the large pressure drop that exists between the UHP pump discharge should be considered when sizing the line and material and for choosing the design and type of valve. The use of an orifice or other means of providing the pressure drop should be considered.

A.16.8.1 The pump system discharge manifold can be equipped with a start/run valve to bypass the normal operating discharge system and primary pressure valve. This start/run valve would divert water flow from the pump discharge to atmosphere or the tank providing easy starting of the pump engine or drive system and avoiding pressure buildup in the discharge manifold until it is needed for operation.

A.16.8.5.1 For apparatus that will be exposed to freezing temperatures, consideration should be given to a winterization system that includes a small tank for antifreeze solution and proper valves to inject a mixture of antifreeze into the pump and hose reel system. It can be very difficult to drain a piston- or plunger-type pump and hose reel with a standard drain valve. Air blow-out systems can be used on trucks with air systems. An antifreeze injection system is a simple and effective way to winterize the pump and hose reel system.

A.16.8.6.1 A large pressure drop exists between the UHP pump discharge and the water tank that should be considered when sizing the line and material. The use of an orifice or other means of providing the pressure drop should be considered. Consideration should be given to using thermally activated overheat protection devices that are available that sense water temperature within the pump. When the water reaches a predetermined temperature, the device releases water from the pump discharge to ground or back to the apparatus water tank.

A.16.10 UHP systems can experience issues with high operating temperatures, or damage due to cavitation or running dry without an adequate water supply. Consideration should be given to specifying an oversight system that can monitor discharge pressure, water temperature, and water tank level/water supply and that can reduce engine speed or shut off the engine if system parameters fail to meet established values and the pump operator is not able to take corrective action in a timely manner.

A.16.12.1.2 The purchaser might want to consider an instruction plate mounted at the pump operator's position giving basic instructions on valve positions for UHP firefighting operations.

A.16.12.4.2 Where an engine is operating at or near full power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that, when touched, can cause extreme discomfort or injury. However, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

A.16.12.5.7 Values for intake and discharge pressure can be obtained with test gauges in 16.12.3.3 connected to the pump intake and discharge. Alternatively, if the pumping test is performed from the apparatus water tank and the intake plumbing does not include provisions for connection of a test gauge, the pressure at the pump intake can be determined by calculating the tank head pressure less the friction loss through the intake plumbing. If the pump discharge does not include provisions for connection of a test gauge and the pump has

more than one discharge outlet, the pump discharge pressure can be measured at an unused discharge outlet connection.

Positive-displacement UHP pumps equipped with trap pressure unloaders trap pressure between a check valve in the outlet of the unloader and the discharge nozzle when the spray nozzle is closed while bypassing pump output back to the pump intake or back to a tank. The pump recirculates water without building any more pressure than is required to overcome the friction loss of pushing the water through the unloader and through whatever passageway (internal passageway or external hose, pipe, and so on) back to intake or tank. UHP systems on which the discharge pressure gauge is installed on the pump head will indicate a significant drop in the observed gauge pressure when the discharge is closed. If the observed final discharge pressure reading during the pressure control test fails to indicate a significant drop, this might indicate that the setting of the unloader is incorrect, the check valve is damaged or fails to fully close, or the bypass passageway has become restricted. Such changes indicate that the unloader should be investigated and repaired.

A.16.12.10 See A.13.13.8.

A.16.12.12.2.3 The closures, caps, or plugs furnished with the apparatus as required by 16.5.3.3 are only required to be capable of withstanding pressures 250 psi above the maximum pump close-off pressure. Special capping means can be used to perform the piping integrity test at 1.4 times the maximum pump close-off pressure.

A.16.12.12.3.1(5) The cooling flow should be as low as possible to prevent damage to the pump while maximizing the hydrodynamic test pressure.

A.17.2.3 Water tanks should have provisions that allow for complete inside cleaning. The purchaser should indicate in the specifications if access to the interior of the tank is required.

A.17.2.4 Water tanks can appear in several different configurations, such as round, elliptical, rectangular, or T-shaped. Handling characteristics of the apparatus can be greatly affected by its vertical and horizontal centers of gravity. The purchaser should indicate the filling and dumping rates required if those rates exceed the requirements of this standard, and any other local needs, and let the apparatus manufacturer design the tank shape to best meet the axle-loading and center-of-gravity requirements.

If the tanks are made as one unit with the body and compartments, the material used is important. It should be corrosion-proof and should not easily cause condensation.

A.17.2.6 The design of a water tank can be a critical factor in the handling characteristics of fire apparatus. If water is free to travel either longitudinally or laterally in a tank, as would be the case if the tank were half full, a tremendous amount of inertia can build up that will tend to force the fire apparatus in the direction the water has been traveling. When the water reaches the end of the tank, the sudden application of force can throw the fire apparatus 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 way to prevent such accidents is to restrict or disrupt the movement of the water so that the inertia will not build up in one direction. This is done with the installation of swash partitions to either contain the water in smaller spaces within the tank (containment method) or disrupt its momentum by changing its direc-

tion of motion (dynamic method). The partitions in a containment system create compartments that are interconnected by openings between them so that air and water can flow at the specified rate when the tank is being filled or emptied. The partitions in a dynamic system are often staggered in an arrangement designed to change the direction of the water and turn it into a turbulent motion that absorbs much of its own energy.

A.17.3.3 A check valve installed in the tank-to-pump line is the most common method used to prevent water from backflowing into the tank at an excessive rate if the pump is being supplied from a hydrant or relay pumper and the tank-to-pump line valve has been inadvertently left in the open position.

A hole up to $\frac{1}{4}$ in. (6 mm) is sometimes provided in the check valve to release steam or other pressure buildup.

A.17.4.1 Where rapid filling of the water tank on a structural fire apparatus from an external source is desired, the purchaser should consider an inlet directly into the tank that is capable of allowing the tank to be filled at a rate of 1000 gpm (4000 L/min). Where such a fill connection is provided, it should conform to the requirements of 17.5.1.

A.17.4.1.1 The intent of 17.4.1.1 is to allow filling the tank by the insertion of a common $2\frac{1}{2}$ in. (65 mm) hose with coupling into the fill opening. The opening does not need to be round in shape.

A.17.4.1.4 An excessive flow rate when a tank is being filled could result in a pressure buildup in the tank that could cause permanent damage or failure.

A.17.4.2.1.1 Adequate venting is usually achieved when the vent area is at least one-quarter the area of the tank outlet. If operations require filling or draining of the tank at rates in excess of the rated capacity of the pump, increased venting capability might be needed. The required rate of filling or draining the tank should be specified by the purchaser.

A.17.4.2.2.1 A vent/overflow outlet is necessary so that overpressurization does not occur within the tank while it is being filled. However, water is likely to spill out of the vent/overflow while the fire apparatus is moving (e.g., accelerating, decelerating, or cornering). The fill tower and vent/overflow outlet should be arranged so that water spillage is minimized and is directed behind the rear tires.

The purchaser might wish to specify a sealed water tank and overflow system design that will eliminate water spill while the vehicle is in motion.

A.17.4.3.1 If a larger fill line is desired, the buyer should consult with the manufacturer on construction of the tank inlet location and any required reinforcement or alternation of the tank baffles. It is necessary to design the tank with venting and overflow capability for the maximum fill rate.

A.17.4.3.2 See A.17.4.3.1.

A.17.4.3.3 See A.17.4.3.1.

A.17.4.3.4 A locking-type ball valve, globe valve, needle valve, or other type of valve capable of regulating flows should be used. A gate valve is not recommended.

A.17.5.1.1 Where large filling rates are used, fill connections should be equipped with a diffuser inside the tank to minimize potential structural damage. It is important that the purchaser

evaluate how the apparatus will be used and define the location and type of fittings desired on this tank fill.

Where rapid filling of the water tank on another type of apparatus from an external use is desired, the purchaser should consider an inlet directly into the tank that is capable of allowing the tank to be filled at a rate of 1000 gpm (4000 L/min). Where such a fill connection is provided, it should conform to the requirements of 17.5.1.

A.17.5.2 It is important that the purchaser evaluate how the apparatus will be used and define the location(s) and types of fittings for these outlets.

Where rapid dumping of the contents of the water tank to an external use is desired on other types of apparatus, the purchaser should consider an outlet directly from the tank that is capable of allowing water to be transferred from the tank at an average rate of at least 1000 gpm (4000 L/min).

A.17.5.2.2 Additional methods might be desired to improve the off-loading rate of gravity dumps. These methods include a jet assist or a pneumatic pump. Control should be from the pump operator's position. Two types of jet assists can be used, one directed into the throat of the gravity dump and the other a peripheral jet system. Figure A.17.5.2.2(a) shows how the traditional jet is installed. A smooth-tipped "jet" nozzle is supplied by a pump that is capable of delivering at least 250 gpm (1000 L/min) at a gauge pressure of 150 psi (1000 kPa). Jet nozzles range in size from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. (19 mm to 32 mm). The diameter of the tip will be determined by the capacity of the pump being used and the diameter of the discharge piping and dump valve.

