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NFPA 1901 Standard for Automotive Fire Apparatus 1996 Edition

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An International Codes and Standards Organization

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NFPA 1901

Standard for

Automotive Fire Apparatus

1996 Edition

This edition of NFPA 1901, *Standard for Automotive Fire Apparatus*, was prepared by the Technical Committee on Fire Department Apparatus and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 20–23, 1996, in Boston, MA. It was issued by the Standards Council on July 18, 1996, with an effective date of August 9, 1996, and supersedes all previous editions.

This edition of NFPA 1901 was approved as an American National Standard on July 26, 1996.

Origin and Development of NFPA 1901

The 1996 edition of NFPA 1901 combines four fire apparatus standards designated as NFPA 1901, *Standard for Pumper Fire Apparatus*; NFPA 1902, *Standard for Initial Attack Fire Apparatus*; NFPA 1903, *Standard for Mobile Water Supply Fire Apparatus*; and NFPA 1904, *Standard for Aerial Ladder and Elevating Platform Fire Apparatus*. This combined document has been named *Standard for Automotive Fire Apparatus*, a title that NFPA 1901 carried prior to being split into four documents in 1991.

In addition to combining the requirements for the four traditional types of fire apparatus, this edition recognizes special service fire apparatus and provides requirements for that type of apparatus. Nontraditional types of fire apparatus can also meet this standard, as it is designed with core chapters that all apparatus must meet regardless of use or function and component chapters that an apparatus must meet if it contains that component. To make the standard more user friendly, the requirements for any component testing are included in the chapter with the requirements for that component.

Many requirements were added throughout the document to improve the safety for fire fighters using the apparatus. These include limiting the height of controls to 72 in. above the standing position of the operator, requiring equipment in driving and crew areas to be securely fastened or in a compartment, increased work lighting around the apparatus, and better grouping of pump controls to keep the operator away from the intake and discharge outlets.

The low voltage electrical chapter was totally rewritten to require load analysis and load management if the total connected load cannot be supplied by the vehicle's alternator. The requirements for warning lights were also rewritten to provide for different lighting when "calling for right-of-way" versus "blocking right-of-way." Requirements for warning lights were increased to provide more visibility of the fire apparatus.

New requirements were added for powered equipment racks, SCBA and cylinder storage, pump and plumbing access, and slip-on fire-fighting modules. The baffling requirements for water tanks were changed to allow for either containment or dynamic baffling to be used. As a fundamental change in the aerial device chapter, water towers were considered devices with elevated stream capability only. If they have a ladder on them, they are considered aerial ladders. Requirements were also added for secondary controls at the tip of an aerial ladder if such controls are provided.

New chapters were added to cover compressed air foam systems, air systems, command and communication areas, and winches.

See Appendix C for a more complete history of the standard.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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

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

Contents

NFPA 1901

Standard for

Automotive Fire Apparatus

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

Information on referenced publications can be found in Chapter 23 and Appendix D.

Chapter 1 Administration

1-1* Scope. This standard shall apply to new automotive fire apparatus designed for structural fire fighting or for supporting associated fire department operations.

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

1-3* Responsibility of Purchaser. It shall be the responsibility of the purchaser to specify the details of the apparatus; its required performance, including where operations at elevations above 2000 ft (610 m) or on grades greater than 6 percent are required; the maximum number of fire fighters to ride within the apparatus; specific added continuous electrical loads which exceed the minimum of this standard; and any hose, ground ladders, or equipment to be carried by the apparatus that exceed the minimum requirements of this standard.

1-4 Responsibility of Contractor.

1-4.1 The contractor shall provide a detailed description of the apparatus, a list of equipment to be furnished, and other construction and performance details to which the apparatus shall conform. This shall include, but shall not be limited to, estimated weight, wheelbase, principal dimensions, transmission, axle ratios, and, if applicable, the rated capacity of the aerial device. The purpose of these contractor specifications is to define what the contractor intends to furnish and deliver to the purchaser.

1-4.2 Responsibility for the apparatus and equipment shall remain with the contractor until they are accepted by the purchaser.

1-4.3 A qualified and responsible representative of the contractor shall instruct personnel specified by the purchaser in the operation, care, and maintenance of the fire apparatus and equipment delivered.

1-5 Definitions.

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

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

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

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

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

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.

Aerial Ladder Platform. A type of aerial device that combines an elevating platform with the continuous egress capabilities of an aerial ladder.

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.

Air Quality Monitors. Instruments that monitor the air for such elements as carbon monoxide levels, moisture levels, and percent of oxygen.

Air Tank. A storage vessel meeting the requirements of either DOT or ASME and used to store an accumulation of air under pressure.

Air Truck. A vehicle used to supply breathing air either to refill self-contained breathing apparatus (SCBA) or to supply respirators directly through hose lines.

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

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

Approved.* Acceptable to the authority having jurisdiction.

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 knuckle joints.

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*.

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

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

Automatic Electrical Load Management System. A device that continuously monitors the electrical system voltage and sheds predetermined loads in a selected order to prevent over discharging of the apparatus' batteries. Shedding of the loads occurs without human intervention and is capable of being manually overridden.

Auxiliary Braking System. A braking system in addition to the service brakes such as an engine retarder, transmission retarder, drive-line retarder, or exhaust retarders.

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.

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

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

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

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

Bonding. The joining of metallic parts to ensure an electrically conductive path that will safely conduct any current likely to be imposed during the life of the apparatus.

Boom. An assembled section of an aerial device. The boom construction can be of the stressed skin box beam type, the trussed lattice type, or the open "U" truss-type design.

Booster Pump. See Auxiliary Pump.

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

Breathing Air. Air that meets the requirements specified in CGA G-7.1, *Commodity Specification for Air*, for Grade D and E air for human respiration and NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

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.

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

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

Cable. A wire rope used to transmit forces from one component to another for the purpose of extending or retracting an aerial device.

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

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

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

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, or passengers, appliances, or equipment related to other than control. Common usage might, but need not, include a cab (or cowl).

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

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

Class B Fire. A fire in flammable liquids, oils, greases, tars, oil-base paints, lacquers, and flammable gases.

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

Combination Vehicle. A vehicle consisting of a pulling tractor and trailer.

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

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

Compressed Air Foam System (CAFS). A foam system that combines air under pressure with foam solution to create foam. A CAFS system consists of a compressed air source, pressurized source of foam solution and discharge hardware.

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

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

Contractor. The person or company responsible for fulfilling an agreed upon contract. The contractor might not necessarily manufacture the vehicle or any portion of the vehicle but is responsible for the completion, delivery, and acceptance of the entire unit.

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

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

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

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

DOT Cylinder. A pressure vessel constructed and tested in accordance with Title 49, *Code of Federal Regulations* (CFR), paragraph 178.37, that is used for the storage and transportation of air under pressure.

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.

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.

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

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

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

Electrical Equipment, Portable. Any electrical equipment that is not fixed.

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. Only one type of warning sound can be produced, but the level or pitch can be varied by the speed of the motor.

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

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.

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.

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

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

FAD. Free air delivery.

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

Fill Station. The area used to refill SCBA cylinders.

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

Fire Pump. A water pump mounted on an apparatus with a rated capacity of 250 gpm (950 L/min) or greater at 150 psi (1035 kPa) net pump pressure, and used for fire fighting.

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

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

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

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

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

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

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.

Gallon. United States gallon.

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

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

GAWR (Gross Axle Weight Rating). The chassis manufacturer's specified maximum load-carrying capacity of an axle system. It is a requirement of the Federal Motor Vehicle Safety Standards and is shown on a label on the vehicle. The system includes, but is not limited to, the axle, tires, suspension, wheels, frame, brakes, and applied engine torque.

GCWR (Gross Combination Weight Rating). The chassis manufacturer's specified maximum load carrying capacity for tractor trailer-type vehicles having three or more axle systems (a multiaxle axle installation is one system.) It is a requirement of the Federal Motor Vehicle Safety Standards and is shown on a label on the vehicle. Where the trailer is detachable, the GCWR limits the axle system(s) maximum load for any replacement trailer.

Generator (Alternator), Fixed. A mechanically driven electrical source, usually 7 kW or greater, that is permanently secured to the vehicle.

Generator (Alternator), Portable. A mechanically driven electrical source, usually less than 7 kW, that can be easily removed from the vehicle and operated at a location that is remote from the vehicle. The device has an integral distribution panel with overcurrent protection and receptacle outlets.

GPM. Gallons per minute.

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

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

Ground-Fault Circuit-Interrupter (GFCI). A device intended for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground fault exceeds some

predetermined value that is less than required to operate the over current protective device of the supply circuit.

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

GVWR (Gross Vehicle Weight Rating). The chassis manufacturer's specified maximum load carrying capacity of a vehicle having two axle systems (a multiaxle axle installation is one system.) It is a requirement of the Federal Motor Vehicle Safety Standards and is shown on a label on the vehicle. It 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.

Hazardous Material Response Vehicle. An emergency vehicle designed to carry various support equipment and personnel to a scene of a hazardous material incident.

Initial Attack Apparatus. Fire apparatus with a permanently mounted fire pump, a water tank, and hose body that meets or exceeds the requirements of this standard. The primary purpose of this type of apparatus is to initiate a fire suppression attack on structural, vehicular, or vegetation fires, and to support associated fire department operations.

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

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.

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

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.

Interior. A sheltered location not exposed to the environment.

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

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.

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.

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.

Line Voltage Circuit, Equipment, or System. An ac or dc electrical circuit, equipment, or system where the voltage to ground or from line to line is 30 volts rms (ac) or 42.4 volts peak (dc) or greater, but does not exceed 250 volts rms (ac) or peak (dc).

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

Listed.* Equipment, materials, or services included in a list published by an organization 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 either that the equipment, material, or service meets identified standards or has been tested and found suitable for a specified purpose.

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

Load Limit Indicator. A load indicator or an instruction plate visible at the operator's position that shows the recommended safe load at any condition of aerial device elevation and extension.

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

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

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. Multistage series/parallel pumps are measured with the pump in the pressure (series) setting.

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

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.

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

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.

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

Net Pump Pressure.* The sum of the discharge pressure and the 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.

Neutral Conductor. The grounded current-carrying conductor of all electrical circuits.

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

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

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

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

Optical Power. The unit of measure designed to combine the flash energy and flash rate of an optical source into one power measurement representing the true visual effectiveness of the emitted light. The units of optical power are candela-seconds/minute.

Optical Source. Any single, independently mounted, light emitting component in a lighting system. 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 cannot be easily modified.

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

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

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

Panelboard. Buses, overcurrent devices, and equipment with or without switches for the control of line voltage circuits that are placed in an electrical cabinet or cutout box mounted on a wall or partition and accessible only from the front.

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

Power Supply Assembly. Any cable or distribution assembly that is partly comprised of the neutral conductor, grounding conductor, and line voltage conductors connected from the load side of the power source to the line side of the primary panelboard.

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

PSI. Pounds per square inch.

PSIG. Pounds per square inch gauge.

PTO. Power takeoff.

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

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

Pumper. Fire apparatus with a permanently mounted fire pump, a water tank, and hose body that meet or exceed the requirements of this standard. The primary purpose of this type of apparatus is to combat structural and associated fires.

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

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

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

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

Rated Capacity (Aerial Device). The total amount of weight of all personnel and equipment that can be safely supported at the outermost rung of an aerial ladder or on the platform of an elevating platform with the waterway uncharged.

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

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

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.

Road Spray Location. Any under-body or under-chassis location which is subject to road spray.

SCFM. Standard cubic feet per minute. An expression of airflow rate in which the airflow rate is corrected to standard temperature and pressure. The metric conversion is shown as SCMS (standard cubic meters per second).

Shall. Indicates a mandatory requirement.

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

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.

Special Services Fire Apparatus. A multipurpose vehicle that primarily provides support services at emergency scenes. These services could be rescue, command, hazardous material containment, air supply, electrical generation and floodlighting, or transportation of support equipment and personnel.

Split Shaft PTO. A power takeoff (PTO) drive system that directs the chassis engine power either to the fire pump or other accessory or to the chassis drive axle. This is accomplished by splitting the chassis driveline that connects the

chassis transmission to the drive axle and inserting the split shaft PTO that has the shift mechanism necessary to direct the chassis engine power as described above.

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

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

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

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

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

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

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

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

Total Connected Electrical Load. The total current required to operate all of the devices permanently connected to the apparatus that can be simultaneously energized but does not include intermittent type loads such as primers and booster reel rewind motors.

Transfer Pump. A separate engine or power takeoff driven water pump mounted on the apparatus with a minimum rated capacity of 250 gpm (945 L/min) at 50 psi (345 kPa) net pump pressure and used primarily for water transfer.

Turntable. A rotating structural component that allows rotation of an aerial device through a rotating bearing and that connects the aerial device to the chassis and stabilization system. It is normally designed to permit continuous 360-degree rotation and could contain an operator's control station.

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

Type 4 Rating. A rating for electrical equipment that is suitable for outdoor use to provide a degree of protection from falling rain, splashing water, and hose-directed water. Equipment rated NEMA Type 4 will be undamaged by the formation of ice on the equipment.

Ultimate Strength. The ultimate strength of a material in tension, compression, or shear, respectively, 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.

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

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

Vibration Isolation. Isolation materials used to prevent structure borne vibrations from reaching attached surfaces.

Water Tower. A device consisting of permanently mounted power operated booms and a waterway designed to supply a large capacity mobile elevated water stream. The booms can be of articulating design or telescoping design.

Wet Location. A nonsheltered location inside a compartment with a door or cover that, while open, exposes the electrical enclosure or panelboard to the same environmental conditions as the exterior of the fire apparatus. A location on a nonenclosed, exterior surface of a fire apparatus body or cab where the enclosure or panel is exposed to the environment. (*See also Road Spray Location.*)

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

1-6 Conversion Factors. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter unit is outside of but recognized by SI and commonly is used in international fire protection. In this standard, values for measurement are followed by an equivalent in SI units, but only the value that first appears shall be considered as the requirement since the value in SI units could be approximate. Table 1-6 provides the conversion factors to be used where SI units are not provided in the text or where more precision is desired.

Table 1-6 Conversion Factors

1 gallon per minute (gpm)	=	3.785 liters per minute (L/min)
1 gallon per minute (gpm)	=	0.833 imperial gallons per minute
1 pound per square inch (psi)	=	6.895 kilopascals (kPa)
1 pound per square inch (psi)	=	0.0690 bar
1 pound per square inch (psi)	=	2.31 feet of water
1 inch of mercury (in. Hg)	=	3.386 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 kilometer per hour (kmph)
1 pound (lb)	=	0.454 kilogram (kg)
1 horsepower (hp)	=	0.746 kilowatt (Kw)

Chapter 2 General Requirements

2-1 General. All types of fire apparatus shall meet the requirements of:

Chapter 1, Administration;

Chapter 2, General Requirements;

Chapter 8, Chassis and Vehicle Components;

Chapter 9, Low Voltage Electrical Systems and Warning Devices;

Chapter 10, Driving and Crew Areas; and

Chapter 11, Body, Compartments, and Equipment Mounting.

2-2 Requirements by Apparatus Type.

2-2.1 In addition to the requirements in Section 2-1, the following also shall apply:

Table 2-2.2 Requirements by Apparatus Type

	Apparatus Function	Pumper Fire Apparatus	Initial Attack Fire Apparatus	Mobile Water Supply Fire Apparatus	Aerial Fire Apparatus	Special Service Fire Apparatus
Chapter 1	Administration	Required	Required	Required	Required	Required
Chapter 2	General Requirements	Required	Required	Required	Required	Required
Chapter 3	Pumper Fire Apparatus	Required	N/A	N/A	N/A	N/A
Chapter 4	Initial Attack Fire Apparatus	N/A	Required	N/A	N/A	N/A
Chapter 5	Mobile Water Supply Fire Apparatus	N/A	N/A	Required	N/A	N/A
Chapter 6	Aerial Fire Apparatus	N/A	N/A	N/A	Required	N/A
Chapter 7	Special Service Fire Apparatus	N/A	N/A	N/A	N/A	Required
Chapter 8	Chassis and Vehicle Components	Required	Required	Required	Required	Required
Chapter 9	Low Voltage Electrical Systems and Warning Devices	Required	Required	Required	Required	Required
Chapter 10	Driving and Crew Areas	Required	Required	Required	Required	Required
Chapter 11	Body, Compartments, and Equipment Mounting	Required	Required	Required	Required	Required
Chapter 12	Fire Pump and Associated Equipment	Required	Required	If specified	If specified	If specified
Chapter 13	Auxiliary Pump and Associated Equipment	If specified	If specified	If specified	If specified	If specified
Chapter 14	Water Transfer Pump and Associated Equipment	N/A	N/A	If specified	N/A	N/A
Chapter 15	Water Tanks	Required	Required	Required	If specified	If specified
Chapter 16	Aerial Devices	If specified	If specified	N/A	Required	If specified
Chapter 17	Foam Proportioning Systems	If specified	If specified	If specified	If specified	If specified
Chapter 18	Compressed Air Foam Systems	If specified	If specified	If specified	If specified	If specified
Chapter 19	Line Voltage Electrical Systems	If specified	If specified	If specified	If specified	If specified
Chapter 20	Command and Communications	If specified	If specified	If specified	If specified	If specified
Chapter 21	Air Systems	If specified	If specified	If specified	If specified	If specified
Chapter 22	Winches	If specified	If specified	If specified	If specified	If specified
Chapter 23	Referenced Publications	Required	Required	Required	Required	Required

(a) A pumper fire apparatus shall comply with Chapter 3.

(b) An initial attack fire apparatus shall comply with Chapter 4.

(c) A mobile water supply fire apparatus shall comply with Chapter 5.

(d) An aerial fire apparatus shall comply with Chapter 6.

(e) A special service fire apparatus shall comply with Chapter 7.

2-2.2 Table 2-2.2 shows the required chapters that shall apply to the construction of the types of fire apparatus in 2-2.1.

2-2.3 In addition to the types of fire apparatus listed in 2-2.1, 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 2-3 with the requirements listed in Section 2-1.

2-3 Fire Apparatus Components. All components shall be installed in accordance with the applicable manufacturer's installation instructions.

2-3.1 Fire Pump. If the apparatus is equipped with a fire pump, the pump and its associated equipment shall meet the requirements of Chapter 12.

2-3.2 Auxiliary Pump. If the apparatus is equipped with an auxiliary pump, the pump and its associated equipment shall meet the requirements of Chapter 13.

2-3.3 Water Transfer Pump. If the apparatus is equipped with a water transfer pump, the pump and its associated equipment shall meet the requirements of Chapter 14.

2-3.4 Water Tank. If the apparatus is equipped with a water tank, the water tank shall meet the requirements of Chapter 15.

2-3.5 Aerial Device. If the apparatus is equipped with an aerial device (aerial ladder, elevating platform, or water tower), the aerial device shall meet the requirements of Chapter 16.

2-3.6 Foam Proportioning System. If the apparatus is equipped with a foam proportioning system, the apparatus shall meet the requirements of Chapter 17.

2-3.7 Compressed Air Foam System. If the apparatus is equipped with a compressed air foam system, the system shall meet the requirements of Chapter 18.

2-3.8 Line Voltage Electrical System. If the apparatus is equipped with a line voltage electrical system (120/240 volts), the system shall meet the requirements of Chapter 19.

2-3.9 Command and Communications. If the apparatus is equipped with a command and communications area, the area shall meet the requirements of Chapter 20.

2-3.10 Air System. If the apparatus is equipped with an air system, the system shall meet the requirements of Chapter 21.

2-3.11 Winch System. If the apparatus is equipped with a winch system, the system shall meet the requirements of Chapter 22.

2-4 Governmental Requirements. The apparatus shall comply with all applicable federal and state motor vehicle laws and regulations.

2-5 Personnel Protection.

2-5.1* Guards, shields, or other protection shall be provided where necessary to prevent injury of personnel by hot, moving, or rotating parts during normal non maintenance operations. Electrical insulation or isolation shall be provided where necessary to prevent electrical shock from onboard electrical systems.

2-5.2 Vehicular workmanship shall ensure a safe operating environment free of accessible sharp projections and edges.

2-5.3 Safety related (caution, warning, danger) tags and labels shall meet the requirements of ANSI Z535.4, *Product Safety Signs and Labels*.

2-6 Controls and Instructions.

2-6.1 Illumination shall be provided for controls, switches, essential instructions, gauges, and instruments necessary for the operation of the apparatus and the equipment provided on it. If external illumination is provided, it shall be a minimum of 5 footcandles (54 lux) on the face of the device. If internal illumination is provided, it shall be a minimum of 4 footlamberts (14 candela/m^2).

2-6.2 All required labels and markings shall be of a type permanent in nature, securely attached, and capable of withstanding the effects of extremes of weather and temperature.

2-6.3 No gauge or visual display shall be more than 84 in. (2134 mm) above the level where the operator stands to read the instrument.

2-6.4 The central midpoint or centerline of any control shall be no more than 72 in. (1830 mm) vertically above the ground or platform that is designed to serve as the operator's standing position.

2-7 Component Protection. Hydraulic lines, air system tubing, control cables, and electrical lines shall be clipped to the frame or body structure of the apparatus and shall be furnished with metal protective looms or grommets at each point where they pass through body panels or structural members.

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

2-8 Vehicle Stability.

2-8.1 The height of the fully loaded vehicle's center of gravity shall not exceed the chassis manufacturer's maximum limit.

2-8.2* The front to rear weight distribution of the fully loaded vehicle as defined in Section 8-1 shall be within the limits set by the chassis manufacturer. The front axle loads shall not be less than the minimum axle loads specified by the chassis manufacturer, under full load and all other loading conditions.

2-8.3 The difference in weight on the end of each axle, from side to side, when the vehicle is fully loaded and equipped as defined in Section 8-1 shall not exceed 7 percent.

2-9* Apparatus Performance.

2-9.1* The apparatus shall meet the requirements of this standard at elevations of 2000 ft (610 m) above sea level.

2-9.2* The apparatus shall meet all the requirements of this standard while stationary on any grade of up to and including 6 percent in any direction.

2-10 Roadability. The apparatus, when fully equipped and loaded as defined in Section 8-1, shall be capable of the following performance on dry, paved roads in good condition:

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

(b)* The apparatus shall attain a minimum top speed of 50 mph (80 kmph) on a level road;

(c)* The apparatus shall be able to maintain a speed of at least 20 mph (32 kmph) on any grade up to and including 6 percent.

2-11 Serviceability.

2-11.1* The apparatus shall be designed so that all the manufacturer's recommended routine maintenance checks of lubricant and fluid levels can be performed easily by the operator without lifting the cab of tilt-cab apparatus or the need for hand tools. Apparatus components that interfere with repair or removal of other major components shall be attached with fasteners, such as capscrews and nuts, so that the components can be removed and installed with ordinary hand tools. These components shall not be welded or otherwise permanently secured into place.

2-11.2 If the vehicle has a tilt-cab mechanism, a redundant holding device shall be provided in addition to the main system holding the cab in the fully raised position. The activation and release of both systems shall be accomplished clear of the cab travel area while still having the travel area in clear view.

2-11.3 Where special tools are required for routine service on any component of the apparatus, such tools shall be provided with the apparatus.

2-11.4 The contractor shall supply, at time of delivery, at least two copies of a complete operation and service manual covering the completed apparatus as delivered and accepted. The manual shall contain the following:

(a) Descriptions, specifications, and ratings of the chassis, pump (if applicable), and aerial device (if applicable);

(b) Wiring diagrams;

(c) Lubrication charts;

(d) Operating instructions for the chassis, any major components such as a pump or aerial device, and any auxiliary systems;

(e) Precautions related to multiple configurations of aerial devices, if applicable;

(f) Instructions regarding the frequency and procedure for recommended maintenance; and

(g) Parts replacement information.

2-11.5* The contractor shall deliver with the apparatus all manufacturers' operations and maintenance documents supplied with components and equipment installed or supplied by the contractor.

2-12 Road Tests.

2-12.1 Road tests shall be conducted in accordance with this section to verify that the completed apparatus is capable of compliance with Section 2-10. The tests shall be conducted at a location and in a manner that does not violate local, state, or federal traffic laws.

2-12.2 The apparatus shall be fully equipped and loaded as required in Section 8-1. The tests shall be conducted on

dry, level, paved roads that are in good condition. The engine shall not be operated in excess of the maximum no-load governed speed.

2-12.3 Acceleration tests shall consist of two runs in opposite directions over the same route.

2-12.3.1 The vehicle shall attain a true speed of 35 mph (56 kmph) from a standing start within 25 seconds.

2-12.3.2 The vehicle shall attain a minimum top speed of not less than 50 mph (80 kmph).

2-12.3.3 If the apparatus is equipped with an auxiliary braking system, the manufacturer shall road test the system to confirm that the system is functioning as intended by the auxiliary braking system manufacturer.

2-12.3.4 The service brakes shall bring the fully laden apparatus to a complete stop from an initial speed of 20 mph (32 kmph), in a distance not exceeding 35 ft (10.7 m) by actual measurement, on a substantially hard, level surface road that is free of loose material, oil, or grease.

2-13* Tests on Delivery. If acceptance tests are desired at the point of delivery, they shall be run in accordance with the provisions of this standard and shall duplicate the tests that the purchaser specifies. Aerial device stability tests shall not be run other than at the manufacturer's facility.

2-14 Data Required of the Contractor. The contractor shall supply, at the time of delivery, at least one copy of the following documents.

(a) The manufacturer's record of apparatus construction details, including the following information:

1. Owner's name and address;
2. Apparatus manufacturer, model, and serial number;
3. Chassis make, model, and serial number;
4. GAWR of front and rear axles;
5. Front tire size and total rated capacity in pounds;
6. Rear tire size and total rated capacity in pounds;
7. Chassis weight distribution in pounds with water and manufacturer mounted equipment (front and rear);
8. Engine make, model, serial number, number of cylinders, bore, stroke, displacement and compression ratio, rated horsepower and related speed per SAE J690, *Certificates of Maximum Net Horsepower for Motor Trucks and Truck Tractors*, and no-load governed speed;
9. Type of fuel and fuel tank capacity;
10. Electrical system voltage and alternator output in amps;
11. Battery make and model, capacity in CCA;
12. Transmission make, model, and type;
13. Pump to drive through the transmission (yes or no);
14. Engine to pump gear ratio and transmission gear ratio used;
15. Pump make, model, rated capacity in gallons per minute, serial number, number of stages, and impeller diameter in inches;
16. Pump transmission make, model, and serial number;
17. Priming device type;
18. Type of pump pressure control system;
19. Auxiliary pump make, model, rated capacity in gallons per minute, serial number, number of stages, and impeller diameter in inches;
20. Water tank certified capacity in gallons;
21. Aerial device type, rated vertical height in feet, rated horizontal reach in feet, and rated capacity in pounds;
22. Paint numbers;
23. Company name and signature of responsible company representative.

(b) If the apparatus has a fire pump, the pump manufacturer's certification of suction capability (*see 12-2.4.1*);

(c) If the apparatus has a fire pump, a copy of the apparatus manufacturer's approval for stationary pumping applications (*see 12-3.1*);

(d) If the apparatus has a fire pump, the engine manufacturer's certified brake horsepower curve for the engine furnished, showing the maximum no-load governed speed (*see 12-3.2*);

(e) If the apparatus has a fire pump, the pump manufacturer's certification of hydrostatic test (*see 12-5.2*);

(f) If the apparatus has a fire pump, the certification of inspection and test for the fire pump (*see 12-13.1*);

(g) If the apparatus has an aerial device, the certification of inspection and test for the aerial device (*see Section 16-24*);

(h) If the apparatus has an aerial device, all the technical information required for inspections to comply with NFPA 1914, *Standard for Testing Fire Department Aerial Devices*;

(i) Weight documents from a certified scale — showing actual loading on the front axle, rear axle(s), and overall vehicle (with the water tank full but without personnel, equipment, and hose) — shall be supplied with the completed vehicle to determine compliance with Section 8-1;

(j) Written load analysis and results of the electrical system performance tests required in Chapter 9;

(k) If the apparatus is equipped with a water tank, the certification of water tank capacity (*see Section 15-6*).

Chapter 3 Pumper Fire Apparatus Requirements

3-1 General. If the apparatus is to function as a pumper, it shall meet the requirements of this chapter.

3-2 Fire Pump. The apparatus shall be equipped with a fire pump that meets the requirements of Chapter 12 and that has a minimum rated capacity of 750 gpm (2850 L/min).

3-3 Aerial Device.

3-3.1 If the pumper fire apparatus is equipped with an aerial device, the aerial device shall meet the requirements of Chapter 16.

3-3.2 If the aerial device is equipped with a permanently mounted waterway, the minimum rated fire pump capacity shall be sufficient to meet the flow requirements of either 16-6.1.2, 16-12.1, or 16-16.2, with a maximum intake pressure of 20 psig (138 kPag).

3-3.3 Provisions shall be made to ensure that the pump operator is not in contact with the ground. Signs shall be placed to warn the pump operator of electrocution hazard.

3-4 Water Tank. The pumper shall be equipped with a water tank(s) that meets the requirements of Chapter 15 and that has a minimum certified capacity (combined, if applicable) of 500 gal (1900 L). If the pumper is equipped with an aerial device, the capacity of the water tank shall be permitted to be reduced to 300 gal (1136 L).

3-5* Equipment Storage. A minimum of 40 ft^3 (1.13 m^3) of enclosed weather-resistant compartmentation shall be provided for the storage of equipment.

3-6* Hose Storage. Hose bed area(s), compartments, or reels that comply with Section 11-10 shall be provided to accommodate the following. These areas need not be contiguous.

(a) A minimum hose storage area of 55 ft^3 (1.56 m^3) for 2½-in. (65-mm) or larger hose;

(b) Two areas, each a minimum of 3.5 ft^3 (0.1 m^3), to accommodate 1½-in. (38-mm) or larger preconnected hose lines.

3-7 Equipment Supplied by the Contractor. The following equipment shall be supplied and mounted by the contractor. The contractor shall provide such brackets or compartments as are necessary to mount the equipment properly.

3-7.1* Ground Ladders. All ground ladders carried on the apparatus shall meet the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*. At a minimum, the following ladders shall be carried on the apparatus:

One straight ladder, a minimum of 14 ft (4.3 m) in length and equipped with roof hooks;

One extension ladder, a minimum of 24 ft (7.3 m) in length;

One 10-ft (3-m) folding ladder.

3-7.2* Suction Hose. A minimum of 15 ft (4.6 m) of soft suction hose or 20 ft (6 m) of hard suction hose shall be carried. Suction hose shall meet the requirements of NFPA 1961, *Standard for Fire Hose*. The purchaser shall specify whether hard or soft suction hose is to be provided, the length and size of the hose, the size of the couplings, the manner in which the suction hose is to be carried or mounted on the apparatus, and the style of brackets desired.

3-7.2.1 Where hard suction hose is provided, a suitable suction strainer shall be furnished.

3-7.2.2 Where soft suction hose is provided, it shall have long handle female couplings with the local hydrant outlet connection on one end and the pump intake connection on the other end.

3-8 Minor Equipment. The list of equipment in 3-8.1 and 3-8.2 shall be available on the pumper fire apparatus before it is placed in service. A detailed list of who is to furnish the items shall be supplied by the purchasing authority. Brackets or compartments shall be furnished to mount or contain the equipment properly.

3-8.1* Fire Hose and Nozzles. The following hose and nozzles shall be carried:

1200 ft (366 m) of 2½-in. (65-mm) or larger fire hose;

400 ft (122 m) of 1½-in. (38-mm), 1¾-in. (44-mm), or 2-in. (51-mm) fire hose;

One combination fog nozzle, 200 gpm (757 L/min) minimum;

Two combination fog nozzles, 95 gpm (360 L/min) minimum;

One playpipe, with shutoffs and 1-in. (25-mm), 1⅛-in. (29-mm), and 1¼-in. (32-mm) tips.

3-8.2* Miscellaneous Equipment. The following additional equipment shall be carried:

One 6-lb (2.7-kg) flathead axe;

One 6-lb (2.7-kg) pickhead axe;

One 6-ft (2-m) pike pole or plaster hook;

One 8-ft (2.4-m) or longer pike pole;

Two portable hand lights with mounting brackets;

One approved dry chemical portable fire extinguisher with a minimum 80 BC rating and a mounting bracket;

One 2½-gal (9.5-L) or larger water extinguisher with bracket;

One gated swivel intake connection with pump intake threads on one end and one or more female connections compatible with the supply hose carried on the other;

One self-contained breathing apparatus complying with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, for each assigned seating position, but not less than four;

One spare SCBA cylinder for each SCBA carried;

One first aid kit;

Four combination spanner wrenches with brackets;

Two hydrant wrenches;

Two double female adapters, sized to fit 2½-in. (65-mm) or larger hose;

Two double male adapters, sized to fit 2½-in. (65-mm) or larger hose;

One rubber mallet, suitable for use on suction hose connections;

Two salvage covers each a minimum size of 12 ft × 14 ft (3.7 m × 4.3 m);

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

Where an aerial device with a permanently mounted ladder is provided, four Class I life safety harnesses meeting the requirements of NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components*.

Chapter 4 Initial Attack Fire Apparatus

4-1 General. If the apparatus is to function as an initial attack fire apparatus, it shall meet the requirements of this chapter.

4-2 Fire Pump. The apparatus shall be equipped with a fire pump that meets the requirements of Chapter 12 and that has a minimum rated capacity of 250 gpm (950 L/min).