The peripheral application of jet assist nozzles has proved highly effective. This approach utilizes two or more jets installed in the sides of the discharge piping just outside the quick dump valve. In addition to the reported discharge advantages of peripheral discharge streams, the externally fed system is easier to plumb and has fewer maintenance problems. The jets, installed 25 degrees to 30 degrees from the piping wall, contact more surface area of the discharging water, thereby increasing water discharge efficiency. Because the water is drawn through the dump valve, less turbulence is created, and the eddy effect often present with traditional in-line jets is overcome. Nozzles made by welding reducer pipe fittings work very effectively as jets. Flow rates of 2000 gpm (8000 L/min) have been obtained using a 300 gpm (1100 L/min) pump to supply two $\frac{3}{4}$ in. (19 mm) nozzles in a 6 in. (150 mm) dump valve configuration. Figure A.17.5.2.2(b) shows a diagram of a peripheral jet assist arrangement.

A pneumatic system can be used to pressurize a tank and assist in expelling water. The vacuum pumps can also be used for filling the tank.

A.17.6.1 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might wish to specify that the water tank capacity also be certified by the independent third-party certification organization.

A.18.1.1 When a foam system is installed on a wildland fire apparatus, the purchaser should consider specifying a water-only (no foam) discharge. A water-only discharge can be used to offload clear water to another apparatus or portable water tank, to prevent foam solution from re-entering the water tank when operating an ejector, and for operation near sensitive environmental areas. Much research and development has been done in recent years with foam and foam systems, particu-

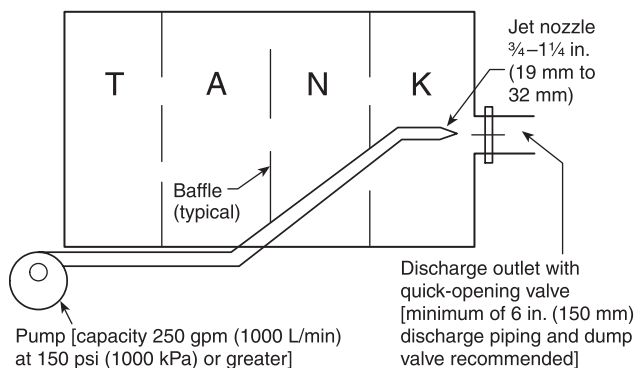
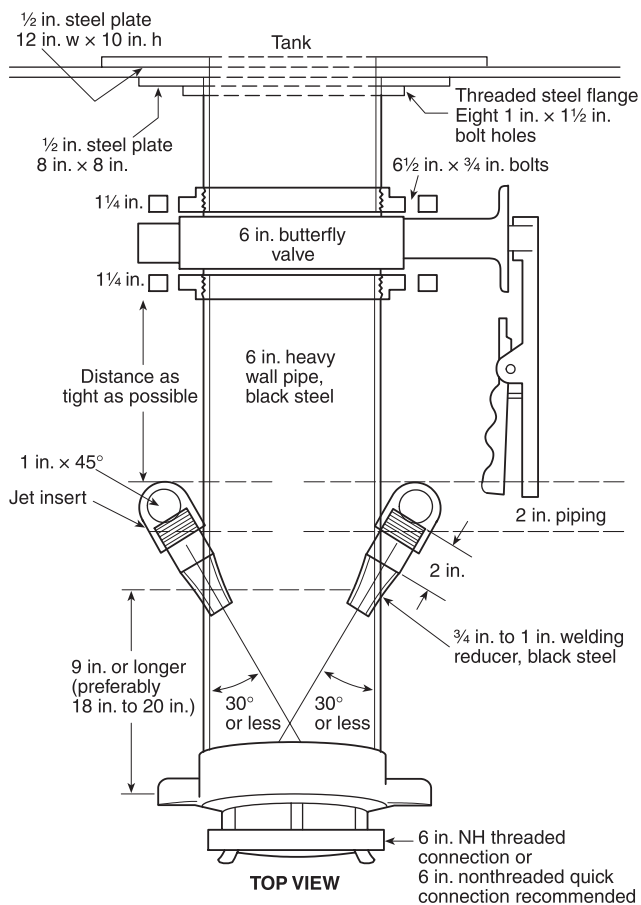


FIGURE A.17.5.2.2(a) Traditional Internal Jet Dump.



For SI units, 1 in. = 25.4 mm.

FIGURE A.17.5.2.2(b) Peripheral Jet Assist Arrangement (Top View).

larly in the areas of Class A and CAFS foams. It is generally accepted that Class A foam can increase efficiency of plain water to approximately double and with CAFS to increase as much as four times. There are many ways to introduce foam into the pumping systems on fire apparatus, some of which are simple and inexpensive. When evaluating options for new apparatus, purchasers should consider their operating requirements to determine their needs for foam systems. The addition of a foam system can add a substantial amount of efficiency to fire scene operations and ultimately increase safety for firefighters.

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. Information on foam concentrates for Class A fires is available in NFPA 1150.

The following terms are not used in this document but are associated with foam proportioning systems and are included here to aid understanding.

Aerated Foam. The end product of a discharge of foam solution and air.

Aspirate. To draw in air. Nozzle aspirating systems draw air into the nozzle to mix with the agent solution.

Aspirated Foam. The end product of a mechanically induced air stream that is drawn into the foam solution at atmospheric pressure to create foam. The aeration is generated by the energy of the foam solution stream.

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

Batch Mix. The manual addition of foam concentrate to a water storage container or tank to make foam solution.

Foam Blanket. A body of foam used for fuel protection that forms an insulating and reflective layer from heat.

Foam-Capable Fire Apparatus. A fire apparatus carrying aspirating foam nozzle(s) and equipped with an automatic regulating foam proportioning system injecting foam concentrate into the discharge or pressure side of the water pump.

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

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

Proportioning Ratio. The ratio of foam concentrate to water, usually expressed as a percentage.

Surface Tension. The elastic-like force in the surface of a liquid that tends to bring droplets together to form a surface.

Wetting Agent. A chemical that reduces the surface tension of water and causes it to spread and penetrate more effectively than plain water but does not foam.

A.18.2 Foam proportioning systems can be designed with the following features:

- (1) The ability to proportion different types of foam concentrate, including Class A and Class B foam concentrates
- (2) The ability to proportion foam concentrate at fixed or variable proportioning ratios
- (3) The ability to proportion foam concentrate into single or multiple discharge outlets
- (4) The ability to supply foam solution and water simultaneously from multiple discharge outlets
- (5) Manual or automatic foam proportioning system operation

A.18.2.1 In-line eductor foam proportioning systems are installed in the water pump discharge as a permanently installed device or as a portable device. Water is forced through the eductor venturi by water pump discharge pressure, creating a vacuum that causes foam concentrate to be pushed by atmospheric pressure into the eductor (into the water stream) at the design rate of the device [see Figure A.18.2.1(a)]. By design, a nonrecoverable pressure drop of 30 percent or greater is required for eductor operation. The maximum recovered pressure, including friction loss and static head pressure, is nominally 65 percent of the inlet pressure to the eductor. The in-line eductor is a manually regulated foam proportioning system.

A variable flow bypass eductor system is a modification of the in-line eductor foam proportioning system. An eductor is placed in a bypass line around the main line waterflow control valve so that when the valve is adjusted to produce waterflow through the bypass eductor, foam concentrate is drawn into the eductor (into the water stream) [see Figure A.18.2.1(b)]. The foam solution in the bypass line is then joined with the main line waterflow downstream of the waterflow control valve. The variable flow bypass eductor is a manually regulated foam proportioning system.

A variable pressure eductor is another modification of the in-line eductor foam proportioning system. This type of eductor is designed to automatically adjust the area of the eductor venturi to compensate for changes in water pressure at the inlet of the device. Better performance (less pressure loss) can be achieved by having the eductor in the straight line position with the main line and the waterflow control valve in the offset position. The reason for this is that the small eductor sets the pressure drop and the water control valve merely matches the pressure losses of the eductor and fittings directing flow to the eductor. If the eductor flow has to flow through two branching tees and two elbows, the water control valve must match those pressure losses. If the eductor is in the straight line position, pressure losses of two branching tees and two elbows are not present in the eductor branch of the variable flow bypass eductor; therefore, the total pressure loss across the proportioning system is only that of the eductor. The variable pressure eductor is a manually regulated foam proportioning system.

A.18.2.2 Self-educing master stream nozzles are mounted on the discharge side of the pump. These devices make up a complete foam proportioning system consisting of a foam proportioner and application device (nozzle). Self-educing master stream nozzles have the following operating characteristics:

- (1) Automatic or operator-adjustable foam solution rates
- (2) Minimal pressure drop

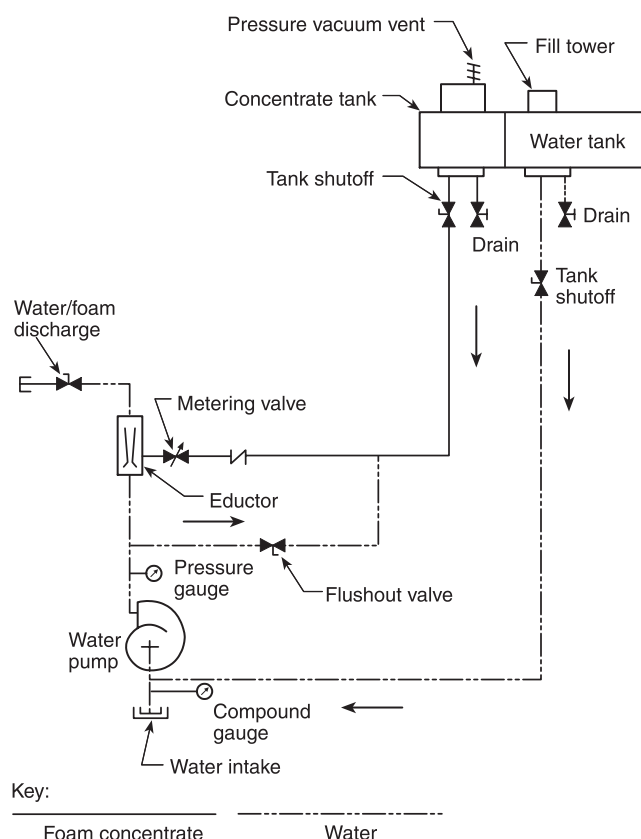


FIGURE A.18.2.1(a) In-Line Eductor Foam Proportioning System.