4-3 Water Tank. Initial attack apparatus shall be equipped with a water tank(s) that meets the requirements

of Chapter 15 and that has a minimum certified capacity (combined, if applicable) of 200 gal (757 L).

4-4* Equipment Storage. A minimum of 22 ft^3 (0.62 m^3) of enclosed weather-resistant compartmentation that meets the requirements of Chapter 11 shall be provided for the storage of equipment.

4-5* Hose Storage. Hose bed area(s), compartments, or reels that meet the requirements of Section 11-10 shall be provided to accommodate the following. These areas need not be contiguous.

(a) A minimum hose storage area of 10 ft^3 (0.283 m^3) for 2½-in. (65-mm) or larger hose; and

(b) Two areas, each a minimum of 3.5 ft^3 (0.1 m^3), to accommodate 1½-in. (38-mm) or larger preconnected hose lines.

4-6 Equipment Supplied by the Contractor. The following equipment shall be supplied and mounted by the contractor. The contractor shall provide such brackets or compartments as are necessary to mount the equipment properly.

4-6.1 Ground Ladders. A 12-ft (3.7-m) or longer extension-type ground ladder shall be carried on the apparatus. All ground ladders on the apparatus shall meet the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders.*

4-6.2* Suction Hose. A minimum of 15 ft (4.6 m) of soft suction hose or 20 ft (6 m) of hard suction hose shall be carried. Suction hose shall meet the requirements of NFPA 1961, *Standard for Fire Hose.* The purchaser shall specify whether hard or soft suction hose is to be provided, the length and size of the hose, the size of the couplings, the manner in which the suction hose is to be carried or mounted on the apparatus, and the style of brackets desired.

4-6.2.1 Where hard suction hose is provided, a suitable suction strainer shall be furnished.

4-6.2.2 Where soft suction hose is provided, it shall have long handle female couplings with the local hydrant outlet connection on one end and the pump intake connection on the other end.

4-7 Minor Equipment. The list of equipment in 4-7.1 and 4-7.2 shall be available on the initial attack fire apparatus before it is placed in service. A detailed list of who is to furnish the items shall be supplied by the purchasing authority. Brackets or compartments shall be furnished to mount or contain the equipment properly.

4-7.1 Fire Hose and Nozzles. The following hose and nozzles shall be carried:

300 ft (91 m) of 2½-in. (65-mm) or larger fire hose;

400 ft (122 m) of 1½-in. (38-mm), 1¾-in. (44-mm), or 2-in. (51-mm) fire hose;

Two combination fog nozzles, 95 gpm (360 L/min) minimum.

4-7.2* Miscellaneous Equipment. The following additional equipment shall be carried:

One 6-lb (2.7-kg) pickhead axe;

One 6-ft (2-m) pike pole or plaster hook;

Two portable hand lights with mounting brackets;

One approved dry chemical portable fire extinguisher with a minimum 80 BC rating and a mounting bracket;

One 2½-gal (9.5-L) or larger water extinguisher with bracket;

One gated swivel intake connection with pump intake threads on one end and one or more female connections compatible with the supply hose carried on the other;

One self-contained breathing apparatus complying with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters,* for each assigned seating position, but not less than two;

One spare SCBA cylinder for each SCBA carried;

One first aid kit;

Two combination spanner wrenches with brackets;

One hydrant wrench;

One double female adapter, sized to fit 2½-in. (65-mm) or larger hose;

One double male adapter, sized to fit 2½-in. (65-mm) or larger hose;

One rubber mallet, suitable for use on suction hose connections;

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

Chapter 5 Mobile Water Supply Fire Apparatus

5-1 General. If the apparatus is to function as a mobile water supply apparatus, it shall meet the requirements of this chapter.

5-2 Pump. If the apparatus is equipped with either a fire or transfer pump or both, the pump(s) shall meet the requirements of Chapter 12 or Chapter 14 respectively.

5-3 Water Tank. The mobile water supply apparatus shall be equipped with a water tank(s) that meets the requirements of Chapter 15 and that has a minimum certified capacity (combined, if applicable) of 1000 gal (3800 L).

5-4* Equipment Storage. A minimum of 20 ft^3 (0.57 ^{3}) of enclosed weather-resistant compartmentation meeting the requirements of Chapter 11 shall be provided for the storage of equipment.

5-5 Hose Storage.

5-5.1* A minimum hose storage area of 6 ft^3 (0.17m^3) for 2½-in. (65-mm) or larger fire hose that meets the requirements of Section 11-10 shall be provided.

5-5.2 If the apparatus is equipped with a fire pump, two areas, each a minimum of 3.5 ft^3 (0.1 m^3), to accommodate 1½-in. (38-mm) or larger preconnected hose lines shall be provided.

5-6* Suction Hose. If the apparatus is equipped with a pump, a minimum of 15 ft (4.6 m) of soft suction hose or 20 ft (2 m) of hard suction hose shall be carried. Suction hose shall meet the requirements of NFPA 1961, *Standard for Fire Hose.* The purchaser shall specify whether hard or soft suction hose is to be provided, the length and size of the hose,

the size of the couplings, the manner in which the suction hose is to be carried or mounted on the apparatus, and the style of brackets desired. The contractor shall supply and mount any specified suction hose.

5-6.1* Where hard suction hose is provided, a suitable suction strainer shall be furnished.

5-6.2 Where soft suction hose is provided, it shall have long handle female couplings with the local hydrant outlet connection on one end and the pump intake connection on the other end.

5-7 Minor Equipment. The list of equipment in 5-7.1 and 5-7.2 shall be available on the mobile water supply fire apparatus before it is placed in service. A detailed list of who is to furnish the items shall be supplied by the purchasing authority. Brackets or compartments shall be furnished to mount or contain the equipment properly.

5-7.1 Fire Hose and Nozzles.

5-7.1.1 The mobile water supply apparatus shall be equipped with at least 200 ft (61 m) of 2½-in. (65-mm) or larger fire hose.

5-7.1.2* If the mobile water supply apparatus is equipped with a fire pump, the following shall be provided:

400 ft (61 m) of 1½-in. (38-mm), 1¾-in. (44-mm), or 2-in. (51-mm) fire hose;

Two combination fog nozzles, 95 gpm (360 L/min) minimum.

5-7.2 Equipment.

5-7.2.1* Mobile water supply fire apparatus shall be equipped with at least the following equipment:

One 6-lb (2.7-kg) flathead or pickhead axe;

One 6-ft (2-m) or longer pike pole or plaster hook;

Two portable hand lights with mounting brackets;

One approved dry chemical portable fire extinguisher with a minimum 80 BC rating and a mounting bracket;

One 2½-gal (9.5-L) or larger water extinguisher with bracket;

One self-contained breathing apparatus complying with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, for each assigned seating position, but not less than two;

One spare SCBA cylinder for each SCBA carried;

One first aid kit;

Two combination spanner wrenches with brackets;

One hydrant wrench;

One double female adapter, sized to fit 2½-in. (65-mm) or larger hose;

One double male adapter, sized to fit 2½-in. (65-mm) or larger hose;

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

5-7.2.2 If the mobile water supply apparatus is equipped with a pump, the following equipment shall be carried on the apparatus:

One gated swivel intake connection with pump intake threads on one end and one or more female connections compatible with the supply hose carried on the other end;

One rubber mallet, suitable for use on suction hose connections.

Chapter 6 Aerial Fire Apparatus

6-1 General. If the apparatus is to function as an aerial fire apparatus, it shall meet the requirements of this chapter. If the apparatus is to function as a pumper with an aerial device, it shall meet all the requirements of Chapter 3 instead of Chapter 6.

6-2 Aerial Device. The apparatus shall be equipped with an aerial ladder, elevating platform, or water tower that meets the requirements of Chapter 16.

6-3 Fire Pump. If the apparatus is equipped with a fire pump, the pump shall meet the requirements of Chapter 12.

6-3.1 Provisions shall be made to ensure that the pump operator is not in contact with the ground. Signs shall be placed to warn the pump operator of electrocution hazard.

6-3.2 If the aerial fire apparatus is equipped with a fire pump that is intended to supply water to a permanently mounted waterway, the minimum rated pump capacity shall be sufficient to meet the flow requirements of 16-6.1.2 or 16-12.1 with a maximum intake pressure of 20 psig (138 kPag).

6-4 Water Tank. If the aerial fire apparatus is equipped with a water tank, it shall meet the requirements of Chapter 15 and have a minimum certified capacity of 150 gal (568 L).

6-5* Equipment Storage. A minimum of 40 ft^3 (1.13 m^3) of enclosed weather-resistant compartmentation meeting the requirements of Chapter 11 shall be provided for the storage of equipment.

6-6 Hose Storage.

6-6.1* Any space on the aerial fire apparatus designed to carry fire hose shall meet the requirements of Section 11-10.

6-6.2 If the apparatus is equipped with a fire pump and a water tank, two areas, each a minimum of 3.5 ft^3 (0.1 m^3) to accommodate 1½-in. (38-mm) or larger preconnected hose lines, shall be provided.

6-7* Ground Ladders. The following ground ladders shall be supplied and mounted by the contractor. The contractor shall provide such brackets or compartments as are necessary to mount the equipment properly. The ground ladders shall meet the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*.

One folding (attic) ladder a minimum of 10 ft (3 m) in length;

Two roof ladders (with folding roof hooks) a minimum of 16 ft (4.9 m) in length;

One combination ladder a minimum of 14 ft (4.3 m) in length;

One extension ladder a minimum of 24 ft (7.3 m) in length;

One extension ladder a minimum of 35 ft (10.7 m) in length.

6-8 Minor Equipment. The list of equipment in 6-8.1 and 6-8.2 shall be available on the aerial fire apparatus before it is placed in service. A detailed list of who is to furnish the items shall be supplied by the purchasing authority. Brackets or compartments shall be furnished to mount or contain the equipment properly.

6-8.1* Aerial fire apparatus shall be equipped with at least the following equipment:

Two 6-lb (2.7-kg) flathead axes;
Three 6-lb (2.7-kg) pickhead axes;
Two 6-ft (2-m) pike poles;
Two 8-ft (2.4-m) pike poles;
Two 12-ft (3.7-m) pike poles;
Two 3-ft to 4-ft (1-m to 1.2-m) pike poles with D handle;
Two crowbars;
Two claw tools;
Two 12-lb (5.4-kg) sledgehammers;
Four portable hand lights with mounting brackets;
One approved dry chemical portable fire extinguisher with a minimum 80 BC rating and a mounting bracket;
One 2½-gal (9.5-L) or larger water extinguisher with bracket;
One self-contained breathing apparatus complying with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, for each assigned seating position, but not less than four;
One spare SCBA cylinder for each SCBA carried;
One first aid kit;
Six salvage covers, at least 12 ft × 18 ft (3.6 m × 5.5 m);
Four combination spanner wrenches with brackets;
Two scoop shovels;
One hose roller (equipment hoist);
One pair bolt cutters, 24 in. (610 mm) minimum;
Four Class I life safety harnesses meeting the requirements of NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components;*
150 ft (46 m) of one-person life safety rope meeting the requirements of NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components*;
150 ft (46 m) of two-person life safety rope meeting the requirements of NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components*;
Two 150-ft (46-m) lengths of utility rope having a breaking strength of at least 5000 lb (2268 kg);

One box of tools to include the following:
One hacksaw with three blades;
One keyhole saw;
One 12-in. (305-mm) pipe wrench;
One 24-in. (610-mm) pipe wrench;
One ballpeen hammer;
One pair tin snips;
One pair pliers;
One pair lineman's pliers;
Assorted types and sizes of screwdrivers;
Assorted adjustable wrenches;
Assorted combination wrenches;

Four wheel chocks, mounted in a readily accessible location(s), that meet or exceed the requirements of SAE J348, *Standard for Wheel Chocks*, for the wheel diameter on which the chocks are to be used.

6-8.2 If the aerial fire apparatus is equipped with a fire pump, the following shall be supplied:

Two double female adapters, sized to fit 2½-in. (65-mm) or larger hose;

Two double male adapters, sized to fit 2½-in. (65-mm) or larger hose;

One rubber mallet, suitable for use on suction hose connections;

One gated swivel intake connection with pump intake threads on one end and one or more female connections compatible with the supply hose carried on the other end;
Two hydrant wrenches.

Chapter 7 Special Service Fire Apparatus

7-1 General. If the apparatus is to function as a special service fire apparatus, it shall meet the requirements of this chapter.

7-2 Pump. If the apparatus is equipped with a fire pump, the pump shall meet the requirements of Chapter 12.

7-3* Equipment Storage. A minimum of 120 ft^3 (3.4 m^3) of enclosed weather-resistant compartmentation meeting the requirements of Chapter 11 shall be provided for the storage of equipment.

7-4 Equipment Supplied by the Contractor. The following equipment shall be supplied and mounted by the contractor. The contractor shall provide such brackets or compartments as are necessary to mount the equipment properly.

7-4.1 Ground Ladders. One 10-ft (3-m) folding ladder or one 16-ft (4.9-m) combination ladder shall be carried on the apparatus. All ground ladders on the apparatus shall meet the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*.

7-4.2* Suction Hose. If the special service fire apparatus is equipped with a fire pump, a minimum of 15 ft (4.6 m) of soft suction hose or 20 ft (6 m) of hard suction hose shall be carried. Suction hose shall meet the requirements of NFPA 1961, *Standard for Fire Hose*. The purchaser shall specify whether hard or soft suction hose is to be provided, the length and size of the hose, the size of the couplings, the manner in which the suction hose is to be carried or mounted on the apparatus, and the style of brackets desired.

7-4.2.1 Where hard suction hose is provided, a suitable suction strainer shall be provided.

7-4.2.2 Where soft suction hose is provided, it shall have long handle female couplings with the local hydrant outlet connection on one end and the pump intake connection on the other end.

7-5* Minor Equipment. The equipment on the following list shall be available on the special service vehicle before it is placed in service. A detailed list of who is to furnish the items shall be supplied by the purchasing authority. Brackets or compartments shall be furnished to mount or contain the equipment properly.

Two portable hand lights with mounting brackets;

One approved dry chemical portable fire extinguisher with a minimum 80 BC rating and a mounting bracket;

One 2½-gal (9.5-L) or larger water extinguisher with bracket;

One self-contained breathing apparatus complying with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, for each assigned seating position, but not less than two;

One spare SCBA cylinder for each SCBA carried;

One first aid kit;

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

Chapter 8 Chassis and Vehicle Components

8-1* Carrying Capacity. The GAWR, and GCWR or GVWR of the chassis shall be adequate to carry the weight of the unequipped apparatus, the fully loaded water and other tanks, the specified hose load, unequipped personnel weight, ground ladders, and miscellaneous equipment allowance as defined in Table 8-1.

8-1.1* The unequipped personnel weight shall be calculated at 200 lb (91 kg) per person multiplied by the number of seating positions on the apparatus.

8-1.2 A final manufacturer's certification of the GVWR or GCWR, along with a certification of the GAWR, shall be supplied on a nameplate affixed to the vehicle.

Table 8-1 Miscellaneous Equipment Allowance

Apparatus Type	Chassis GVWR	Equipment Allowance
Pumper fire apparatus	All	2000 lb (908 kg)
Initial attack fire apparatus	10,000 lb to 15,000 lb (4540 kg to 6810 kg)	900 lb (410 kg)
	15,001 lb to 20,000 lb (6810 kg to 9080 kg)	1500 lb (680 kg)
	20,001 lb and up (9080 kg and up)	2000 lb (908 kg)
Mobile water supply fire apparatus	All	1000 lb (454 kg)
Aerial fire apparatus	All	2500 lb (1134 kg)
Special service fire apparatus	10,000 lb to 15,000 lb (4540 kg to 6810 kg)	2000 lb (908 kg)
	15,001 lb to 20,000 lb (6810 kg to 9080 kg)	2500 lb (1134 kg)
	20,001 lb and up (9080 kg and up)	3000 lb (1360 kg)

8-2 Engine and Engine System Design.

8-2.1* Chassis Engine.

8-2.1.1* An engine governor or electronic fuel control system shall be installed that will limit the speed of the engine under all conditions of operation to that speed established by the engine manufacturer; this shall be the maximum no-load governed speed.

8-2.1.2 Audible and visual warning devices that are visible from the driver's position shall be provided to alert the driver to high engine temperature or low oil pressure conditions.

8-2.1.3* Automatic engine shutdown systems shall not be permitted unless they are an integral part of the standard engine management system which cannot be disabled.

8-2.1.4* An engine speed control device shall be installed to allow an increase in the engine speed when the apparatus is parked. An interlock shall prevent the operation of this engine speed control unless the parking brake is fully engaged and the transmission is in neutral or park, or unless the engine speed control is used with chassis engine driven components, in which case, it shall be properly interlocked with the engagement of those components.