A.18.2.3 An intake-side foam proportioning system is a manually regulated system. An in-line device installed in the water pump intake line provides a connection through a foam concentrate metering valve to the foam concentrate tank. The vacuum created by the water pump allows atmospheric pressure to push foam concentrate directly into the pump intake. Hydrant or relay operation is not possible with this type of foam proportioning system.

A.18.2.4 Around-the-pump proportioning systems operate with an eductor installed between the water pump discharge and the intake. A small flow of water from the water pump discharge passes through the eductor, which creates a vacuum that causes foam concentrate to be pushed into the eductor and discharged into the pump intake. Around-the-pump foam proportioning systems require a pressure differential of 30 percent to 50 percent of inlet pressure for efficient operation.

A manual around-the-pump proportioning system utilizes a manually adjustable foam concentrate metering valve to control the proportioning ratio. [See Figure A.18.2.4(a).]

A flowmeter sensing around-the-pump proportioning system utilizes a flowmeter sensing system to monitor total solution flow and foam concentrate flow. The flow data are transmitted to an electronic control that regulates the proportioning ratio through a foam concentrate metering valve. [See Figure A.18.2.4(b).]

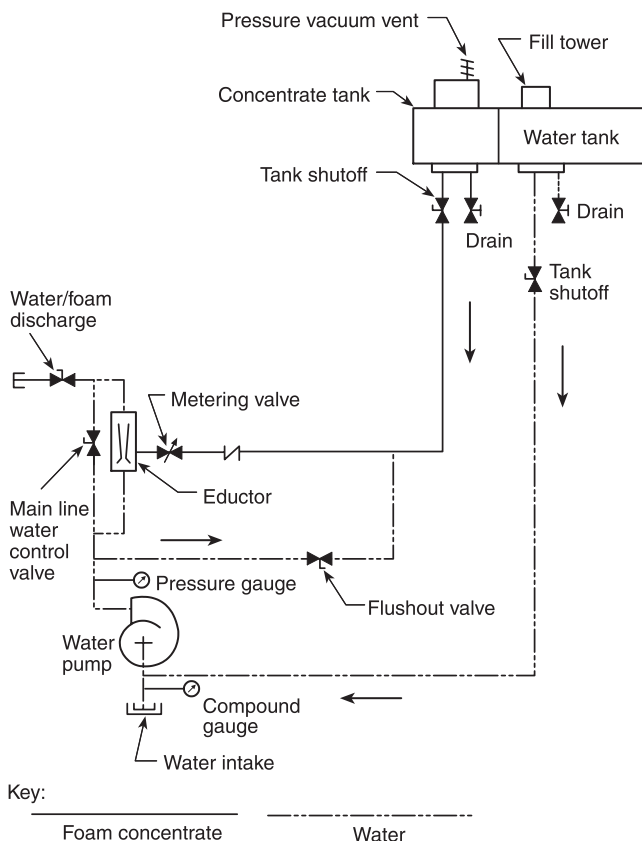


FIGURE A.18.2.1(b) Variable Flow Bypass Eductor System.

A.18.2.5 Balanced pressure foam proportioning systems are installed on the discharge side of the water pump. Two orifices discharge water and foam concentrate into a common ratio controller (proportioner) located in the water pump discharge. By adjusting the area of the orifices to a particular ratio, the percentage of injection can be controlled if the intake pressures are equal. The method of controlling or balancing the foam concentrate pressure with the water pressure varies with different balanced pressure system designs. The two basic types of balanced pressure systems are systems without a foam concentrate pump and systems with a concentrate pump. Balanced pressure foam proportioning systems generally are automatic regulating foam proportioning systems.

Balanced pressure systems without a foam concentrate pump are referred to as “pressure proportioning systems” [see Figure A.18.2.5(a)]. These systems utilize a pressure vessel with an internal bladder to contain the foam concentrate. When in operation, water pump pressure is allowed to enter the pressure vessel between the shell and the internal bladder to exert pressure on the internal bladder. The foam concentrate is forced out of the bladder to the foam proportioner at a pressure equal to the water pump pressure.

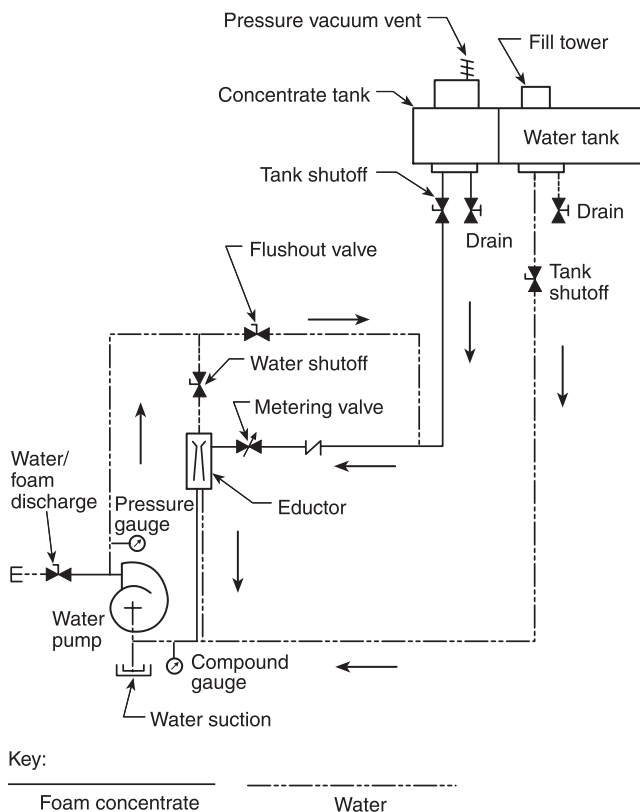


FIGURE A.18.2.4(a) Manual Around-the-Pump Proportioning System.

Two basic types of balanced pressure foam proportioning systems utilize a foam concentrate pump: a bypass system and a demand system. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank in these types of foam proportioning systems.

The bypass system utilizes a valve in the foam concentrate pump recirculating line that balances the foam concentrate and water pressure by bypassing excess foam concentrate. [See Figure A.18.2.5(b).]

The demand system is designed to control the speed of the foam concentrate pump, resulting in control of the pump discharge pressure to achieve a balance of foam concentrate and water pressure within the system. [See Figure A.18.2.5(c).]

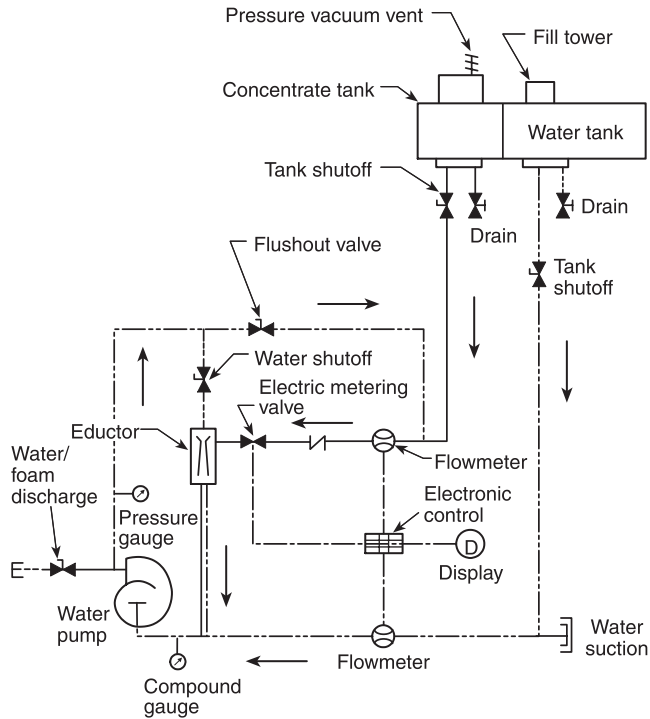


FIGURE A.18.2.4(b) Flowmeter Sensing Around-the-Pump Proportioning System.

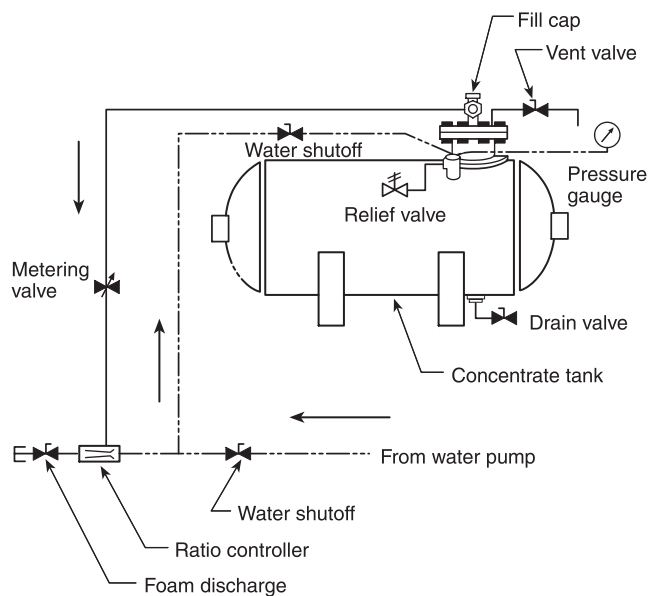


FIGURE A.18.2.5(a) Pressure Proportioning Balanced Pressure Proportioning System.