8-2.1.5 The engine and transmission installation shall meet the engine and transmission manufacturer's installation recommendations for the service intended.

8-2.1.6 An engine hourmeter shall be provided.

8-2.2 Cooling System.

8-2.2.1* The cooling system of the engine 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.

8-2.2.2 Where automatic radiator shutters are supplied, provisions shall be required to return the shutters to the open position in the event of the failure of the automatic control. If this cannot be accomplished, manual controls shall be supplied.

8-2.2.3 Readily accessible drain valves shall be installed at the lowest point of the cooling system and at such other points as are necessary to permit complete removal of the coolant from the system. Drain valves shall be designed such that they will not open accidentally due to vibration.

8-2.2.4 The radiator shall be mounted so as to prevent the development of leaks caused by twisting or straining, where the apparatus operates over uneven ground. Radiator cores shall be compatible with commercial antifreeze solutions.

8-2.3 Lubrication System.

8-2.3.1* The engine shall be provided with an oil filter of the type approved by the engine manufacturer.

8-2.3.2 The engine oil fill pipe shall be large enough and located to allow easy filling.

8-2.3.3 A permanent plate in the driving compartment shall specify the quantity and type of the following fluids used in the vehicle:

(a) Engine oil;
(b) Engine coolant;
(c) Chassis transmission fluid;
(d) Pump transmission lubrication fluid;
(e) Pump primer fluid;
(f) Drive axle(s) lubrication fluid;
(g) Air-conditioning refrigerant;
(h) Air-conditioning lubrication oil;
(i) Power steering fluid;
(j) Cab tilt mechanism fluid;
(k) Transfer case fluid;
(l) Equipment rack fluid;
(m) Air compressor system lubricant;
(n) Generator system lubricant.

8-2.4 Fuel and Air System.

8-2.4.1* Diesel Engines.

8-2.4.1.1* An air filter shall be provided. Air inlet restrictions shall not exceed the engine manufacturer's recommendations. The air inlet shall be protected to prevent water and burning embers from entering the air intake system. An air restriction indicator shall be mounted in the cab and visible to the driver.

8-2.4.1.2* The fuel supply lines and fuel filters shall meet the engine manufacturer's recommendations.

8-2.4.1.3* Where an electric fuel priming system is furnished, the valving and piping shall be arranged and labeled so that it can be operated only to reprime the fuel system. When the system is not being intentionally operated, it shall be isolated from the normal fuel system and inoperable.

8-2.4.2 Gasoline Engines.

8-2.4.2.1 An air filter shall be provided. Air inlet restrictions shall not exceed the engine manufacturer's recommendations. The air inlet shall be protected so as to prevent water and burning embers from entering the air intake system. An air restriction indicator shall be mounted in the cab and visible to the driver.

8-2.4.2.2 Fuel lines and filters or strainers that meet the engine manufacturer's recommendations shall be provided. The filters or strainers shall be of a serviceable type and mounted in an accessible location. Where two or more fuel lines are installed, separate fuel pumps operating in parallel with suitable check valves and filtering devices shall be provided. The fuel line(s) shall be located or protected so as not to be subjected to excessive heating from any portion of a vehicle exhaust system. The line(s) shall be protected from mechanical damage. Suitable valves and drains shall be installed. The gasoline feed system shall include an electrically operated fuel pump located within or adjacent to the fuel tank.

8-2.5* Exhaust System. The exhaust piping and discharge outlet shall be located or shielded so as not to expose any portion of the apparatus or equipment to excessive heating. Exhaust pipe discharge shall be directed away from any operator's position. Silencing devices shall be provided. Exhaust backpressure shall not exceed the limits specified by the engine manufacturer. Where parts of the exhaust system are exposed so that they are likely to cause injury to operating personnel, suitable protective guards shall be provided.

8-3 Vehicle Components.

8-3.1 Braking System.

8-3.1.1 The vehicle shall be equipped with an all wheel anti-lock brake system if such a system is available from the chassis manufacturer.

8-3.1.2* Service brakes and parking brakes shall be independent and separate systems. All brakes shall be readily accessible for adjustment.

8-3.1.3 The service brake application valve, when applied, shall operate all the service brakes on the vehicle or combination vehicle.

8-3.1.4* Where air-actuated braking systems are provided, they shall include:

(a) An automatic moisture ejector;

(b) An air drier;

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

(d) A quick buildup section in the air reservoir system arranged so that the apparatus is able to move within 60 seconds of start-up from a completely discharged air system. 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. On a chassis that cannot be equipped with a quick buildup air brake system, an onboard automatic electric compressor with an automatically ejected electric shoreline or a fire station compressed air shoreline hookup shall be permitted, to maintain full operating air pressure while the vehicle is not running.

8-3.1.5* Parking brakes shall control the rear wheels, or all wheels, and shall be of the positive, mechanically-actuated type. The parking brake system shall hold the fully loaded apparatus on at least a 20 percent grade. A lockup device to retain applied pressure on hydraulic-actuated service brake systems, or the use of the "park" position on an automatic transmission shall not be substituted for a separate parking brake system. Parking brakes on steerable axles of tiller vehicles shall be provided where necessary to meet the requirements of this standard. Air-applied brakes or mechanically-actuated brakes are acceptable on these axles.

8-3.1.6 The service brakes shall be capable of bringing the fully laden apparatus to a complete stop from an initial speed of 20 mph (32 kmph), in a distance not exceeding 35 ft (10.7 m) by actual measurement, on a substantially hard level surface road that is free of loose material, oil, or grease.

8-3.1.7* All apparatus with a GVWR of 36,000 lb (16,330 kg) or greater shall be equipped with an auxiliary braking system.

8-3.2 Suspension and Wheels.

8-3.2.1* Each load-bearing tire and rim of the apparatus shall not carry a weight in excess of the recommended load for the operation of truck tires of the size used, as published in the *Yearbook of the Tire and Rim Association, Inc.*, and as recommended by the tire manufacturer, when the apparatus is loaded as indicated in Section 8-1. Where the vehicle tires are utilized as part of an aerial device stability system, the maximum loads imposed on the tires shall not exceed the tire manufacturer's maximum static load rating.

8-3.2.2 Axle housings and any other components except wheels and tires shall clear the road surface by at least 8 in. (203 mm).

8-3.2.3* An angle of approach and an angle of departure of at least 8 degrees shall be maintained at the front and rear of the vehicle when it is normally loaded as indicated in Section 8-1.

8-3.2.4 Fenders and guards shall be braced and firmly secured. Clearance for tire chains shall be provided in accordance with SAE J683, *Tire Chain Clearance— Trucks, Buses (except Suburban, Intercity, and Transit Buses), and Combinations of Vehicles.*

8-3.2.5 The steering mechanism shall be capable of turning the front wheels to an angle of at least 30 degrees to either the right or left for nondriving front axles, and at least 28 degrees for driving front axles. Power steering or power-assisted steering shall be provided.

8-3.2.6 If a tractor-drawn vehicle is provided for an aerial fire apparatus, it shall consist of a tractor with a suitable, permanent, nonkingpinned "fifth wheel" mounted upon the rear of the chassis to carry the forward end of the aerial ladder trailer unit. 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.

8-3.2.6.1 A steering wheel shall be provided to steer the rear wheels of the trailer unit. The steering shall be of the power or power-assisted type. A minimum wheel cramp angle of 20 degrees right and left shall be provided.

8-3.2.6.2 An audible and visual warning system shall be provided to warn both drivers when the jackknife position approaches the manufacturer's maximum allowable position.

8-3.2.6.3 If the manufacturer's design requires that the load from the aerial device not be transferred to the rear springs of the tractor, a suitable device shall be installed that will prevent such a weight transfer.

8-3.3* Transmission. The transmission shall be rated for heavy-duty service and shall be designed to match engine torque and speed to the load demand. The transmission shall provide the driver with the selection of individual gears, or ranges of gears, necessary to meet the performance requirements of this standard.

8-3.4 Fuel Tank.

8-3.4.1* The fuel capacity shall be sufficient to allow the engine to drive the pump for 2½ hours at rated pump capacity at 150 psi (1035 kPa) net pump pressure and at the suction conditions specified in this standard, or to operate at 60 percent of gross engine horsepower for 2½ hours, whichever is greater. The tank fill opening shall be conspicuously labeled for the proper fuel.

8-3.4.2* Only one fuel tank shall be furnished where the rated tank capacity is 50 gal (190 L) or less. The fuel gauge shall indicate the proportionate amount of fuel in the tank system at all times.

8-3.4.3 The tank fill piping shall be placed so it is protected from mechanical damage during the normal use of the fire apparatus, and both the tank and the fill piping shall be placed so they are not exposed to heat from the exhaust system or other source of ignition. The tank shall be placed so it is easily removable for repairs. A means for draining the tank without removing the tank shall be supplied.

8-3.5* 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.

Chapter 9 Low Voltage Electrical Systems and Warning Devices

9-1* General. Any 12-volt or 24-volt electrical systems or warning devices installed on the fire apparatus shall be appropriate for the service intended and shall meet the specific requirements of this chapter.

9-2 Wiring. All electrical circuit feeder wiring supplied and installed by the apparatus manufacturer shall meet the requirements of this section.

9-2.1* The 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. Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent. The use of star washers for circuit ground connections shall not be permitted. All circuits shall otherwise be wired in conformance with SAE J1292, *Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring.*

9-2.2 Wiring and Wire Harness Construction.

9-2.2.1 Insulated Wire and Cable. All insulated wire and cable shall conform to SAE J1127, *Battery Cable*; SAE J1128, *Low Tension Primary Cable*; or SAE J1560, *Low Tension Thin Wall Primary Cable.*

9-2.2.1.1 All conductors shall be constructed in accordance with SAE J1127, *Battery Cable*; SAE J1128, *Low Tension Primary Cable*; or SAE J1560, *Low Tension Thin Wall Primary Cable*; except when good engineering practice dictates special strand construction. Conductor materials and stranding, other than copper, shall be permitted if all applicable requirements for physical, electrical, and environmental conditions are met as dictated by the end application.

9-2.2.1.2 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127, *Battery Cable*; SAE J1128, *Low Tension Primary Cable*; or SAE J1560, *Low Tension Thin Wall Primary Cable*, except when good engineering practice dictates special conductor insulation.

9-2.2.2 The overall covering of conductors shall be moisture-resistant loom or braid. This overall covering shall have a minimum rating of 289°F (143°C) and a flammability rating of VW-1 as defined in UL 62, *Standard for Flexible Cord and Fixture Wire.*

9-2.3 The overall covering of jacketed cables shall be moisture resistant and have a minimum temperature rating of 289°F (143°C).

9-2.4 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection and shall be installed in accordance with the device manufacturer's instructions. Wire nut, insulation displacement, and insulation piercing connections shall not be used.

9-2.5 Wiring shall be thoroughly secured in place and protected against heat, liquid contaminants, and damage.

9-2.6* 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 schematic. [*See 2-11.4(b).*]

9-2.7 Circuits shall be provided with properly rated low voltage overcurrent protective devices. Such devices shall be readily accessible and protected against heat in excess of the components rating, mechanical damage, and water spray. Circuit protection shall be accomplished by utilizing fuses, circuit breakers, or fusible links that conform to one of the following SAE standards: SAE J156, *Fusible Links*; SAE J553, *Circuit Breakers*; SAE J2077, *Miniature Blade Type Electrical Fuses*; SAE J554, *Electric Fuses (Cartridge Type)*; or SAE J1888, *High Current Time Lag Electrical Fuses.*

9-2.8 Switches, relays, terminals, and connectors shall have a direct current (dc) rating of 125 percent of maximum current for which the circuit is protected.

9-3 Power Supply.

9-3.1* A 12-volt or 24-volt electric alternator shall be provided. It shall have a minimum output at idle to meet the minimum continuous electrical load of the apparatus as defined in 9-3.2, at 200°F (93°C) ambient temperature within the engine compartment, and shall be provided with full automatic regulation.

9-3.2 The minimum continuous electrical load shall consist of the total amperage required to simultaneously operate the following in a stationary mode at the scene:

(a) The propulsion engine and transmission;

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

(c) The radio (s) at a duty cycle of 10 percent transmit and 90 percent receive. For calculation and testing purposes, a default value of 5.0 amps continuous shall be used;

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

(e) The minimum optical warning system required in Section 9-8, where the apparatus is blocking right-of-way;

(f) The continuous electrical current required to simultaneously operate any fire pumps, aerial devices, and hydraulic pumps;

(g)* Other warning devices and electrical loads defined by the purchaser as critical to the mission of the apparatus.

9-3.3* The condition of the low voltage electrical system shall be indicated by a system that provides an audible and visual warning to persons on, in, or near the apparatus of an impending electrical system failure caused by the excessive discharge of the battery set. The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the system voltage. If system voltage is monitored, the alarm shall sound if the system voltage at the battery or at the master load disconnect switch drops below 11.8 volts for 12-volt nominal systems, or 23.6 volts for 24-volt nominal systems, for more than 120 seconds.

9-3.4 A voltmeter shall be mounted on the driver's instrument panel to allow direct observation of the system voltage.

9-3.5 Load Management.

9-3.5.1* If the total connected electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 9-3.1, an automatic electrical load management system shall be required.

9-3.5.2 The minimum continuous electrical loads defined in 9-3.2 shall not be subject to automatic load management.

9-4* Batteries.

9-4.1 Batteries shall be of the high cycle type.

9-4.2 The battery system shall be able to restart the engine after providing the minimum continuous electrical load for at least 10 minutes with the engine off. The minimum continuous electrical load shall not discharge the battery system by more than 50 percent of the reserve capacity rating during the 10-minute period.

9-4.3 The battery system CCA rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer.

9-4.4 The batteries shall be securely mounted and protected against mechanical damage and direct road spray.

9-4.4.1 The batteries shall be readily accessible for examination, test, and maintenance.

9-4.4.2* Where an enclosed battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes. The batteries shall also be protected against vibration and temperatures that exceed the battery manufacturer's recommendation.

9-4.5* An onboard battery conditioner or charger, or a polarized inlet, shall be provided for charging all batteries. Where an onboard conditioner or charger is supplied, the associated line voltage electric power system shall be installed in accordance with Chapter 19.

9-4.6 A master load disconnect shall be provided between the starter solenoid(s) and the remainder of the electrical loads on the apparatus. The batteries shall be connected directly to the starter solenoid(s).

9-4.6.1 The alternator shall be wired directly to the batteries through the ammeter shunt(s), if one is provided, and not through the master load disconnect switch.

9-4.6.2* A green "battery on" pilot light that is visible from the driver's position shall be provided.

9-4.7 To minimize the load placed on the electrical system during apparatus start-up for an emergency response, a sequential switching device shall be permitted to energize the optical warning devices required in 9-3.2 and other high current devices. Where incorporated, the device shall first energize the electrical devices required in 9-3.2 within 5 seconds.

9-5 Starting Device.

9-5.1 An electrical starting device shall be provided for the engine.

9-5.2 Where the electrical starting device is operating under maximum load, the voltage drop of the conductors between the battery and the starting device shall be in accordance with SAE J541, *Voltage Drop for Starting Motor Circuits.*

9-6 Temperature Exposure. Any alternator, electrical starting device, ignition wiring, distributor, or ignition coil shall be moisture resistant and protected such that it is not exposed to a temperature that exceeds the component manufacturer's recommendations.

9-7* Electromagnetic Interference. Electromagnetic interference suppression shall be provided as required to satisfy the radiation limits specified in SAE J551, *Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz).* The purchaser shall indicate if testing and certification under SAE J551 is required.

9-8 Optical Warning Devices. Each apparatus shall have a system of optical warning devices that meets or exceeds the requirements of this section.

9-8.1* The optical warning system shall be divided into upper and lower warning levels.

9-8.2 For the purpose of defining and measuring the required optical performance, the apparatus shall be divided into four warning zones. The four zones shall be determined by drawing lines through the geometric center of the apparatus at 45 degrees to a line lengthwise of the apparatus through the geometric center. The four zones

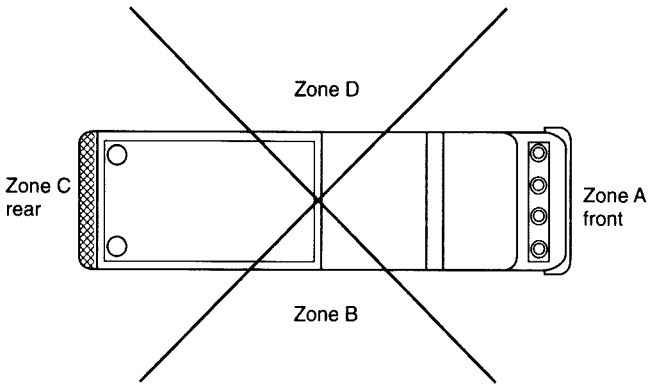


Figure 9-8.2 Warning zones for optical warning devices.

shall be designated A, B, C, and D in a clockwise direction with zone A to the front of the apparatus. (*See Figure 9-8.2.*)

9-8.3 Each optical warning device shall be installed on the apparatus and connected to the apparatus's electrical system in accordance with the requirements of this standard and the requirements of the manufacturer of the device.