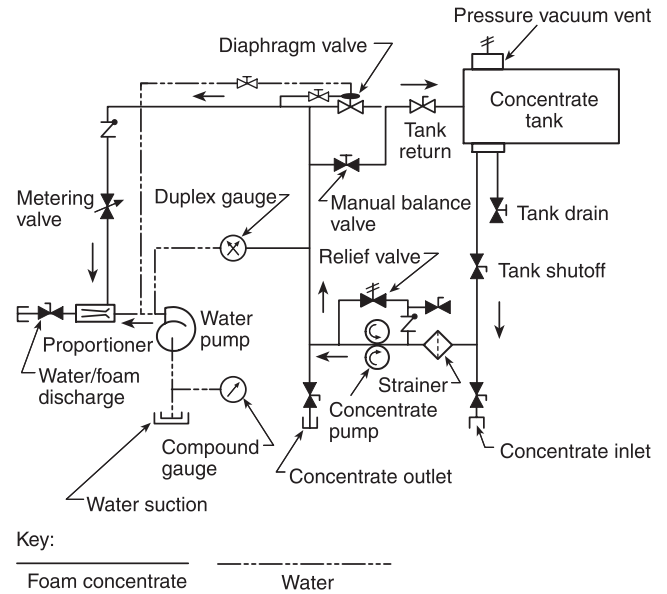


FIGURE A.18.2.5(b) Bypass Balanced Pressure Proportioning System.

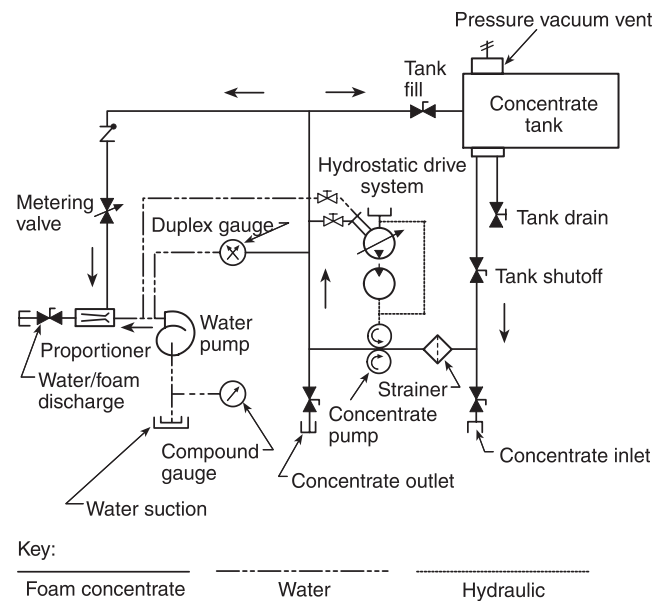


FIGURE A.18.2.5(c) Demand Balanced Pressure Proportioning System.

A.18.2.6 Direct injection foam proportioning systems utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while the foam concentrate tank is being refilled. Direct injection foam proportioning systems generally are automatic regulating foam proportioning systems.

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

- (1) An electronic control receives electronic signals corresponding to the proportioning ratio from the control panel and waterflow data from the flowmeter. The electronic control then commands the foam concentrate pump module to deliver foam concentrate at the proportional rate. [See Figure A.18.2.6(a).]
- (2) An electronic control receives electronic signals corresponding to the foam concentrate flow from a foam concentrate flowmeter, the proportioning ratio from the control panel, and waterflow data from the water flowmeter. The electronic control regulates the proportioning ratio through a foam concentrate metering valve. [See Figure A.18.2.6(b).]

A conductivity-sensing direct injection foam system utilizes an electrical conductivity sensor(s) to sample the fire pump discharge water prior to foam concentrate injection and transmits this information to an electronic control. A second electrical conductivity sensor samples the foam solution and transmits this information to the electronic control that regulates the foam pump motor speed based on the ratio selected by the operator. Since flow rate affects conductivity readings, a flowmeter transmits the flow rate through the process manifold to the electronic control. [See Figure A.18.2.6(c).]

A.18.2.7 In a water motor foam proportioning system, a water motor drives a positive displacement foam concentrate pump.

The water motor can be either a positive displacement type or a turbine type. Water motor foam proportioning systems are automatic regulating foam proportioning systems.

Where a positive displacement water motor drives the foam concentrate pump, the ratio of the water motor displacement to the displacement of the foam concentrate pump is the ratio of the desired foam solution. A positive displacement water motor proportioning system requires no external power. [See Figure A.18.2.7(a).]

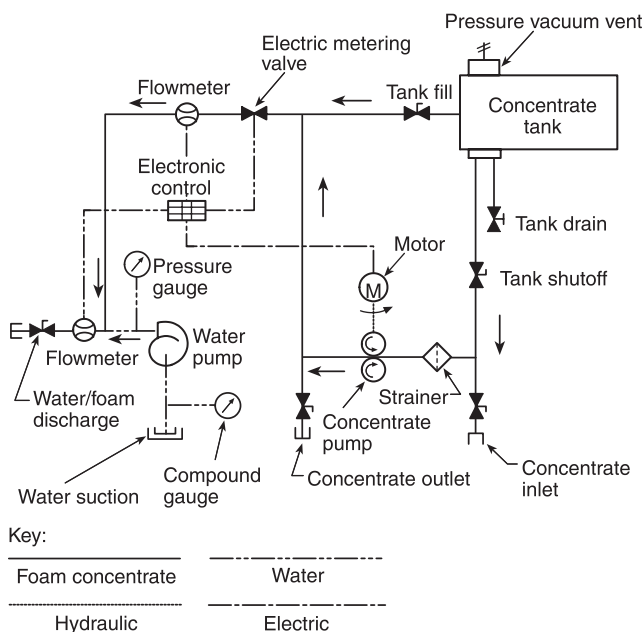


FIGURE A.18.2.6(b) Dual-Meter Flow-Sensing Direct Injection Foam Proportioning System.

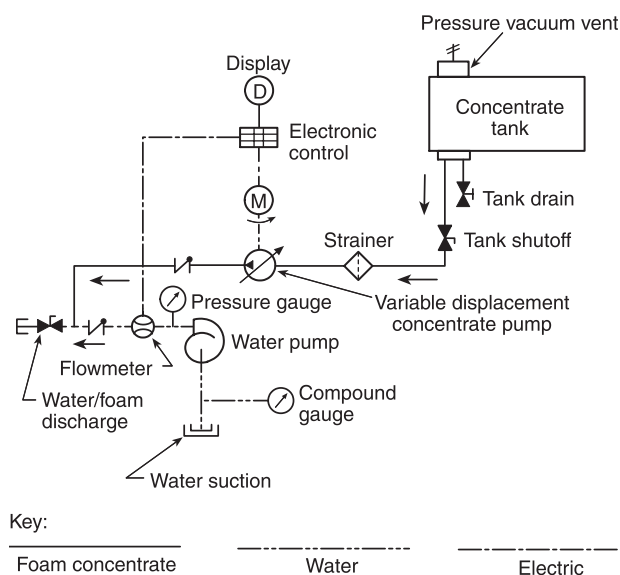


FIGURE A.18.2.6(a) Single-Meter Flow-Sensing Direct Injection Foam Proportioning System.

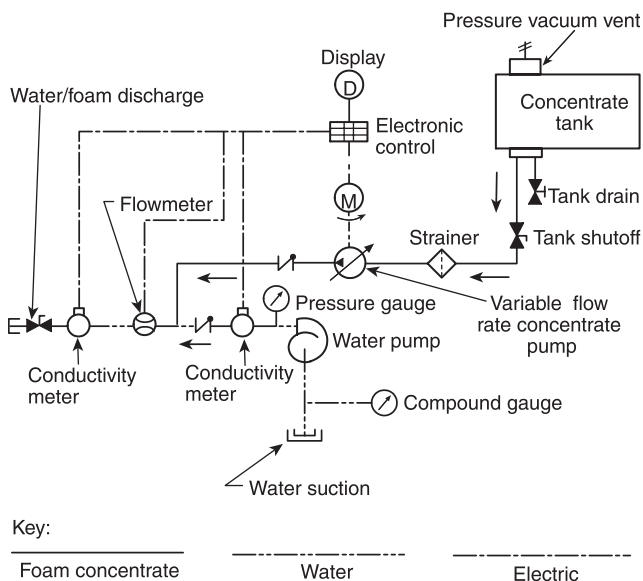


FIGURE A.18.2.6(c) Conductivity-Sensing Direct Injection Foam Proportioning System.

A water turbine-driven foam proportioning system uses a water turbine to power a positive displacement foam concentrate pump. Flowmeters sense the foam concentrate pump output and the waterflow, sending signals to an electronic control that regulates the proportioning ratio by adjusting the water turbine speed. [See Figure A.18.2.7(b).]

A.18.3.1 Proportioning systems that introduce foam concentrate or other additives into the water pumping system at a higher pressure than the water pressure have the potential to backflow foam concentrate or foam solution into an external water source. This condition could occur when there is no water flowing and the foam proportioning system is activated in the automatic mode. Backflow prevention devices utilized in the water piping prior to the introduction of the water additive are designed to prevent such occurrences. Use of these devices could create additional friction loss in the system and should

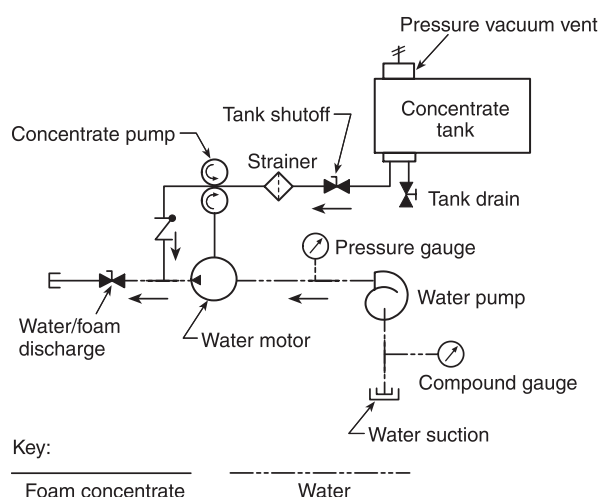


FIGURE A.18.2.7(a) Water Motor Foam Proportioning System.

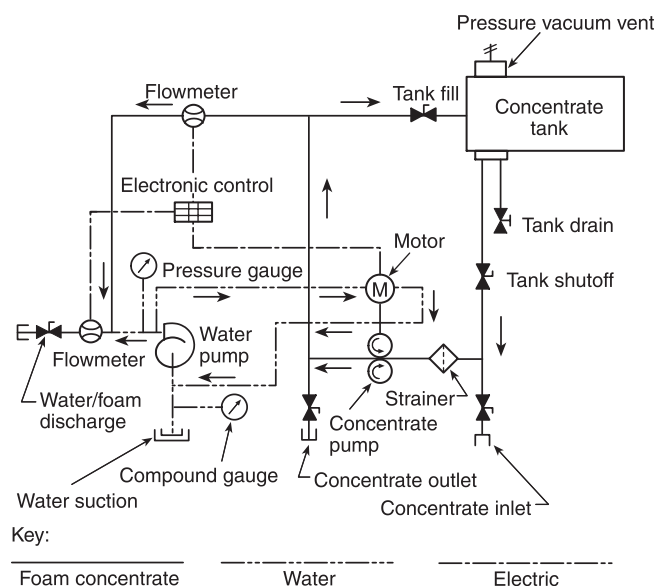


FIGURE A.18.2.7(b) Water Turbine-Driven Flow-Sensing Direct Injection Foam Proportioning System.

be used or installed following the proportioning system manufacturer's recommendations.

A.18.3.4 Most foam concentrate manufacturers differentiate between the materials they recommend for foam proportioning system components that are designed to be flushed with water after operation and those components that are intended to be continuously wetted with foam concentrate.

A.18.3.7 The use of fire chemicals, including foam, might be restricted in sensitive natural and cultural resource areas. Some land management agencies prohibit fire chemicals from being used within a specified distance of any waterway to protect critical habitats, including threatened and endangered species. To operate in these areas, the purchaser should consider specifying a water-only (no foam) discharge. In addition, the purchaser should specify that the pump recirculation line be plumbed such that the water returning to the water tank is free of foam solution if a foam proportioner is installed on the apparatus.

A.18.4.1 It is desirable to have a visual indicator on the operator's panel that shows whether the foam proportioning system is in the "operating" position or the "off" position. A visual means of indicating positive foam concentrate flow at the operator's panel is also helpful.

A.18.6.3.2 Suitable means to attach the cover to the fill tower could include a threaded cap or a hinged cover with a mechanical latching device.

A.18.6.6 On fire apparatus where a single foam storage tank is used, provisions should be made to flush the tank and all foam concentrate plumbing to avoid contamination of dissimilar foam concentrates when switching types or brands.

A.18.6.8 The foam concentrate tank(s) can be an integral part of the water tank.

A.18.6.10.2 Different types and brands of concentrates can be incompatible with each other and should not be mixed in storage. Concentrate viscosity varies with different types of products and temperatures.

A.18.6.12 The purchaser might want to consider a foam tank refill system to allow refilling the foam tank with a pump, so firefighters do not need to climb on top of the apparatus and lift foam pails to the top of the apparatus. It should discharge to the bottom of the tank to minimize aeration.

A.18.7 The foam concentrate pump is a critical component of both balanced pressure and direct injection foam proportioning systems. Positive displacement pumps are recommended for several reasons. Positive displacement pumps are relatively slow in speed compared to centrifugal pumps, which is advantageous with viscous foam concentrates that are difficult to shear. Centrifugal pumps can become air bound when trying to pump viscous foam concentrates, which results in a complete shutdown of the system. The self-priming feature of positive displacement pumps allows them to draw foam concentrate from drums or any external source without priming the pump.

A.18.7.2 Corrosion-resistant materials are materials such as brass, copper, Monel®, stainless steel, or equivalent materials.

A.18.7.5 A suitable intake connection is required for the type of system being utilized to operate from an external source as specified by the purchaser.

A.18.9.3(5) It is necessary for the operator to be familiar with the specific types of foam concentrates the foam proportioning system manufacturer has designed the system to operate with and proportion accurately. The foam proportioning system might require modification or recalibration if a foam concentrate is introduced into the system that was not intended by the system's manufacturer for use in the system.

A.18.10 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might wish to specify that these tests also be certified by the independent third-party certification organization.

A.18.10.1 The following are four methods for testing a foam proportioning system for calibration accuracy:

- (1) Substituting water for foam concentrate
- (2) Measuring foam concentrate pump output directly
- (3) Determining foam percentage by use of a refractometer
- (4) Determining foam percentage by use of a conductivity meter

Test Method 1: Substituting Water for Foam Concentrate. The foam proportioning system is operated at the waterflow rates at which the system is to be tested. Water is used as a substitute for foam concentrate. The substitute water for the foam concentrate is drawn from a calibrated tank instead of foam concentrate from the foam concentrate tank. The volume of water drawn from the calibrated tank divided by the volume of water pumped over the same time period multiplied by 100 represents the percentage of foam the foam proportioning system is producing.

Test Method 2: Measuring Foam Concentrate Pump Output Directly. With some direct injection systems, it is possible to directly measure the foam concentrate pump output. With the foam proportioning system operating at a given waterflow rate and either foam concentrate or water used as a substitute for foam concentrate, the output of the foam concentrate pump is measured by diverting that output into a calibrated container for direct measurement over a given period of time. An alternative is to measure the foam concentrate or water substitute flow with a calibrated meter.

Test Method 3: Determining Foam Percentage by Use of a Refractometer. A refractometer is used to measure the refractive index of a foam solution sample.

First, a base calibration curve is prepared using the same water and foam concentrate that will be used with the system to be tested. Three known foam solution samples are needed and should include the following:

- (1) The nominal intended percentage
- (2) The nominal intended percentage plus 1 percent
- (3) The nominal intended percentage minus 1 percent

If the nominal intended percentage is 1 percent or less, the three samples should be as follows:

- (1) The nominal intended percentage
- (2) The nominal intended percentage plus 0.3 percent
- (3) The nominal intended percentage minus 0.3 percent

The required amount of water is placed in a 100 mL or larger graduated cylinder, leaving space for the foam concentrate. A 10 mL pipette or 10 cc syringe is used to carefully add the required amount of foam concentrate to the water. Each measured foam solution is then poured from the graduated

cylinder into a 100 mL or larger plastic bottle, and the bottle is marked indicating the percentage solution it contains. The bottle is capped and thoroughly shaken to mix the foam solution.

An alternative method for making the three foam solution samples is to use a very accurate scale. The density of the foam concentrate must be known and can be found on the product data sheet or the safety data sheet (SDS) for the foam concentrate. For example, to make a 100 mL sample of a 3 percent foam solution using a foam concentrate with a density of 1.04, 97 g of water is measured into a beaker and 3.12 g of foam concentrate is added to the beaker ($1.04 \times 3 \text{ g} = 3.12 \text{ g}$).

After the foam solution samples are thoroughly mixed, a refractive index reading is taken of each foam solution sample. This is done by placing a few drops of the solution on the refractometer prism, closing the cover plate, and observing the scale reading at the dark field intersection. Because the refractometer is temperature compensated, it could take 10 seconds to 20 seconds for the sample to be read properly. It is 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 percentage of concentration on the other. This plotted curve serves as the known baseline for the test series. The solution samples should be set aside in the event the measurements need to be checked.

Foam solution samples are then collected from the proportioning system, making certain that the samples are taken at an adequate distance downstream from the foam proportioning system being tested to allow for complete mixing of the water and the foam concentrate. Refractive index readings of the samples are taken and compared to the plotted curve to determine the percentage of foam.

This method might not be accurate for aqueous film-forming foam (AFFF), alcohol-resistant foam, or certain other types of foam that typically exhibit very low refractive index readings. Also, the refractometer method should not be used when testing foam percentages of 1 percent or lower because the accuracy for determining the percentage of foam concentrate in a solution when using a refractometer is ± 0.1 percent, at best. For that reason, Test Method 4, the conductivity method, might be preferable where AFFF, alcohol-resistant foam, or 1 percent or less foam (Class A foam) is to be tested.