9-8.4 A master optical warning device switch that energizes all of the optical warning devices shall be provided.

9-8.5 The optical warning system on the fire apparatus shall be capable of two separate signaling modes during emergency operations. One mode shall signal to drivers and pedestrians that the apparatus is responding to an emergency and is calling for the right-of-way. The other mode shall signal that the apparatus is stopped and is blocking the right-of-way.

9-8.6* Switching shall be provided that senses the position of the parking brake or the park position of an automatic transmission. When the master optical warning system switch is closed, and the parking brake is released or the automatic transmission is not in park, the warning devices signaling the call for right-of-way shall be energized. When the master optical warning system switch is closed, and the parking brake is on or the automatic transmission is in park, the warning devices signaling the blockage of the right-of-way shall be energized. The system shall be permitted to have a method of modifying the two signaling modes.

9-8.7 The optical warning devices shall be constructed or arranged to avoid the projection of light either directly or through mirrors into any driving or crew compartment(s).

9-8.8 The front optical warning devices shall be placed so as to maintain the maximum possible separation from the headlights.

9-8.9 The optical sources shall be of sufficient number and arranged so that failure of a single optical source does not create a measurement point in any zone without a warning signal at a distance of 100 ft (30 m) from the geometric center of the apparatus.

9-8.10 Flashers.

9-8.10.1 The minimum flash rate of any optical source shall be 75 flashes per minute and the minimum number of flashes at any measurement point shall be 150 flashes per minute.

9-8.10.2 The flasher of any current-interrupted flashing device shall otherwise meet the requirements of SAE J1054, *Warning Lamp Alternating Flashers.*

9-8.11 Permissible colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table 9-8.11. All colors shall be as specified in SAE J578, *Color Specification*, for white, red, yellow, or blue.

Table 9-8.11 Zone Colors

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

9-8.12 Requirements for Large Apparatus. If the apparatus has a bumper-to-bumper length of 22 ft (6.7 m) or more, or has an optical center on any optical warning device greater than 8 ft (2.4 m) above grade, the requirements of 9-8.12.1 through 9-8.12.6 shall apply.

9-8.12.1 The upper level optical warning devices shall be mounted as high and as close to the corner points of the apparatus as is practical in order to define the clearance lines of the apparatus. However, these optical warning devices shall not be mounted above the maximum height, specified by the device manufacturer, that gives an intensity value at 4 ft (1.2 m) above grade and 100 ft (30.5 m) from the optical warning device of less than 50 percent of that required at the optical center.

9-8.12.2 The lower level optical warning devices shall be mounted as close to the corner points of the apparatus as is practical with the optical center of the device at a distance of 18 in. to 62 in. (457 mm to 1575 mm) above grade.

9-8.12.3* A midship optical warning device shall be mounted on both the right and left sides of the apparatus with the optical center of the device at a distance of 18 in. to 62 in. (457 mm to 1575 mm) above grade. 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 15 ft (4.6 m) or less.

9-8.12.4* For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone total optical power requirement shown in Table 9-8.12.4.

9-8.12.5 No individual measurement point shall be less than that shown in Table 9-8.12.4.

9-8.12.6* The minimum optical warning system shall require no more than an average of 45 amps for the operation of the upper level and lower level devices. On apparatus whose length requires two midship lights per side, the optical warning system shall require no more than an average of 50 amps for the operation of the upper level and lower level devices. On apparatus whose length requires three midship lights per side, the optical warning system shall require no more than an average of 55 amps for the operation of the upper level and lower level devices.

9-8.13 Requirements for Small Apparatus. If the apparatus has a bumper-to-bumper length of less than 22 ft (6.7 m)

Table 9-8.12.4 Minimum Optical Power Requirement for Large Apparatus

Zone	Level	Mode of Operation					
		Clearing Right-of-Way			Blocking Right-of-Way		
		H	At Any H Point	At Any Point 5° Up or 5° Down from H	H	At Any H Point	At Any Point 5° Up or 5° Down from H
A	Upper	1,000,000	10,000	3500	400,000	10,000	3500
B	Upper	400,000	10,000	3500	400,000	10,000	3500
C	Upper	400,000	10,000	3500	800,000	10,000	3500
D	Upper	400,000	10,000	3500	400,000	10,000	3500
A	Lower	150,000	3750	1300	150,000	3750	1300
B	Lower	150,000	3750	1300	150,000	3750	1300
C	Lower	150,000	3750	1300	150,000	3750	1300
D	Lower	150,000	3750	1300	150,000	3750	1300

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

and has the optical center of all optical warning devices at 8 ft (2.4 m) or less above grade, the requirements of 9-8.13.1 through 9-8.13.5 shall apply.

9-8.13.1 The upper level optical warning devices shall be mounted as high as practical, but not over 8 ft (2.4 m), at their optical center. They shall be permitted to be combined in one or more enclosures and shall be permitted to be mounted on the cab roof or any other convenient point.

9-8.13.2 The lower level optical warning devices shall be mounted as close as practical to the front corner points of the apparatus with the optical center of the device at a distance of 18 in. to 48 in. (457 mm to 1220 mm) above grade.

9-8.13.3 For each operating mode, the combined optical power of all the optical sources mounted on both the upper and lower levels shall meet or exceed the zone total optical power shown in Table 9-8.13.3.

Table 9-8.13.3 Minimum Optical Power Requirement for Small Apparatus

Zone	Mode of Operation					
	Clearing Right-of-Way			Blocking Right-of-Way		
	H	At Any H Point	At Any Point 5° Up or 5° Down from H	H	At Any H Point	At Any Point 5° Up or 5° Down from H
A	1,000,000	10,000	3500	400,000	10,000	3500
B	200,000	8000	3500	200,000	10,000	3500
C	400,000	10,000	3500	800,000	10,000	3500
D	200,000	8000	3500	200,000	10,000	3500

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

9-8.13.4 No individual measurement point shall be less than that shown in Table 9-8.13.3.

9-8.13.5 The minimum optical warning system shall require no more than an average of 35 amps for the operation of the devices.

9-8.14 Tests of Optical Warning Devices.

9-8.14.1 Mechanical and Environment Test. All optical warning devices including those normally tested under SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance and Service Vehicles*, and SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, shall be tested in conformance with SAE J845, *360 Degree Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*. All devices shall comply with the following performance requirements of that standard:

Vibration	High temperature
Moisture	Low temperature
Dust	Durability
Corrosion	Warpage

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

9-8.14.2 Photometric Test Procedures for Optical Devices. Testing shall be performed by, or on behalf of, the device manufacturer to ensure compliance with the requirements of 9-8.14.2.1 through 9-8.14.2.4. The results of the testing shall be used by the apparatus builder or purchaser to determine compliance with this standard. The goniometer, integrating photometer, and other equipment used to make the test measurements shall meet the requirements of SAE J1330, *Photometry Laboratory Accuracy Guidelines*.

9-8.14.2.1 The optical source shall be mounted in a suitable goniometer and operated as it would be in a normal system application. The minimum distance between the light emitting surface of the source under test and the front face of the photometer detector shall be 59 ft (18 m). The goniometer shall be oriented to the appropriate point, and the integrating photometer shall be set to integrate light pulses from the source for 20 seconds.

9-8.14.2.2 For all tests performed with the power applied, the lighting system, or component thereof, shall be operated at 12.8 volts + 0.1 volt for 12-volt rated equipment and 25.6 volts + 0.2 volt for 24-volt rated equipment measured at the point of entry into the component. If the equipment is rated for operation on both 12 volts and 24 volts, the tests shall be performed at both voltages.

9-8.14.2.3 The technique described in 9-8.14.2.1 shall be performed along the horizontal plane passing through the optical center beginning at the optical center and repeated at 5-degree intervals to the left and right of the optical center throughout the active horizontal angle of light emission of the optical source.

9-8.14.2.4 Measurements shall be repeated at 5 degrees up and 5 degrees down from the horizontal plane passing through the optical center beginning at a point on a line passing through the optical center and perpendicular to horizontal plane and passing through the optical center. The measurements shall be repeated at 5-degree intervals to the left and right of this line throughout the active horizontal angle of light emission of the optical source. If the optical warning device contains more than one optical source, the test shall be repeated for each optical source.

9-8.15* Certification of Compliance. The apparatus manufacturer shall be permitted to demonstrate compliance of the warning system by one of the following methods:

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

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

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

9-9 Audible Warning Devices.

9-9.1* Audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren shall be provided. The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens*. A means shall be provided to allow the activation of the siren within convenient reach of the driver.

9-9.2 Where furnished, air horns, electric siren(s), and electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as practical. Audible warning equipment shall not be mounted on the roof of the apparatus.

9-10 Work Lighting.

9-10.1 The work area immediately behind the vehicle shall be illuminated to a level of at least 3 footcandles (33 lux) within a 10 ft by 10 ft (3 m by 3 m) square to the rear of the vehicle. If a hose bed is provided, lighting on this hose bed shall be at a level of 3 footcandles (33 lux) or higher. Lateral hose beds (crosslays) that are permanently covered shall not be required to be illuminated.

9-10.2 The apparatus shall be equipped with lighting capable of providing illumination at a minimum level of 1 footcandle (11 lux) on ground areas within 30 in. (762 mm) of the edge of the apparatus in areas designed for personnel to climb onto the apparatus or descend from the apparatus to the ground level. Lighting designed to provide illumination on areas under the driver and crew riding area exits shall be activated automatically when the exit doors are opened. All other ground area lighting shall be switchable.

9-10.3 Apparatus shall have sufficient lights to properly illuminate the crew compartment(s); any operator's panel; the engine compartment; the pump compartment; each enclosed tool and equipment compartment greater than 4 ft^3 (0.11 m^3) in volume and having an opening greater than 144 $in.^2$ (930 cm^2); and work areas, steps, and walkways.

9-10.4 Switches for all work lighting shall be readily accessible. The lights shall be arranged to minimize accidental breakage.

9-11 Hazard Light. 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 passenger or equipment compartment door is open, any ladder or equipment rack is not in the stowed position, a stabilizer system is deployed, a powered light tower is extended, or any other device is opened, extended, or deployed that creates a hazard or is likely to cause damage to the apparatus if the apparatus is moved. The light shall be marked "Do Not Move Apparatus When Light Is On."

9-12 Backup Alarm. An electric or electronic backup alarm shall be provided that meets the Type D (87 dba) requirements of SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*.

9-13 Stop, Tail, and Directional Lights. The apparatus shall be equipped with all stop, tail, and directional lights required by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, *Lamps, reflective devices, and associated equipment*. Equipment shall be mounted so that it will not obscure the rear stop, tail, and directional lights. Directional lights shall be visible from the front, sides, and rear of the apparatus. On apparatus 30 ft (10 m) in length or longer, a turn signal shall be mounted approximately midway along the apparatus at approximately running board height.

9-14 Electrical System Performance Tests.

9-14.1* The apparatus low voltage electrical system shall be tested and certified. The certification shall be delivered to the purchaser with the apparatus.

9-14.2 Tests shall be performed when the air temperature is between 0°F and 100°F (18°C and 38°C).

9-14.3 Test Sequence. The following three tests shall be performed in the order indicated below. Before each test, the batteries shall be fully charged. A full charge condition shall be when the charge voltage stabilizes at the voltage regulator set point and the lowest charge current is maintained for 10 minutes. Failure of any of these tests shall require a repeat of the sequence.

9-14.3.1 Reserve Capacity Test. The engine shall be started and kept running until the engine and engine compartment temperatures are stabilized at normal operating temperatures and the battery system is fully charged. The engine shall be shut off and the minimum continuous electrical load shall be activated for 10 minutes. All electrical loads shall be turned off prior to attempting to restart the engine. The battery system shall then be capable of restarting the engine. Failure to restart the engine shall be considered a test failure.

9-14.3.2 Alternator Performance Test at Idle. The minimum continuous electrical load shall be activated with the engine running at idle speed. The engine temperature shall be stabilized at normal operating temperature. The battery system shall be tested to detect the presence of battery discharge current. The detection of battery discharge current shall be considered a test failure.

9-14.3.3 Alternator Performance Test at Full Load. The total continuous electrical load shall be activated with the engine running up to the engine manufacturer's governed speed. The test duration shall be a minimum of 2 hours. Activation of the load management system shall be permitted during this test. However, an alarm sounded by excessive battery discharge, as detected by the system required in 9-3.3, or a system voltage of less than 11.7 volts dc for a 12-volt nominal system or 23.4 volts dc for a 24-volt nominal system, for more than 120 seconds, shall be considered a test failure.

9-14.4 Low Voltage Alarm Test.

9-14.4.1 Following the completion of the above tests, the engine shall be shut off. The total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates.

9-14.4.2 The battery voltage shall be measured at the battery terminals. With the load still applied, a reading of less than 11.7 volts dc for a 12-volt nominal system or 23.4 volts dc for a 24-volt nominal system shall be considered a test failure.

9-14.4.3 The battery system shall then be able to restart the engine. Failure to restart the engine shall be considered a test failure.

9-15 Documentation. At the time of delivery, the manufacturer shall provide the following:

(a) Documentation of the electrical system performance tests;

(b) A written load analysis, including:

1. The nameplate rating of the alternator;

2. The alternator rating under the conditions specified in 9-3.1;

3. Each component load specified in 9-3.2 comprising the minimum continuous load;

4. Additional loads that, when added to the minimum continuous load, determine the total connected load;

5. Each individual intermittent load.

Chapter 10 Driving and Crew Areas

10-1 General.

10-1.1* Each crew riding position shall be provided with a seat and an approved seat belt designed to accommodate a human with and without heavy clothing. Each crew riding position shall be within a fully enclosed personnel area. Materials used within the driving and crew compartment shall comply with Federal Motor Vehicle Safety Standard (FMVSS) No. 302, *Flammability of interior materials*. All forward facing seats adjacent to a side wall shall be provided with a Type 2 pelvic and upper torso restraint style seat belt assembly conforming to the Federal Motor Vehicle Safety Standard (FMVSS) No. 209, *Seat belt assemblies*. All seat belt assembly anchorages shall conform to the Federal Motor Vehicle Safety Standard (FMVSS) No. 210, *Seat belt assembly anchorages*. Tiller seats shall have a lap belt.

10-1.2 Signs that read "Occupants must be seated and belted when apparatus is in motion" shall be provided. They shall be visible from each seated position. A label that states the number of personnel the vehicle is designed to carry shall be located in an area visible to the driver.

10-1.3 At any seat location the maximum noise level shall be 90 dba without any warning devices in operation, as measured by the test procedure defined in Title 49, *Code of Federal Regulations* (CFR), paragraph 393.94(c), except that the test shall be performed with the vehicle traveling at a steady speed of 45 mph (72 kmph) on a level, hard, smooth surface road.

10-1.4 All interior crew and driving compartment door handles shall be designed and installed to protect against accidental or inadvertent opening.

10-1.5 Head height at any seat shall be at least 37 in. (940 mm) from the seat to the ceiling with the seat depressed 1 in. (25 mm). Each seating space shall have a minimum width of 22 in. (560 mm) at the shoulder level. Seat cushions shall be a minimum of 18 in. (458 mm) in width and 15 in. (381 mm) from the front of the cushion to the face of the seat back. A back cushion that extends from the face of the seat vertically at least 18 in. (458 mm) and that is a minimum of 18 in. (458 mm) wide shall be provided. The back cushion shall be permitted to be split to accommodate a fully recessed SCBA and bracket. Where the back cushion is split, a head rest shall be supplied.

10-1.6* Where SCBA units are mounted within the driving or crew compartment, a positive mechanical means of holding the SCBA device in its stowed position shall be provided. The bracket holding device shall retain the SCBA unit when subjected to a 10-G dynamic deceleration test and shall be installed in accordance with the bracket manufacturer's requirements.

10-1.7 All equipment required to be used during an emergency response shall be securely fastened. All equipment not required to be used during an emergency response, with the exception of SCBA units, shall not be mounted in the 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.

10-1.8 Steps and access handrails that comply with 11-7.1 through 11-7.3 and Section 11-8 shall be provided as necessary for access to all driving and crew compartments.

10-1.9 Where the crew compartment and the driving compartment are separated, prohibiting direct voice communication, a two-way buzzer or two-way voice intercom system shall be provided.

10-2* Driving Compartment.