Test Method 4: Determining Foam Percentage by Use of a Conductivity Meter. The conductivity test method is based on changes in electrical conductivity as foam concentrate is added to water. Conductivity is a very accurate method, provided there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages. Because saltwater and brackish water are very conductive, this method might not be suitable where these waters are used because of the small conductivity changes as foam concentrate is added. If saltwater or brackish water is used, it is necessary to make foam solutions in advance to determine if adequate changes in conductivity can be detected. This method cannot be used if the water has more total solids than the foam concentrate.

The following three variations of this test method can be used to determine the foam percentage by the conductivity method:

- (1) *Direct reading conductivity method.* A sample of the water to be used in the test is put in a 100 mL or larger container. The conductivity meter head is immersed in the water sample, and the meter display is set at zero. If the direct reading foam solution conductivity meter is mounted in a discharge line, the meter should be set at zero with plain water flowing.
If the conductivity meter manufacturer does not indicate that the percentage of foam solution can be read directly for the foam concentrate being used, a calibration curve needs to be developed. The calibration curve might show that the direct meter readings are correct for the foam concentrate being used, or it might indicate that the calibration curve needs to be used when that foam concentrate is used in the test.
The foam proportioning system is operated, and a sample of the foam solution produced by the system is collected using a 100 mL or larger container. The conductivity meter head is immersed in the foam solution sample, and the percentage of the foam solution is read on the meter display. If the conductivity meter is mounted in a discharge line, the percentage of the foam solution is read on the meter display while foam solution is being discharged.
- (2) *Conductivity comparison method.* A sample of the water to be used in the test is put in a 100 mL or larger container. Using a conductivity meter reading in microsiemens per centimeter (mscm), the conductivity value of the water sample is determined. The foam proportioning system is operated, and a sample of the foam solution produced by the system is collected in a 100 mL or larger container. Using the conductivity meter, the conductivity value of the foam solution sample is determined. The conductivity value of the water sample is subtracted from the conductivity value of the foam solution sample, and the result is divided by 500 to obtain the percentage of foam concentrate in the solution.

[A.18.10.1]

$$\text{percentage of foam} = \frac{\left(\text{conductivity of} \right)_{\text{foam solution}} - \left(\text{conductivity} \right)_{\text{of water}}}{500}$$

Note that the divisor is 500 only if the conductivity meter units are microsiemens per centimeter. Other units of conductivity can be used, but the value of the divisor (500) will need to be adjusted.

- (3) *Conductivity calibration curve method.* A base calibration curve is prepared using the water and foam concentrate from the system to be tested. Three known foam solution samples are made using the procedure in Test Method 3. After the foam solution samples are thoroughly mixed, the conductivity of each solution is measured using a conductivity meter. Care should be taken to ensure that the proper procedures are used for taking readings and that the meter is switched to the correct conductivity range. Most synthetic-based foams used with freshwater result in foam solution conductivity readings of less than 2000 mscm. Protein-based foams used with freshwater generally produce conductivity readings in excess of

2000 mscm. Because of the temperature-compensation feature of the conductivity meter, it could take a short time to obtain a consistent reading.

Once the solution samples have been measured and recorded, the bottles should be set aside as control sample references. The conductivity readings then should be plotted on standard graph paper. It is more convenient to place the foam solution percentage on the horizontal axis and the conductivity readings on the vertical axis.

A straight line should be drawn that approximates the connection of all three points. While it might not be possible to connect all three points with a straight line, they should be very close. If not, the conductivity measurements should be repeated, and, if necessary, new control sample solutions should be prepared and used until all three points plot in a nearly straight line. This plot serves as the known base (calibration) curve to be used for the test series.

Once a base curve has been plotted, foam solution samples are collected from the proportioning system. The conductivity of the test samples is measured, and the percentage of foam solution is determined from the base curve. Foam solution samples that have been allowed to drain from expanded foam should not be used, because they can produce misleading conductivity readings.

A.18.10.1.2 Depending on the foam proportioner technology, the manufacturer could require the system to be calibrated at the low end, at the high end, or somewhere midrange, to ensure the system meets the accuracy requirements in the standard. For example, if the system runs richer as percentages increase, the manufacturer could anchor the low percentage during calibration. Therefore, the manufacturer needs to have the flexibility to pick this point, knowing how the technology reacts over the full operating range.

A.18.11.1(2) Users may want to specify additional test points and viscosities to ensure that their full range of operational requirements is satisfied.

A.18.11.1(3) See A.18.10.1.

A.19.1 The following terms are not used in this document but are associated with CAFS and are included here to aid in understanding.

CAFS-Capable Fire Apparatus. A fire apparatus equipped with a compressed air foam system (CAFS) with the following capabilities:

- (1) Automatic regulating foam proportioning system capable of injecting foam concentrate into the discharge or pressure side of the pump
- (2) Air compressor with the capacity to supply the required standard cubic feet per minute (SCFM) of air and automatic air pressure controls
- (3) Controls to mix the air and foam solution

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

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

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

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

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

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

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

A.19.2.2.1 The airflow in standard cubic feet per minute (SCFM) [standard cubic meters per minute (SCMM)] at 125 psi (862 kPa) represents a rating of the air compressor capacity. Air compressor capacity varies according to the delivery pressure of the compressor. The basis for rating air compressors for CAF systems in NFPA 1900 is 125 psi (862 kPa). It is recognized that in actual operation the air pressure of the CAF stream might vary from this rating basis due to operational characteristics of the CAF system.

The 125 psi (862 kPa) rating point utilized in determining the pressure rating for air compressors used in compressed air foam systems (CAFS) has been identified as a minimum requirement based on significant testing by multiple firefighting agencies. The ability of the compressor to perform at 125 psi (862 kPa) ensures that the CAFS will perform in instances where long hose lays are used, ensures a safe amount of reach in firefighting activities, and allows for lines to be safely charged without risk of kinking during interior attack or other instances where hoses might be wrapped around obstructions.

A.19.2.5 Pressure in the form of compressed air can remain trapped in a CAFS as a result of the system being deactivated. It is important for the operator to relieve any pressure in the foam proportioning system and connected hose lines before disconnecting hose lines or performing any operation that opens the system to atmosphere.

A.19.4 If the expansion ratio is to be tested, the following equipment and test procedures are recommended:

- (1) *Equipment.*
 - (a) Gram scale, 1500 g capacity accurate to 0.1 g
 - (b) One 1000 mL container that can be struck at 1000 mL (a 1000 mL graduated cylinder cut off at 1000 mL works well)
- (2) *Procedure.* The empty container is placed on the scale, and the scale is set to zero. Using the container, a full sample of foam is collected, and the foam is struck at the 1000 mL level. The container is placed on the scale and the mass is read in grams.

[A.19.4]

$$\text{Expansion} = \frac{1000}{\text{Foam mass in grams}}$$

The foam mass in grams assumes that 1 g of foam solution occupies 1 mL of volume.

A.19.4.2 It is recommended that compressed air not be injected into the discharge piping until the flow of foam solution has been established. The nozzle reaction at the end of a hose

can be quite high if air and water are flowing in the discharge line. The nozzle reaction could be a safety issue if the operator is not expecting or not properly braced to withstand this reaction force. The reaction force is substantially reduced when a foam solution is flowing in the discharge hose. Also, a charged CAFS line should be opened slowly to lower the nozzle reaction force that can be very high if opened rapidly.

A.19.5 Any components of the piping system exposed to pressurized air from the CAFS should be designed for a burst gauge pressure of at least 500 psi (3400 kPa).

A.19.7.5 Some systems provide automatic regulation of the waterflow; however, instrumentation is still useful to the operator. Even automatic systems have adjustments and performance limits that warrant instrumentation. Where the system design does not allow for such automatic regulation or where the operator has the ability to control waterflow or airflow, air and water flowmeters are necessary for the operator to monitor the operational performance of the CAFS where the nozzle person cannot be seen. Where pumping long hose lays or pumping to great heights, the operator needs to know what is flowing to be certain the proper product is being delivered.

A.19.9 If the tests of some components of the apparatus are being certified by an independent third-party certification organization, the purchaser might want to specify that these tests also be certified by the independent third-party certification organization.

A.19.9.1.1.1 The CAFS capacity rating test is performed with the system discharging 2 gpm of water for every 1 SCFM (250 L/min of water for every 1 SCMM) of compressed air discharge. This test verifies that the system is capable of these capacities without failure of any component of the CAFS. It is recognized that in actual firefighting use, the ratio of waterflow to airflow might vary depending on how wet or dry the CAF stream is desired for a particular application.

A.19.9.1.3.3 Care should be taken to avoid injuries to personnel from the discharging airstream. Only those persons actually conducting the tests should be in the test area, and they should wear protection for their ears, eyes, and face from noise and dust during the airflow test.

A.20.1 If the purchaser intends to suspend personnel or equipment from the aerial device using wire ropes or chains, the purchaser should inform the manufacturer of the intended use so proper mounting devices and locations as well as associated capacities can be determined. Equipment users have the potential to overload the aerial device components if improper methods are used.

A.20.2.2.2 The rated horizontal reach of the aerial ladder could be less than the extended length of the aerial that is used to determine the rated vertical height. This might be necessary to maintain the defined stability requirements as outlined in Section 20.28.

A.20.11.3.1 A two-way communication system at two positions on the apparatus is considered a minimum. Depending on the configuration of the apparatus, the purchaser might want to consider communication systems at additional positions, such as at a pump panel or at the monitor operating position on the ladder.

A.20.12.2.1 Turntable bearing bolts are required to be checked through torque verification at regular intervals. The

apparatus body should be constructed so as to make this task relatively simple by unbolting access panels, ladder slides, and other obstructions. Space should be provided for checking and torquing of the bearing bolts above and below the turntable using the appropriate tools.

A.20.12.4 The controls located at the tip of an aerial ladder are intended primarily to perform the final positioning of the aerial ladder in rescue or other firefighting operations. These controls are not intended to replace the lower control position as the primary operating position for the aerial ladder. Where the tip control is used, the operator(s) needs to take the following precautions:

- (1) Tip control operators need to be aware of personnel who are on the ladder sections behind them.
- (2) Lower control operators need to remain in position and deactivate the tip controls when anyone is moving on the ladder.
- (3) Tip control operators need to take care to place their feet on the steps at the tip to avoid injury to their feet from the moving ladder sections below.
- (4) Tip control operators need to be belted in position to protect against abrupt or unexpected ladder movements.

A.20.13 The arrangement of the waterway could be a telescoping pipe to a fly section or a nontelelescoping pipe to the tip of the base section.

A.20.13.4.5 The tip of an aerial ladder should be capable of being positioned up to a window or other location to allow firefighters and civilians to climb onto the aerial ladder easily. It might be preferable to keep the monitor behind the last rung of the fly section to protect it in the road position.

A.20.13.6 The arrangement of the external inlet should be specified by the purchaser based on the intended local operation in supplying water to the waterway.

If the normal operations are to supply the waterway through the external inlet, a valve should be provided where large diameter hose is to be used. A valved three- or four-inlet siamese should be provided when 2½ in. or 3 in. (65 mm or 75 mm) supply lines are used. Attention should be given to the inlet arrangement to limit friction loss. Also, if the apparatus is equipped with a fire pump and the purchaser wants to use the auxiliary inlet as a discharge, a slow-operating valve needs to be installed in the riser to the swivel.

A.20.13.9 Where freezing conditions are expected, an automatic drain valve should be specified in order to drain the waterway when water is not flowing.

A.20.14.2.2 The rated horizontal reach of the aerial platform might be less than the extended length of the aerial that is used to determine the vertical height. This could be necessary to maintain the defined stability requirements as outlined in Section 20.28.

A.20.14.4 Anchorage systems for fall protection systems exist in several different classes, and the purchaser should be aware of the following differences in fall protection harnesses:

- (1) *Travel restraint system.* Used to limit movement in the confines of the aerial platform and uses a belt hook and 450 lb (205 kg) rated anchorage point.
- (2) *Fall restraint system.* Similar to a travel restraint system, but with more freedom of movement in the platform and

uses a belt, 18 in. to 24 in. (45.7 cm to 60.96 cm) lanyard, and 900 lb (408 kg) rated anchorage point.

- (3) *Fall arrest system.* Used to arrest an occupant in a fall from a working level. The fall arrest system uses a body harness, shock absorbing lanyard, and an 1800 lb (815 kg) rated anchorage point.

The rating of the fall protection harness is a rating of the anchorage itself. The rated capacity of the aerial is not to be exceeded because of the fall protection harness attachment rating.

A.20.14.4.5 The test outlined in 20.14.4.5 should not imply that the load capacity or stability of the aerial device is meant to meet or comply with the anchor test load requirements.

A.20.15.6 Platform capacity ratings can be established in many different operating positions other than full extension and zero degrees elevation. Platforms are often rated at higher capacities as elevation angles increase or when the device is not fully extended. Most manufacturers provide distributed load capacities (several persons), depending on the aerial's extension and elevation. Combination ratings that include capacity at the tip while discharging water are normally provided. These can vary with elevation and extension and are examples of multiple configurations. It is important that the manufacturer clearly define for the user the ladder's rated capacity in various positions and operation modes.

Aerial control systems can now limit the motion of the aerial device based on the following conditions:

- (1) Geometric position of the aerial device
- (2) Weights and loads (ice, wind, nozzle reactions, slope conditions, etc.) applied to the aerial device that create overturning loads
- (3) Stabilizer extension at each location
- (4) Position of the aerial device with respect to the centerline of the truck

These geometric conditions are complex, and the electronic systems should clearly monitor the required inputs and validate the range of motion with the loads applied while maintaining the required safety factors for vehicle stability and structural safety.

A.20.16.2.1 A two-way communication system at two positions on the apparatus is considered a minimum. Depending on the configuration of the apparatus, the purchaser might want to consider communication systems at additional positions such as the pump panel.

A.20.17.1 Position lights on the outer corners of the platform can be helpful in providing increased visibility of the platform's location from the ground operator's position.

A.20.17.3.1 See A.20.12.2.1.

A.20.19.3.4 Because the water system can be closed at both the top and the bottom of the waterway, the purchaser might want to require a vacuum relief valve.

A.20.19.5 The arrangement of the external inlet should be specified by the purchaser based on the intended local operation in supplying water to the waterway. If the normal operations are to supply the waterway through the external inlet, a valve should be provided where large diameter hose is to be used. A valved three- or four-inlet siamese should be provided when 2½ in. or 3 in. (65 mm or 75 mm) supply lines are used.

Attention should be given to the inlet arrangement to limit friction loss. Also, if the apparatus is equipped with a fire pump and the purchaser wants to use the auxiliary inlet as a discharge, a slow-operating valve needs to be installed in the riser to the swivel.

A.20.19.9.1 Where freezing conditions are expected, an automatic drain valve should be specified in order to drain the waterway when water is not flowing.

A.20.20.3 The rated horizontal reach of the water tower could be less than the extended length of the water tower that is used to determine the vertical height. This may be necessary to maintain the defined stability requirements as outlined in Section 20.28.

A.20.22.3.1 See A.20.12.2.1.

A.20.23.5 See A.20.19.5.

A.20.23.9 Where freezing conditions are expected, an automatic drain valve should be specified in order to drain the waterway when water is not flowing.

A.20.25.1 If the operator's position is located on the turntable, the operator should have at least 5 ft² (0.46 m²) of standing and working space exclusive of other space required. The purchaser should specify any special requirements for the operator's position or for other space required on the turntable for personnel to stand or work.

A.20.25.2 Aerial ladder operational controls should be located such that the operator can see the tip of the aerial ladder in all operating positions. The operator's position is often located on the turntable.

A.20.25.6.1 For LED lights, photometric stability typically takes about one hour of continuous operation. For halogen lights, photometric stability typically takes about 30 minutes or less of continuous operation.

A.20.26.1 Structural load-bearing parts refers to cylinder walls, pistons, piston rods, clevises, pins, or other parts that bear the load that keeps an aerial device from falling but that are not part of a seal or sealing device. Subsection 20.18.1 does not refer to valves, control levers, manifolds, or other hydraulic system components that do not structurally bear a load. Static sealing parts refers to components such as o-rings that can be used to seal in hydraulic pressure, but do not move against another surface during operation.

A.20.26.2 Some examples of hydraulic system components are hose, tubing, and fitting.

A.20.26.3 Some examples of normally rated performance criteria are flow, pressure drop, revolutions per minute (RPM), torque, and speed. Components that are normally rated by performance criteria are pumps, motors, directional control valves, and rotation swivels. Dynamic sealing parts refers to piston or rod seals used in cylinder construction, or shaft seals in rotary components. It can also apply to internal seals on spool valves if the seal is between parts that have relative motion with respect to each other.

A.20.26.7 While this standard requires the hydraulic system to have adequate cooling for continuous operation for 2½ hours, prolonged operation under adverse environmental conditions could cause the hydraulic oil to rise in temperature beyond its recommended temperature range. The purchaser might wish

to specify an indicator and an alarm that warns the operator if the fluid temperature begins to overheat.

A.20.27.1 Structural safety factors are widely recognized terms in good engineering practice but can be unfamiliar to those using this standard.

The following combination of loads should be evaluated to determine compliance with this standard. To clarify, the terms are defined as follows:

Dead Load Stress (DL). Stress produced by the aerial device structure and all materials, components, mechanisms, or equipment permanently fastened thereto. If this equipment is installed by the manufacturer before delivery, it is included in the dead load. Equipment added to the aerial device by the fire department that exceeds the manufacturer's recommendations needs to be subtracted from the rated capacity.

Rated Capacity Stress (RL). Stress produced by the rated capacity of the aerial device applied at the tip of the fly section for an aerial ladder [minimum 250 lb (114 kg) at an elevation of zero degrees and full extension] or on the platform of an elevating platform apparatus [minimum 750 lb (340 kg) at an elevation of zero degrees and full extension].

Water Reaction Stress (WL). Stress produced by nozzle reaction force and the weight of the water in the water delivery system.

Material Yield Strength (FY). The stress at which a material exhibits a specified permanent distortion or set.

- (1) With no water in the system, the aerial device positioned at full extension, zero-degree elevation and loaded at the rated capacity, the criterion for structural safety is as follows: The stress produced by two times the dead load stress (*DL*) plus the stress produced by two times the rated capacity stress (*RL*) should not exceed the material yield strength (*FY*), as shown in the following equation. This is a 2:1 safety factor.

[A.20.27.1a]

$$2 \times DL + 2 \times RL \leq FY$$

- (2) With water flowing in the system and the aerial device in the position that creates the highest stress, the criterion for structural safety is as follows: The stress produced by two times the dead load stress (*DL*) plus the stress produced by two times the rated capacity stress (*RL*) plus the stress produced by the water reaction stress (*WL*) should not exceed the material yield strength (*FY*), as shown in the following equation:

[A.20.27.1b]

$$2 \times DL + 2 \times RL + WL \leq FY$$

Other combinations of loading, including wind loads, ice loads, and impact loads, can be included as additional live loads in determining structural safety factors and rated capacities.