10-2.1* A fully-enclosed driving compartment with seating capacity for not less than two persons shall be provided except at a tiller driving position. (*See 10-3.1.*)

10-2.2 The driver's seat shall be readily adjustable by the driver in accordance with SAE J1517, *Driver Selected Seat Position*, so that the driver's ankle rests on the accelerator pedal at not less than 90 degrees in the "idle" position and not more than 130 degrees in the "full-throttle" position.

The seat shall be arranged to accommodate a human in at least the fifth percent female through the 95th percent adult male as defined in SAE J833, *Human Physical Dimensions*.

10-2.3* The front passenger's seat(s) shall be mounted so that the clear viewing of the right side mirror shall not be obstructed by the occupants of the seat(s) while in the normal seated positions.

10-2.4 The following instrumentation and controls shall be mounted in the driving compartment and shall be clearly identified and visible to the driver while seated. 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.

(a) Speedometer;
(b) Tachometer;
(c) Odometer;
(d) Oil pressure indicator or gauge;
(e) Coolant temperature indicator or gauge;
(f) Automatic transmission temperature indicator or gauge, if applicable;
(g) Voltmeter;
(h) Hazard indicator light (*see Section 9-11*);
(i) Air pressure gauge(s), if applicable;
(j) Turn signal control and indicator lights;
(k) Headlight/DOT light switch;
(l) High beam headlight switch and indicator;
(m) Fuel level gauge(s);
(n) Master ignition switch (if a key is provided, it shall be unable to be removed from the cab interior);
(o) Heater/defroster controls;
(p) Warning lights and siren switches;
(q) Master electrical load switch;
(r) Battery on indicator light;
(s) Windshield wipers and washer;
(t) PTO-engaged indicator, if applicable;
(u) Stabilizers not stowed, if applicable;
(v) Height of vehicle sign;
(w) Pump controls, if applicable.

10-3 Tractor-Drawn Vehicles. Where a tractor-drawn vehicle with tillered steering is provided, the requirements of this section also shall apply.

10-3.1 A fully-enclosed driving compartment with seating for one person shall be provided at the rear wheel's steering position. No side compartmentation shall be installed that obscures the ability of the tiller operator to see the tiller axle fender area.

10-3.2* The manufacturer shall provide a seat with an approved seat belt within the enclosure. The seating space shall have a minimum of 22-in. (560-mm) width at the shoulder level. The seat cushion shall be a minimum of 18 in. (457 mm) in width and 15 in. (381 mm) from the front of the cushion to the face of the seat back. A back cushion shall be provided.

10-3.3 The seat shall be readily adjustable by the driver. The adjustment range shall be at least 3 in. (76 mm) from front to rear.

10-3.4 A warning indicator in the driving compartment shall activate if the parking brake is released and the tiller driver is not signaling his presence.

10-3.5 A two-way buzzer system or a two-way voice intercom shall be provided for communication between the drivers. Where a buzzer system is used, either a horn button or floor switch shall be provided to activate the buzzer.

10-3.6 A heater or ventilation system, and defroster shall be provided.

10-3.7 A windshield wiper and washer shall be provided.

10-3.8 The following instrumentation and controls shall be mounted in the driving compartment and shall be clearly identified and visible to the driver while seated.

(a) Heater/defroster controls;
(b) Turn signal indicator lights;
(c) Two-way buzzer signal switch;
(d) Windshield wiper control.

10-3.9 Controls and switches that are expected to be operated by the tiller steering wheel driver while the apparatus is in motion shall be within convenient reach for that driver.

10-3.10 Exterior rearview mirrors shall be provided at the tiller position.

Chapter 11 Body, Compartments, and Equipment Mounting

11-1 Compartmentation.

11-1.1* Any enclosed external compartments shall be weather resistant, ventilated, and have provisions for drainage of moisture. In addition, any compartment that is more than 4 ft^3 (0.11 m^3) in volume or has an opening greater than 144 $in.^2$ (929 cm^2) shall be lighted.

11-1.2 All electrical junctions or wiring within compartments shall be protected from mechanical damage resulting from equipment stored in the compartment. All terminal strips shall have protective covers.

11-2* Radio Space. A suitably protected space or compartment shall be provided for the installation of radio equipment.

11-3* Equipment Containment. Equipment holders or compartments shall be provided for all tools, equipment, and other items that are on the apparatus. Equipment holders shall be attached firmly and shall be designed so that equipment remains in place under all vehicle operating conditions. All tools and equipment shall be readily accessible.

11-4 Powered Equipment Racks. When a powered equipment rack is provided, it shall meet the requirements of this section.

11-4.1 The equipment rack shall be constructed of materials that are capable of carrying the equipment that is intended to be mounted on the equipment rack.

11-4.2 A lock shall be provided that will retain the equipment rack in the road travel position when the vehicle is in motion. An interlock shall be provided to prevent operation of the equipment rack unless the apparatus parking brake has been activated.

11-4.3 Controls shall be provided in a position where the operator has visual contact with the travel of the equipment rack.

11-4.4 A visual signal shall be provided at the driver's position to indicate that the equipment rack is in motion, or in the down position, and that the parking brake is not engaged.

11-4.5 Flashing lights facing the front and rear shall be provided on the equipment rack and shall be illuminated whenever the equipment rack is in the down position. Such lights shall be of sufficient intensity to warn oncoming personnel that the equipment rack is in the down position.

11-4.6 The outward side of the equipment rack that protrudes beyond the body of the apparatus shall be stripped or painted with reflective material so as to indicate a hazard or obstruction.

11-5* SCBA Storage. Storage of complete SCBA units or SCBA cylinders shall be arranged to prevent damage, injury, or abrasion to the SCBA from other equipment stored in the general area.

11-5.1 If a SCBA unit or cylinder is stored within a driving or crew compartment, the mounting shall comply with the requirements of 10-1.6. Mounting clamps or securing devices shall be of a type that positively latch around the cylinder, with a release system easily accessible by the user.

11-5.2 If the 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.

11-5.3 The holding or clamping device shall not injure, wear, scrape, or otherwise affect the SCBA unit or cylinder, including damage to the paint or reflective finish, while the cylinder is being placed in, stored, or removed from the holder.

11-5.4 The SCBA storage area shall be a ventilated, dry area away from all heat sources that could damage the SCBA (e.g., mufflers, engines).

11-5.5* Vertical Storage of SCBA Cylinders in Tubes.

11-5.5.1 The base of the storage tube shall have a rubber, plastic, or similar device to prevent wear on the cylinder or damage if the cylinder is accidentally dropped into the storage position.

11-5.5.2 Each storage tube shall have a drain to prevent accumulation of moisture.

11-5.6* Horizontal Storage of SCBA Cylinders.

11-5.6.1 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 to keep the cylinder from hitting or rubbing on compartment doors by preventing movement or shifting when in transit.

11-5.6.2 The rear wall of each SCBA storage area or tube shall be covered with a rubber, plastic, or similar material to prevent wear on cylinders.

11-6 Pump and Plumbing Access.

11-6.1 A removable access panel shall be provided for quick access to the pump and plumbing. The panel shall be a minimum of 450 in.^{2} (2900 cm^2), and no one dimension on the access opening shall measure less than 18 in. (457 mm).

11-6.2 The access panel shall be capable of being opened or removed without the use of special tools.

11-6.3 The clear space required by the pump manufacturer to perform in-truck overhaul and maintenance shall be provided.

11-7 Stepping Surfaces.

11-7.1* Steps, platforms, or secure ladders shall be provided so fire fighters have access to all working and storage areas of the apparatus. The maximum stepping height shall not exceed 18 in. (458 mm), with the exception of the ground to first step, which shall not exceed 24 in. (610 mm). A permanently attached supplemental access/egress means from the ground to these steps, platforms, or secure ladders shall be provided where the ground to the first step, platform, or ladder exceeds 24 in. (610 mm). The supplemental access means shall consist of a step(s), platform(s), or ladder(s). The ground to first step height shall be determined with the apparatus on level ground. 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 16-21. All steps shall have a minimum area of 35 in.^{2} (225 cm^2), shall be of such a shape that a 5-in. (127-mm) diameter disk does not overlap any side when placed on the step, and shall be arranged to provide at least 8 in. (203 mm) of clearance between the leading edge of the step and any obstruction. All platforms shall have a minimum depth of 8 in. (203 mm) from the leading edge of the platform to any obstruction. All ladders shall have at least 7 in. (178 mm) of clearance between any rung and the body or other obstruction.

11-7.2 All steps, platforms, or ladders shall sustain a minimum static load of 500 lb (227 kg) without deformation.

11-7.3 All steps, platforms, or ladders shall have skid-resistant surfaces. 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.

11-7.4 A label shall be located on the vehicle at the rear step areas, and at any cross walkways, if they exist. The label(s) shall warn personnel that riding in or on these areas while the vehicle is in motion is prohibited.

11-8* Access Handrails. Access handrails shall be provided at all entrances to the driving or crew compartment, and at all positions where steps or ladders for climbing are located. Access handrails shall be constructed of, or covered with, a slip-resistant, noncorrosive material. Handrails shall be between 1 in. and 1⅝ in. (25 mm and 41 mm) in diameter and have a minimum clearance between the handrails and any surface of at least 2 in. (51 mm). All handrails shall be designed and mounted to reduce the possibility of hand slippage and to avoid snagging of hose, equipment, or clothing.

11-9 Metal Finish.

11-9.1* All exposed ferrous metal surfaces that are not plated or stainless steel shall be cleaned and prepared thoroughly and shall be painted or coated. The paint or coating,

including any primer, shall be applied in accordance with the paint or coating manufacturer's recommendation. The purchaser shall specify if nonferrous body components are to be painted and any lettering, numbering, or decorative striping to be furnished.

11-9.2 A reflective stripe(s) shall be affixed to the perimeter of the apparatus. The stripe or combination of stripes shall be a minimum of 4 in. (100 mm) in total width and shall conform to ASTM D 4956, *Standard Specifications for Retroreflective Sheeting for Traffic Control*, Type III, Class 1 or Class 3. At least 50 percent of the cab and body length on each side, at least 50 percent of the width of the rear, and at least 25 percent of the width of the front of the apparatus shall have the reflective material affixed to it. A graphic design meeting the reflectivity requirements of this paragraph 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 above.

11-10* Hose Storage.

11-10.1* If a hose storage area(s) is provided, the area(s) shall be reinforced at the corners. The bottom shall be made of removable sections fabricated from noncorrosive materials. The bottom shall be constructed to prevent the accumulation of water and allow ventilation to aid in drying of hose. The interior shall be smooth and free from all projections, such as nuts, sharp angles, or brackets, that might cause damage to the hose. Reels, handrails, ladders, and equipment holders shall not be placed to obstruct the laying or removal of hose from the storage area.

11-10.2 Any hose storage area designed to carry 2½-in. (65-mm) or larger hose shall be a minimum of 60 in. (1525 mm) in length.

11-11 Slip-on Fire-Fighting Module. If the pump, piping, and tank are built as a slip-on, self-contained unit, it shall meet the mounting requirements of this section and major components of the slip-on unit; pump, pumping engine, tank, electrical, and plumbing shall meet the requirements of applicable chapters covering those components.

11-11.1* The weight of a completed skid-mounted fire-fighting package, including fuel, oil, and standard equipment normally carried, shall be distributed on the frame to provide a properly balanced unit when it is lifted or moved.

11-11.2 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.

11-11.3 Mounting.

11-11.3.1 The slip-on unit shall be mounted in a manner that allows access to the engine, pump, and auxiliary systems for routine maintenance. The slip-on unit shall not be welded or otherwise permanently secured to other components.

11-11.3.2 The slip-on unit shall be mounted in a manner to prevent damage by vibration.

11-11.3.3 Special anchorage shall be provided on the vehicle chassis and on the skid-mounted fire-fighting package to secure the skid-mounted fire-fighting package to the vehicle chassis. This anchorage shall be designed to prevent movement of the unit during rapid acceleration or deceleration.

Chapter 12 Fire Pump and Associated Equipment

12-1 Application. If the apparatus is equipped with a fire pump, the provisions of this chapter shall apply.

12-2 Design and Performance Requirements.

12-2.1 The fire pump shall be mounted on the apparatus and have a minimum rated capacity of 250 gpm (946 L/min) at 150 psi (1035 kPa) net pump pressure. Pumps of higher capacity shall be rated at one of the capacities specified in Table 12-2.4.1(a). Power to drive the fire pump shall be permitted to be provided by the same engine used to propel the apparatus or by a separate engine.

12-2.2 Where the apparatus is designed for pump and roll operations, the minimum performance shall be 20 gpm (76 L/min) at 100 psi (690 kPa) at an apparatus ground speed on level ground of 2 mph (3.2 kmph).

12-2.3 Pumping System Capability.

12-2.3.1 The pumping system provided shall be capable of delivering:

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

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

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

12-2.3.2* 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 through 20 ft (6 m) of suction hose, under the conditions specified in Table 12-2.4.1(a) for the rated capacity of the pump, and discharging water in not more than 30 seconds for pumps of less than 1500 gpm (5678 L/min) and not over 45 seconds for pumps of 1500 gpm (5678 L/min), or larger capacity. An additional 15 seconds shall be permitted to meet these requirements where the pump system includes an auxiliary 4-in. (100-mm) or larger intake pipe having a volume of 1 ft^3 (28,316 cm^3) or more.

12-2.3.3 The completed pumping system shall be capable of developing a vacuum of 22 in. Hg (74.5 kPa) by means of the pump priming device and sustaining the vacuum for at least 5 minutes with a loss not to exceed 10 in. Hg (33.9 kPa). This shall be demonstrated with all intake valves open, all intakes capped or plugged, all discharge caps removed, and without the use of the pump primer during the 5-minute period.

12-2.4 Pump Suction Capability.

12-2.4.1* The pump manufacturer shall certify that the fire pump is capable of pumping 100 percent of rated capacity at 150 psi (1035 kPa) net pump pressure from draft, through 20 ft (6 m) of suction hose with a strainer attached under the following conditions:

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

(b) Atmospheric pressure of 29.9 in. Hg (101.2 kPa) (corrected to sea level);

NOTE: At an altitude of 2000 ft (610 m) the actual (uncorrected) atmospheric pressure equivalent to the sea level reading of 29.9 in. Hg (101.2 kPa) is 27.8 in. Hg (94.1 kPa).

Table 12-2.4.1(a) Rated Capacities and Maximum Suction Hose Size, Number of Suction Lines, and Lift for Fire Pumps

Rated Capacity		Maximum Suction Hose Size		Maximum Number of Suction	Maximum Lift	
(gpm)	(L/min)	(in.)	(mm)	Lines	(ft)	(m)
250	950	3	76	1	10	3
300	1136	3	76	1	10	3
350	1325	4	100	1	10	3
450	1700	4	100	1	10	3
500	1900	4	100	1	10	3
600	2270	4	100	1	10	3
700	2650	4	100	1	10	3
750	2850	4½	113	1	10	3
1000	3785	5	125	1	10	3
1250	4732	6	150	1	10	3
1500	5678	6	150	2	10	3
1750	6624	6	150	2	8	2.4
2000	7570	6	150	2	6	1.8
2250	8516	8	150	3	6	1.8
2500	9463	8	150	3	6	1.8
2750	10,410	8	150	4	6	1.8
3000	11,356	8	150	4	6	1.8

(c) Water temperature of 60°F (15.6°C);

(d) Suction hose size, number of hoses, and lift as indicated in Table 12-2.4.1(a);

(e) Friction and entrance loss in suction hose, including strainer, as given in Table 12-2.4.1(b).

12-2.4.2* The pump manufacturer shall certify that the pump is capable of pumping rated capacity at 150 psi (1035 kPa) net pump pressure at any of the following special conditions when these conditions are specified by the purchaser:

(a) At an elevation above 2000 ft (610 m);

(b) At lifts higher than those listed in Table 12-2.4.1(a) or through more than 20 ft (6 m) of suction hose, or both;

(c) For pumps having a rated capacity of 1500 gpm (5678 L/min) or larger, through a single suction hose only, or through the number of hoses listed in Table 12-2.4.1(a) attached to one side of the apparatus only.

12-3 Pumping Engine Requirements.

12-3.1 The apparatus manufacturer shall approve the use of the pumping engine for stationary pumping applications for the type and size of the fire apparatus and the rating of the pump being furnished.

12-3.2 The engine shall be capable of performing the pumping tests herein specified without exceeding the maximum no-load governed speed of the engine as shown on a certified brake horsepower curve of the type of engine used without accessories. This brake horsepower curve certification shall be signed by a responsible official of the engine manufacturer.

12-3.3 On fire pumps of 750 gpm (2850 L/min) or greater, the engine/pump combination shall be capable of delivering the rated pump capacity at 165 psi (1138 kPa) net pump pressure.

12-3.4* If a separate pumping engine is provided, it shall meet the requirements of 8-2.1.1, 8-2.1.2, 8-2.2, 8-2.3.1, 8-2.3.2, 8-2.4, 8-2.5, and Sections 9-4 and 9-5.

12-3.5 A supplementary heat exchanger cooling system shall be provided on the pump drive engine. Proper valving shall 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 shall 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. An appropriate drain(s) shall be provided to allow draining the heat exchanger to prevent damage from freezing.

12-3.6 Where a separate engine is used to drive the pump, an amber indicator light that is energized when the pump engine ignition is energized shall be provided in the driving compartment. It shall be marked "Pump Engine Ignition."

12-4 Power Train Capability.

12-4.1 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 12-2.3.1 without exceeding the component manufacturer's continuous duty torque rating.

12-4.2 When pumping continuously at each of the pump performance points specified in 12-2.3.1, 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.

12-5 Construction Requirements.

12-5.1* Wetted moving parts shall be constructed of a corrosion-resistant material.

12-5.2 The pump body shall be subjected to a hydrostatic test of 500 psig (3450 kPag) for 10 minutes. The pump manufacturer shall provide a certificate of completion for the hydrostatic test.

12-5.3 Where an auxiliary pump is provided in combination with a fire pump and where the pumps are interconnected so that pressure from one pump can be transmitted to the other pump, suitable check valves, intake or discharge relief valves, pump drive gear ratios, or other automatic means shall be provided to avoid pressurizing either pump beyond its maximum rated hydrostatic pressure.

12-5.4 The entire discharge and intake piping system, valves, drain cocks and lines, and intake and outlet closures, excluding the tank fill and tank to pump lines on the tank side of the valves in those lines, shall be suitable to withstand a minimum hydrostatic burst pressure of 500 psig (3450 kPag).

12-5.5 The pump shall be capable of producing fire streams which are free from pulsations. When an accumulator is used to provide a pulsation free fire flow, the accumulator shall be constructed and tested in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 2.

12-5.6 The pump shall allow a positive pressure water source to directly add to the pump's net pump pressure.

12-5.7 The pump shall pass debris that is small enough to pass through the strainer(s) at the pump(s) intakes.

12-5.8 The pump design shall permit the pump discharges, at rated performance, to be closed totally within 3 seconds without undue shock or damage with all relief systems not activated.

Table 12-2.4.1(b) Friction and Entrance Loss in 20 ft (6 m) of Suction Hose, Including Strainer

	Suction Hose Size (inside diameter)									
	3 in.		3½ in.		4 in.		4½ in.		5 in.	
Flow Rate (gpm)	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
250	5.2 (1.2)	4.6								
175	2.6 (0.6)	2.3								
125	1.4 (0.3)	1.2								
300	7.5 (1.7)	6.6	3.5 (0.8)	3.1						
210	3.8 (0.8)	3.4	1.8 (0.4)	1.6						
150	1.9 (0.4)	1.7	0.9 (0.2)	0.8						
350			4.8 (1.1)	4.2	2.5 (0.7)	2.1				
245			2.4 (0.5)	2.1	1.2 (0.3)	1.1				
175			1.2 (0.3)	1.1	0.7 (0.1)	0.6				
450					4.1 (1.0)	3.6	2.7 (0.4)	2.6		
315					2.0 (0.5)	1.8	1.2 (0.2)	1.1		
225					1.0 (0.2)	0.9	0.6 (0.1)	0.5		
500					5.0 (1.3)	4.4	3.6 (0.8)	3.2		
350					2.5 (0.7)	2.1	1.8 (0.4)	1.6		
250					1.3 (0.4)	1.1	0.9 (0.3)	0.8		
600					7.2 (1.8)	6.4	5.3 (1.0)	4.7	3.1 (0.6)	2.7
420					3.5 (1.0)	3.1	2.5 (0.5)	2.2	1.6 (0.3)	1.4
300					1.8 (0.4)	1.6	1.3 (0.2)	1.0	0.6 (0.1)	0.5
700					9.7 (2.7)	8.6	7.3 (1.3)	6.4	4.3 (0.8)	3.8
490					4.9 (1.1)	4.3	3.5 (0.7)	3.1	2.0 (0.4)	1.8
350					2.5 (0.7)	2.2	1.6 (0.3)	1.4	0.9 (0.2)	0.8

	Suction Hose Size (inside diameter)											
	4 in.		4½ in.		5 in.		6 in.		Two 4½ in.		Two 5 in.	
Flow Rate (gpm)	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
750	11.4 (2.9)	9.8	8.0 (1.6)	7.1	4.7 (0.9)	4.2	1.9 (0.4)	1.7				
525	5.5 (1.5)	4.9	3.9 (0.8)	3.4	2.3 (0.5)	2.0	0.9 (0.2)	0.8				
375	2.8 (0.7)	2.5	2.0 (0.4)	1.8	1.2 (0.2)	1.1	0.5 (0.1)	0.5				
1000			14.5 (2.8)	12.5	8.4 (1.6)	7.4	3.4 (0.6)	3.0				
700			7.0 (1.4)	6.2	4.1 (0.8)	3.7	1.7 (0.3)	1.5				
500			3.6 (0.8)	3.2	2.1 (0.4)	1.9	0.9 (0.2)	0.8				
1250					13.0 (2.4)	11.5	5.2 (0.9)	4.7	5.5 (1.2)	4.9		
875					6.5 (1.2)	5.7	2.6 (0.5)	2.3	2.8 (0.7)	2.5		
625					3.3 (0.7)	2.9	1.3 (0.3)	1.1	1.4 (0.3)	1.2		
1500							7.6 (1.4)	6.7	8.0 (1.6)	7.1	4.7 (0.9)	4.2
1050							3.7 (0.7)	3.3	3.9 (0.8)	3.4	2.3 (0.5)	2.0
750							1.9 (0.4)	1.7	2.0 (0.4)	1.8	1.2 (0.2)	1.1
1750							10.4 (1.8)	9.3	11.0 (2.2)	9.7	6.5 (1.2)	5.7
1225							5.0 (0.9)	4.6	5.3 (1.1)	4.7	3.1 (0.7)	2.7
875							2.6 (0.5)	2.3	2.8 (0.6)	2.5	1.6 (0.3)	1.4
2000									14.5 (2.8)	12.5	8.4 (1.6)	7.4
1400									7.0 (1.4)	6.2	4.1 (0.8)	3.7
1000									3.6 (0.8)	3.2	2.1 (0.4)	1.9
2250											10.8 (2.2)	9.5
1575											5.3 (1.1)	4.7
1125											2.8 (0.5)	2.5
2500											13.0 (2.4)	11.5
1750											6.5 (1.2)	5.7
1250											3.3 (0.7)	2.9

Table 12-2.4.1(b) Friction and Entrance Loss in 20 ft (6 m) of Suction Hose, Including Strainers (continued)

	Suction Hose Size (inside diameter)									
	Two 6 in.		Three 6 in.		Four 6 in.		8 in.		Two 8 in.	
Flow Rate (gpm)	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
1500	1.9 (0.4)	1.7								
1050	0.9 (0.3)	0.8								
750	0.5 (0.1)	0.5								
1750	2.6 (0.5)	2.3								
1225	1.2 (0.3)	1.1								
875	0.7 (0.2)	0.6								
2000	3.4 (0.6)	3.0								
1400	1.7 (0.3)	1.5								
1000	0.9 (0.2)	0.8								
2250	4.3 (0.8)	3.8								
1575	2.2 (0.4)	1.9								
1125	1.1 (0.2)	1.0								
2500	5.2 (0.9)	4.7								
1750	2.6 (0.5)	2.3								
1250	1.3 (0.3)	1.1								
3000	7.6 (1.4)	6.9	3.4 (0.6)	3.0			8.5 (1.6)	7.5		
2100	3.7 (0.7)	3.4	1.7 (0.3)	1.5			4 (0.8)	3.5		
1500	1.9 (0.4)	1.7	0.9 (0.2)	0.8			1.9 (0.4)	1.7		

NOTE: Figures in parentheses indicate increment to be added or subtracted for each 10 ft (3 m) of hose less than or greater than 20 ft (6 m).

12-6 Pump Intake Connections.

12-6.1* Intake(s) of the same or larger size and quantity than the maximums specified in Table 12-2.4.1(a) for suction hose size and number of hoses shall be provided.

12-6.1.1 The intakes specified in 12-6.1 shall have male National Hose threads.

12-6.1.2 If the couplings on the suction hose carried on the apparatus are of a different size or have other means of hose attachment than the intakes, suitable adapters shall be provided on each appropriate intake.

12-6.1.3 If an inlet located at the pump operator's position is valved, it shall be provided with a permanent label that states "Warning — Serious Injury or Death Could Occur if Inlet(s) Is Supplied by a Pressurized Source When the Valve Is Closed."

12-6.2 Each intake shall have a removable or accessible strainer inside the connection.

12-6.3 At least one auxiliary valved intake shall be provided that is controllable at the pump operator's position. The valve and piping shall be of 2½ in. (65 mm) minimum size and shall be equipped with a female swivel coupling with National Hose threads.

12-6.4 Any 3-in. (76-mm) or larger intake valve shall be a slow operating valve.

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

12-6.5 Each valved intake shall be equipped with a bleeder valve having a minimum ¾-in. (19-mm) pipe thread connection, located in close proximity to the intake, to bleed off air or water from a hose connected to the intake. The valve shall be operational without the operator having to get under the apparatus. If a valved appliance is attached to an intake, it shall be equipped with a ¾-in. (19-mm) bleeder valve on each intake.

12-6.6 All intakes shall be provided with caps or closures suitable to withstand a hydrostatic burst pressure of 500 psig (3450 kPag). Intakes having male threads shall be equipped with caps; intakes having female threads shall be equipped with plugs. 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.

12-6.7 Caps or closures for 3½-in. (89-mm) and smaller intakes shall be secured to the apparatus with suitable chains or cables.

12-7 Pump Discharge Outlets.

12-7.1* Discharge outlets 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 12-7.1.

Table 12-7.1 Discharge Rates by Outlet Size

Outlet Size (in.)	Outlet Size (mm)	Flow Rates (gpm)	Flow Rates (L/min)
2½	65	250	950
3	76	375	1420
3½	89	500	1900
4	100	625	2365
4½	113	750	2850
5	125	1000	3785

12-7.1.1 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 (3785 L/min) outlet.

12-7.1.2 A minimum of two 2½-in. (65-mm) outlets shall be provided on any pump rated at 750 gpm (2850 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.

12-7.1.3* All 2½-in. (65-mm) or larger outlets shall be equipped with male National Hose threads. Adapter couplings with special threads or other means for hose attachment shall be permitted to be furnished on any or all outlets.

12-7.2* Any preconnected 1½-in. (38-mm), 1¾-in. (44-mm), or 2-in. (51-mm) hose line shall be supplied by at least 2-in. (51-mm) piping and valves. This shall include the piping to the preconnected hose storage areas specified in 3-6(b), 4-5(b), 5-5.2, or 6-6.2, as applicable.

12-7.3 All discharge outlets, except outlets to which a hose will be preconnected, shall be equipped with caps or closures suitable to withstand a minimum hydrostatic burst pressure of 100 psig (690 kPag) over the maximum pump close-off pressure or 500 psi (3450 kPa), whichever is greater. Where adapters are provided on the discharge outlets, the closures shall fit on the adapters. Caps or closures for outlets 3½ in. (89 mm) and smaller in size shall be secured to the apparatus with suitable chains or cables.

12-7.4 All discharge outlets shall be equipped with valves that can be opened and closed smoothly and readily at the flows shown in Table 12-7.1 at pump discharge pressures of 250 psig (1724 kPag). The flow regulating element of each valve shall not change its position under any condition of operation involving discharge pressures to the maximum pressure of the pump; the means to prevent a change in position shall be incorporated in the operating mechanism and shall be permitted to be manually or automatically controlled. Any 3-in. (76-mm) or larger discharge valve shall be a slow operating valve.

12-7.5 All 2½-in. (65-mm) or larger discharge outlets shall be equipped with a drain or bleed-off valve having a minimum ¾-in. (19-mm) pipe thread connection for draining or bleeding off pressure from a hose connected to the outlet.

12-7.6 Any 2-in. (51-mm) or larger discharge outlet which is normally located more than 42 in. (1067 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.

12-7.7* All pump discharges shall have valves controllable at the pump operator's position. Secondary valves shall be permitted to be provided at the discharge outlet if required for special applications.

12-7.8 No discharge outlet larger than 2½ in. (65 mm) shall be located at the pump operator's panel. 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.

12-7.9 Where the valve operating mechanism does not indicate the position of the valve, an indicator shall be provided to show when the valve is closed.

12-8 Pump Drains. A suitable, readily accessible, and labeled drain valve(s) shall be provided to allow draining the pump and all water-carrying lines and accessories. The drain valve(s) shall be operational without the operator having to get under the apparatus.

12-9 Pump Operator's Position.

12-9.1* There shall be an area where the pump controls, gauges, and other instruments are located. It shall be known as the pump operator's panel.

12-9.2 All gauges, discharge outlets, pump intakes, and controls shall be illuminated to a minimum lighting level of 5 footcandles (54 lux). The pump compartment and the priming lubricant or reservoir area, if applicable, shall also be illuminated.

12-9.3 The central midpoint or centerline of any valve control shall be no more than 72 in. (1829 mm) vertically above the ground or platform that is designed to serve as the operator's standing position.

12-9.4* All required markings shall be of a type permanent in nature, capable of withstanding the effects of extremes of weather and temperature, and shall be securely attached.

12-10* Pump Controls.

12-10.1 Provisions shall be made for placing the pump drive system in operation using controls and switches that are clearly identified and within convenient reach of the operator. Indicator and interlock systems shall be provided as required by this pump control section.

12-10.1.1 Where the apparatus is equipped with an automatic chassis transmission and the fire pump is driven through the automatic transmission, an interlock system shall be provided to ensure that the pump drive system components are properly engaged in the pumping mode of operation so that the pumping system can be safely operated from the pump operator's position. (*See 12-11.2.*)

12-10.1.2 Where the pump is driven by the chassis engine and transmission retarders, engine compression brakes, or engine exhaust brakes are furnished, they shall be automatically disengaged for pumping operations. Where an automatic fan clutch is furnished, the fan shall be engaged for pumping operations.

12-10.2* Any control device used in the pumping system power train between the engine and the pump shall be equipped with a means to prevent unintentional movement of the control device from its set position.

Exception: Auxiliary manual pump shift override devices shall not require such means.

12-10.3 A nameplate 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 easily read from the driver's position.

12-10.4 Where the pump is driven by the chassis engine through a split shaft PTO, the driving compartment speedometer shall register when the pump shift has been completed and the chassis transmission is in pump gear.

12-10.5 Where the pump is driven by a split shaft PTO and the chassis is equipped with either a manual or automatic shift chassis transmission, a green indicator light shall be located in the driving compartment. This indicator light shall be energized when the pump shift has been completed and shall be marked "Pump Engaged." Where an automatic

chassis transmission is provided, a second green indicator light in the driving compartment and a green indicator light located at the pump operator's position shall be provided and energized when both the pump shift has been completed and the chassis transmission is engaged in pump gear. The light in the driving compartment shall be marked "OK to Pump." The light on the pump operator's panel shall be positioned adjacent to, and preferably above, the throttle control and shall be marked "Warning: Do Not Open Throttle Unless Light Is On." This light shall also be energized when the chassis transmission is in the neutral position and the parking brake is engaged. (*See also 12-11.2.*)

12-10.6 Where an automatic chassis transmission is provided and the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and is used for stationary pumping with the chassis transmission in neutral, or for pump and roll with the chassis transmission in any forward or reverse gear, shift indicator lights shall be provided as follows:

(a) Two green indicator lights in the driving compartment. One of the lights shall be energized when the pump drive has been engaged and shall be marked "Pump Engaged." The second light shall be energized when both the pump drive has been engaged and the chassis transmission is in neutral and shall be marked "OK to Pump."

(b) One green and one red indicator light on the pump operator's panel. The green light shall be energized when the chassis transmission is in neutral and the parking brake is engaged. The green light shall be positioned adjacent to, and preferably above, the throttle and shall be marked "Warning: Do Not Open Throttle Unless Light Is On." The red light shall be energized when the chassis transmission is not in neutral and the ignition switch is activated and shall be located adjacent to, and preferably above, the throttle, and shall be marked "Danger: Do Not Open Throttle." (*See also 12-11.2.*)

12-10.7 Where a manual chassis transmission is provided and the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and used for stationary pumping, a green indicator light that is energized when the pump is engaged shall be provided in the driving compartment and shall be marked "Pump Engaged."

12-10.8 With parallel/series centrifugal pumps, the control positions for parallel operation (volume) and series operation (pressure) shall be clearly indicated. The control for changing the pump from series to parallel, and vice versa, shall be operable at the pump operator's position.

12-10.9* Pressure Control System.