A.20.28.1 Water, hose, ground ladders, and other equipment on the apparatus all provide stability when they are in place. However, at a fire, this equipment and water are often removed. Therefore, stability needs to be measured under worst conditions, which is with the equipment removed.

A.20.28.5.4 If the apparatus is intended to be operated on structures such as parking ramps that have specific pressure limitations, the specific ground loading as determined by the appropriate civil engineer, or regulatory authority, should provide a specific ground contact limitation that can be included in the specification. This could limit the size, reach, or capacity of apparatus that will meet such a specification.

A.20.30.3.2(5) The manufacturer should state the wind speed capability with the aerial device at its rated vertical height. The wind pressure load should be evenly distributed from the base to the tip.

The load chart information can be provided in printed or electronic display screen format. If the primary load chart is electronic, a readily accessible printed form should be supplied.

A.20.31.2.8 The lifting of a tire or stabilizer on the opposite side of the apparatus from the load does not necessarily indicate a condition of instability.

A.20.32 The purchaser might want to specify that this test be conducted with the certification tests required by Section 20.31 and that the test results be certified by the independent third-party certification organization.

A.21.1 A typical electrical system might consist of a generator system that is bonded to the chassis frame rail. Conductors making up the power supply assembly include the neutral conductor (N), grounding conductor (G), and line voltage conductors (L_1 , L_2 , L_3).

The neutral conductor of the power supply assembly is grounded to the generator frame. This is the only location that the neutral conductor is grounded in the entire system. The power supply assembly terminates at the panelboard for distribution to the rest of the system. Figure A.21.1 shows a typical system on a fire apparatus.

It is the responsibility of the purchaser to provide the contractor with sufficient information to enable the contractor to supply an electrical system that will meet the needs of the fire department.

For each piece of line voltage electrical equipment installed on the apparatus or operated using the apparatus line voltage electrical system, the purchaser should provide the following information:

- (1) The type of electrical current required, that is, alternating current (ac), direct current (dc), or either ac or dc, as follows:
 - (a) If ac is required, the nominal operating voltage, the maximum amperage, and whether it is single-phase or three-phase. For electronic equipment and some motors, the required quality of the ac power should also be stated, including the upper and lower limits of voltage and the allowable variation of frequency and waveform.
 - (b) If dc is required, the nominal operating voltage and the maximum operating current. For special equipment, the required quality of the dc power should also be stated, including the upper and lower limits of voltage and the amount of ripple voltage.
- (2) The required minimum continuous output wattage of the electrical source or sources that power the system, or if more than one type of current or voltage is required, the

maximum output wattage for each type of current or voltage.

Generally, the line voltage electrical system should be sized based on the total amount of fixed and portable equipment that is likely to be operated at the same time. 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 only incandescent lighting is involved, ac or dc power can be used. Where other electrical devices such as motor-driven equipment or electronic equipment are involved, single-phase ac power at 60 Hz is normally required. However, because of the substantial reduction of size and cost that results from three-phase operation, ac motors larger than 5 hp are usually designed to operate on three-phase ac current. Attempting to operate electrical equipment using the wrong type of electrical power will almost always damage the electrical equipment.

The following factors are guidelines for determining the line voltage electrical loads present on an apparatus and determining the size of power source required. Various electrical loads are placed on apparatus for specific purposes, yet a number are installed for convenience usage. The purchaser should start by creating a tabulated list of line voltage electrical items (lights, cord reels, receptacles, etc.) and their wattage ratings so a total electrical load can be determined. It is the responsibility of the purchaser to specify the ratings to be used when calculating power source loads.

Loads or Receptacles. For plug-connected equipment and receptacles, either work with the loads that can be connected or with the power available from receptacles that could have equipment connected to them. Do not add both in the calculation. If the power source will normally power only equipment carried on that piece of apparatus, use a total of loads carried on the apparatus. If the power source might power equipment carried on other apparatus as well, work with the total capacity represented by the receptacles provided. Fixed loads permanently connected are always included. The following loads and receptacles should be specified:

- (1) *Fixed mounted lighting.* All lighting that is mounted directly to the apparatus should be itemized with the manufacturer's wattage ratings. This includes light towers, brow lights, scene lights, and interior lights.
- (2) *Removable lighting.* All lights mounted on the apparatus using a plug and receptacle connection scheme should be itemized with the light manufacturer's wattage rating. This includes tripod lights mounted on the top or back of apparatus bodies that can be unplugged, removed from the apparatus, set up on the ground or inside a building, and powered with the use of an extension cord.
- (3) *Dedicated receptacles.* For receptacles located and intended to always power a specific piece of equipment such as a hydraulic rescue tool (HRT) power unit, battery charger, light, or other piece of equipment, use the wattage of the connected equipment.
- (4) *Cord reels.* Rate cord reels to their circuit breaker rated amperage when determining generator loads. Wattage rating should be voltage times circuit breaker amperage. For 120/240 volt cord reels, use 240 times the circuit breaker rating.
- (5) *Side-of-body receptacles.* Rate side-of-body receptacles at half their amperage capacity when determining generator

- loads. If specific devices will be connected to side-of-body receptacles most of the time, the higher wattage rating of the specific device should be used.
- (6) *Interior receptacles.* Rate interior duplex receptacles at 180 watts. If specific devices will be connected to specific receptacles, use the higher wattage rating of the specific device connected to the receptacle.
 - (7) *Motor loads.* Motor loads put large ac demands on generators. Consult the system manufacturer for wattage ratings for motor-driven systems. A general rule is that motors require about 740 W/hp for running. An allowance should be added for the largest motor for starting at about twice the running wattage or the manufacturer's stated starting wattage. Some variable speed motors for smoke fans have little or no additional starting power draw. If equipment with large motors are to be driven, consult with the manufacturer of the equipment for their experience on what size and types of generators have been successfully used for driving their equipment.

Power Source Sizing. Once all the line voltage devices and receptacles on the apparatus have been identified and their wattage rating determined, the size of the generator needed can be determined. It is always a good idea to make an allowance for future additions and spare capacity.

Table A.21.1(a) shows an example of a calculation for sizing a generator that is intended to power the electrical equipment onboard a rescue unit but is not intended to typically power electrical equipment from other apparatus. Note that for the largest motor load, the HRT power unit, the starting load is used. For other motors, the running power is used.

For the equipment in Table A.21.1(a), a 15,000 watt generator would be the minimum that should be considered. A significant driving factor in requiring this size generator is the starting draw of the HRT power unit. Once the power unit is started, the total draw with all equipment running would drop to about 10,000 watts, giving a comfortable safety margin. Some generators have a peak or intermittent rating that exceeds the continuous power rating. This peak capability can be used for motor starting, since such loads last only a few seconds.

Table A.21.1(b) shows the calculations for the electrical load for the equipment and receptacles that might be on an attack pumper.

For this example, a 15,000 watt generator also would be the minimum that should be considered. Because that would allow little reserve capacity for future use, a larger generator might be considered. Even though the pumper might not carry this much equipment, if the apparatus is at the front of the fire building, lights and fans from other apparatus can be brought to the scene and plugged into the electrical system on this apparatus.

The selection of a smaller generator puts the generator at risk of being overloaded and potentially damaged.

It is recommended the purchaser review the line voltage components and review the generator size to verify that proper operation of the apparatus can be achieved. If there is more load than power supply, reducing line voltage loads or selecting a larger generator is recommended.

A.21.2.4 Portable line voltage electrical equipment added by the fire department should also be listed and utilized only in accordance with the manufacturer's instructions.

A.21.2.6.4 Although a splash shield will lessen the amount of road spray that reaches the generator, it will not protect the generator if the apparatus is driven through deep water. Care should also be taken if the apparatus is driven off-road, because a splash shield is not a skid pan and will not protect the generator from physical abuse.

A.21.2.7 Switch mode power supplies and variable speed motor drives often have noninusoidal current waveforms. Particularly when powered by small generators, as opposed to a nationwide grid of massive generators, this can also distort the voltage waveform. These disruptions can cause generators to provide incorrect voltage or frequency and, in some cases, cause them to shut down. The disruption to voltage waveform can also cause other devices, particularly sensitive electronic equipment, to malfunction or overheat. Spikes in voltage can damage other equipment. Loads with a power factor (i.e., the ratio of real power to apparent power) less than 1.0 also require a larger generator than expected. While reduced power factor is usually the result of a phase shift between voltage and current wave forms, a noninusoidal current waveform also creates a power factor less than 1.0.

The effects from such equipment can be very difficult to track down. The equipment affected (e.g., generator or load) is usually not the equipment causing the problem. Often, the effects are only seen with certain combinations of equipment

Table A.21.1(a) Sample Calculation of Electric Loads for Equipment Carried on a Rescue Unit

Device	Notes	Rated Voltage	Rated Amperage	Number Carried	Generator Load Wattage
Brow light	Permanently connected	240		1	750
Pole lights	1000 W lights	240		2	2,000
Portable lights	500 W lights	120		4	2,000
16 in. smoke fan	800 W run, 2000 W start	120		1	800
HRT power unit	4000 W run, 9000 W start	240		1	9,000
Battery charger	On transfer switch	120		1	200
Total					14,750