12-10.9.1 A system shall be provided that, when set in accordance with the manufacturer's instructions, will automatically control the discharge pressure to a maximum of 30 psi (207 kPa) pressure rise above the set pressure(s) when all discharge valves are closed no more rapidly than in 3 seconds, and no more slowly than in 10 seconds, during all of the following conditions:

(a) Over a range of discharge pressures from 100 psi to 300 psi (690 kPa to 2069 kPa) net pump pressure with intake pressure between –10 psig and 185 psig (–69 kPag and 1276 kPag) and discharge pressure between 90 psig and 300 psig (621 kPag and 2069 kPag);

(b) Over a range of flows from 150 gpm (568 L/min) to the rated capacity of the pump.

12-10.9.2 The system shall be equipped with an amber indicating light that is energized when the system is in control of the pressure. The system shall be controllable by one person at the pump operator position.

12-10.9.3 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.

12-10.9.4* The pressure control system shall be certified as meeting the requirements of 12-10.9.1.

12-10.10 A priming device shall be provided and controlled from the pump operator's position. It shall be capable of meeting the requirements of 12-2.3.2 and of developing a vacuum of 22 in. Hg (74.5 kPa) at an altitude of 2000 ft (610 m). An exhaust primer shall not be used. The priming device shall be capable of operating with no lubricant, a biodegradable lubricant, or a nontoxic lubricant.

12-10.11 All pump controls and devices shall be installed so as to be protected against mechanical damage or the effects of adverse weather conditions upon their operation.

12-11 Pump Engine Controls.

12-11.1* A throttle control that holds its set position shall be provided to control the pump engine speed. It shall be located not higher than 72 in. (1829 mm), nor lower than 42 in. (1067 mm) from the operator's standing position with all instruments in full view.

12-11.2 Where the chassis engine drives the pump and electric or electronic engine throttle controls are provided, an interlock shall prevent advancement of the engine speed at the pump operator's panel unless the parking brake is engaged and the chassis transmission is in neutral; or the parking brake is engaged, the water pump is engaged and the chassis transmission is in pumping gear. The indicator lights located on the pump operator's panel that are specified in 12-10.5 and 12-10.6(b) are not required.

12-12 Instrumentation.

12-12.1* The following controls and instruments shall be provided and installed as a group at the pump operator's position:

(a) A master pump intake pressure indicating device;
(b) master pump discharge pressure indicating device;
(c) A weatherproof tachometer;
(d) A pumping engine coolant temperature indicator;
(e) A pumping engine oil pressure indicator;
(f) A voltmeter;
(g) The pump pressure control(s);
(h) The pumping engine throttle;
(i) The primer control;
(j) The water tank to pump valve control;
(k) The water tank fill valve control; and
(l) The water tank level indicator.

These instruments and controls shall be placed to keep the pump operator as far as practical from all discharge and intake connections and in a location where they are readily

visible and operationally functional while the operator remains stationary.

12-12.1.1 The weatherproof tachometer shall indicate the speed of the pumping engine.

12-12.1.2 The pumping engine oil pressure and engine-coolant temperature indicators shall be equipped with audible and visual warnings.

12-12.1.3 All engine operation indicators on the pump operator's panel shall be in addition to those on the vehicle's instrument panel.

12-12.2 Master Pump Intake and Discharge Pressure Indicating Devices.

12-12.2.1 Master pump intake and pump discharge pressure indicating devices shall be located close to each other with the intake pressure indicating device to the left of the pump discharge pressure indicating device. They shall read from 30 in. Hg (101.6 kPa) vacuum to at least 300 psig (2070 kPag) but not more than 600 psig (4140 kPag). Pressure indicating devices shall be marked "Pump Intake" for the intake pressure indicating device and "Pump Discharge" for the discharge pressure indicating device.

12-12.2.1.1 Where analog gauges are used, 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. The accuracy of gauges shall be a minimum of Grade 1A as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*. Numerals for master gauges shall be a minimum of 0.25 in. (6.4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation and shock; and have internal mechanisms that do not require periodic lubrication.

12-12.2.1.2 If digital master pressure indicating devices are used, the digits shall be at least $\frac{1}{2}$ in. (12.7 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

12-12.3* Discharge Outlet Instrumentation. A flow meter or a pressure indicating device shall be provided for each discharge outlet $1\frac{1}{2}$ in. (38 mm) or larger in size and shall be marked to indicate the outlet to which it is connected. Any discharge outlet $3\frac{1}{2}$ in. (89 mm) or larger, if equipped with a flow meter, shall also be provided with a pressure indicating device. The pressure indicating device or flow meter display shall be located adjacent to the corresponding valve control with no more than 6 in. (150 mm) separating the pressure indicating device or flow meter bezel and the valve control centerline. If both a flow meter and pressure indicating device are provided for an individual discharge outlet, the pressure indicating device shall be located within 6 in. (150 mm) of the valve control midpoint or centerline and the flow meter display shall be adjacent to and within 2 in. (50 mm) of the pressure indicating device bezel. Pressure indicating devices shall be connected to the outlet side of the valve. Flow meters shall display flow in no greater than 10 gpm (38 L/min) increments.

12-12.3.1 Where analog pressure gauges are used, they shall have a minimum accuracy of Grade B as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*. Numerals for gauges shall be a minimum $\frac{5}{32}$ in. (4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation, and shock; and have internal mechanisms that do not require periodic lubrication.

12-12.3.2 If a digital pressure indicating device is used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

12-12.4 All pressure indicating devices and flow meters shall be mounted and attached so they are protected from accidental damage and excessive vibration.

12-12.5 All pressure indicating devices and flow meters shall be capable of continuous operation to –40°F (–40°C) without damage.

12-12.6 Connections for test gauges shall be provided at the pump operator's position. One shall be connected to the intake side of the pump, and the other shall be connected to the discharge manifold of the pump. They shall have a 0.25-in. (6.4-mm) standard pipe thread, shall be plugged, and shall be suitably identified.

12-13 Required Testing.

12-13.1 Pump Certification.

12-13.1.1 If the fire pump has a rated capacity of 750 gpm (2850 L/min) or greater capacity, the pump shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus. The tests shall be conducted at the manufacturer's approved facility and certified by an independent testing organization approved by the purchaser. The certification shall include at least the pumping test (*see 12-13.2*), the pumping engine overload test (*see 12-13.3*), the pressure control system test (*see 12-13.4*), the priming device tests (*see 12-13.5*), and the vacuum test (*see 12-13.6*). If the apparatus is equipped with a water tank, the water tank to pump flow test (*see 12-13.7*) shall be included.

12-13.1.2 If the fire pump has a rated capacity of less than 750 gpm (2850 L/min), the pump shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus. The tests shall be conducted at the manufacturer's approved facility and certified by the contractor. The certification shall include at least the pumping test (*see 12-13.2*), the pressure control system test (*see 12-13.4*), the priming device tests (*see 12-13.5*), and the vacuum test (*see 12-13.6*). If the apparatus is equipped with a water tank, the water tank to pump flow test (*see 12-13.7*) shall be included.

12-13.1.3 A test plate shall be provided at the pump operator's position that gives the rated discharges and pressures together with the speed of the engine as determined by the certification test for each unit, the position of the parallel/series pump as used, and the no-load governed speed of the engine as stated by the engine manufacturer on a certified brake horsepower curve. The plate shall be completely stamped with all information at the factory and attached to the vehicle prior to shipping.

12-13.2 Pumping Tests.

12-13.2.1 Conditions for Test.

12-13.2.1.1 The test site shall be adjacent to a supply of clear water at least 4 ft (1.2 m) deep, with the water level not more than 10 ft (3 m) below the center of the pump intake, and close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water when connected to the pump by 20 ft (6 m) of suction hose.

12-13.2.1.2* Tests shall be performed when conditions are as follows:

Air temperature:	0°F to 100°F (–18°C to 38°C)
Water temperature:	35°F to 90°F (2°C to 32°C)
Barometric pressure:	29 in. Hg (98.2 kPa), minimum (corrected to sea level)

12-13.2.1.3 Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests. If the chassis engine drives the pump, the electrical loads and conditions specified in 9-14.3.3 shall be applied during the pumping portion of this test.

12-13.2.1.4 All structural enclosures, such as floorboards, gratings, grills, and heat shields, not furnished with a means for opening them in normal service shall be kept in place during the tests.

12-13.2.2 Equipment.

12-13.2.2.1 The suction hose shall be of the appropriate size for the rated capacity of the pump [*see Table 12-2.4.1(a)*]. A suction strainer and hose that will allow flow with total friction and entrance loss not greater than that specified in Table 12-2.4.1(b) shall be used.

12-13.2.2.2 Sufficient fire hose shall be provided to allow discharge of rated capacity to the nozzles or other flow measuring equipment without exceeding a flow velocity of 35 fps (10.7 mps) [approximately 500 gpm (1900 L/min) for 2½-in. (65-mm) hose].

12-13.2.2.3 Where nozzles are used they shall be smooth-bore; inside diameters shall be from ¾ in. to 2½ in. (19 mm to 65 mm).

12-13.2.2.4 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*, and shall be at least size 3½ per ASME B40.1, paragraph 3.1. 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 150 psig (1035 kPag) for a compound gauge. The discharge pressure gauge shall have a range of 0 psig to 400 psig (0 kPag to 2758 kPag). Pitot gauges shall have a range of at least 0 psig to 160 psig (0 kPag to 1103 kPag). A mercury manometer shall be permitted to be used in lieu of a pump intake gauge. All gauges shall have been calibrated in the month preceding the tests. Calibrating equipment shall consist of a dead weight gauge tester or a master gauge meeting the requirements for Grade 3A or 4A gauges, as defined in ASME B40.1, that has been calibrated by its manufacturer within the preceding year.

12-13.2.2.5 All test gauge connections shall include "snubbing" means, such as needle valves to damp out rapid needle movements.

12-13.2.2.6 Speed measuring means other than the engine speed tachometers on the pump operator's panel (*see 12-12.1.1*) or in the driving compartment (*see 10-2.4*) shall be used to measure the rotational speed of the pump drive system such that the pump impeller shaft speed can be calculated. Such speed measuring means shall be accurate to within ± 50 rpm of actual speed.

12-13.2.3* Procedure. The ambient air temperature, water temperature, vertical lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to and after each pump test. The engine, pump, transmission, and all parts of the apparatus shall exhibit no undue heating, loss of power, overspeed, or other defect during the entire test.

12-13.2.3.1 If the apparatus is equipped with a fire pump rated at 750 gpm (2850 L/min) or greater, the pump shall be subjected to a 3-hour pumping test consisting of 2 hours of continuous pumping at rated capacity at 150 psi (1035 kPa) net pump pressure, followed by ½ hour of continuous pumping at 70 percent of rated capacity at 200 psi (1380 kPa) net pump pressure, and ½ hour of continuous pumping at 50 percent of rated capacity at 250 psi (1725 kPa) net pump pressure. The pump shall not be stopped until after the 2-hour test at rated capacity, unless it becomes necessary to clean the suction strainer. The pump shall be permitted to be stopped between tests to allow changing hose or nozzles, to clean the strainer, or to add fuel for the pump drive engine.

The capacity, discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes. The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

12-13.2.3.2* If the apparatus is equipped with a fire pump rated at less than 750 gpm (2850 L/min), the pump shall be subjected to a 50-minute pumping test consisting of ½ hour of continuous pumping at rated capacity at 150 psi (1035 kPa) net pump pressure, followed by 10 minutes of continuous pumping at 70 percent of rated capacity at 200 psi (1380 kPa) net pump pressure, and 10 minutes of continuous pumping at 50 percent of rated capacity at 250 psi (1725 kPa) net pump pressure. The pump shall not be stopped until after the ½-hour test at rated capacity, unless it becomes necessary to clean the suction strainer. The pump shall be permitted to be stopped between tests to allow changing hose or nozzles or to clean the strainer.

The capacity, discharge pressure, intake pressure, and engine speed shall be recorded at least every 10 minutes. At each test sequence a minimum of three readings shall be recorded. The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

12-13.3 Pumping Engine Overload Test. If the pump has a rated capacity of 750 gpm (2850 L/min) or greater, the apparatus shall be subjected to an overload test consisting of pumping rated capacity at 165 psi (1138 kPa) net pump pressure for at least 10 minutes. This test shall be performed immediately following the pumping test of rated capacity at 150 psi (1035 kPa).

The capacity, discharge pressure, intake pressure, and engine speed shall be recorded at least three times during the overload test.

12-13.4 Pressure Control System Test. The pressure control system on the pump shall be tested as follows:

(a) The pump shall be operated at draft, delivering rated capacity at 150 psig (1035 kPag) net pump pressure.

(b) The pressure control system shall be set in accordance with the manufacturer's instructions to maintain the discharge pressure at 150 psig (1035 kPag).

(c) All discharge valves shall be closed no more rapidly than in 3 seconds' time and no more slowly than in 10 seconds' time. The rise in discharge pressure shall not exceed 30 psi (207 kPa) and shall be recorded.

(d) The original conditions of pumping rated capacity at 150 psig (1035 kPag) shall be reestablished. The discharge pressure shall be reduced to 90 psig (620 kPag) by throttling the engine fuel supply, with no change to the discharge valve settings, hose, or nozzles.

(e) The pressure control system shall be set according to the manufacturer's instructions to maintain 90 psig (620 kPag) discharge pressure.

(f) All discharge valves shall be closed no more rapidly than in 3 seconds' time and no more slowly than in 10 seconds' time. The rise in discharge pressure shall not exceed 30 psi (207 kPa) and shall be recorded.

(g) The pump shall be operated at draft pumping 50 percent of rated capacity at 250 psig (1725 kPag) net pump pressure.

(h) The pressure control system shall be set in accordance with the manufacturer's instructions to maintain 250 psig (1725 kPag) discharge pressure.

(i) All discharge valves shall be closed no more rapidly than in 3 seconds' time and no more slowly than in 10 seconds' time. The rise in discharge pressure shall not exceed 30 psi (207 kPa) and shall be recorded.

12-13.5 Priming Device Tests.

12-13.5.1 With all intake valves open, all intakes capped or plugged, and all discharge caps removed, the primer shall be operated in accordance with the manufacturer's instructions. The maximum vacuum attained shall be at least 22 in. Hg (74.5 kPa). At altitudes above 2000 ft (610 m), the vacuum attained shall be permitted to be less than 22 in. Hg × 1 in. Hg (74.5 kPa × 3.4 kPa) for each 1000 ft (305 m) of altitude above 2000 ft (610 m).

12-13.5.2 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. The interval from the time the primer was started until the time the pump is discharging water shall be noted. This test shall be permitted to be performed in connection with priming the pump for the pumping test.

The time required to prime the pump if the rated capacity is 1250 gpm (4732 L/min) or less shall not exceed 30 seconds. If the rated capacity is 1500 gpm (5678 L/min) or more, the time to prime the pump shall not exceed 45 seconds. An additional 15 seconds shall be permitted to meet these requirements when the pump system includes an auxiliary 4-in. (100-mm) or larger intake pipe having a volume of 1 ft^3 (28,316 cm^3) or more.

12-13.6 Vacuum Test. A vacuum test shall be performed and shall consist of subjecting the interior of the pump, with all intake valves open, all intakes capped or plugged, and all discharge caps removed to a vacuum of 22 in. Hg (74.5 kPa) by means of the pump priming device. The vacuum shall not drop more than 10 in. Hg (33.9 kPa) in 5 minutes. The primer shall not be used after the 5-minute test period has begun. The engine shall not be operated at any speed greater than the no-load governed speed during this test.

12-13.7 Water Tank to Pump Flow Test. A water tank to pump flow test shall be conducted as follows:

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

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

(c) The tank fill line and by-pass cooling line shall be closed.

(d) Hose lines and nozzles suitable for discharging water at the rated tank to pump flow rate shall be connected to one or more discharge outlets.

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

(f) The engine throttle shall be adjusted until the required flow rate -0/+ 5 percent is established (*see 15-3.2*). The discharge pressure shall be recorded.

(g) The discharge valves shall be closed and the water tank refilled. The by-pass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits.

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

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

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

12-13.8* Manufacturer's Predelivery Test. The manufacturer shall conduct a piping hydrostatic test prior to delivery of the apparatus. The test shall be conducted as follows. The pump and its connected piping system shall be hydrostatically tested to 250 psi (1725 kPa). The hydrostatic test shall be conducted with the tank fill line valve, the by-pass line valve if so equipped, and the tank to pump valve closed. All discharge valves shall be open and the outlets capped. All intake valves shall be closed, and nonvalved intakes shall be capped. This pressure shall be maintained for 3 minutes.

Chapter 13 Auxiliary Pump and Associated Equipment

13-1* Application. If the apparatus is equipped with an auxiliary pump, the provisions of this chapter shall apply.

13-2* Power Train Capability.

13-2.1* 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.

13-2.2* When pumping rated capacity and pressure, lubricant temperatures in any power train component shall not exceed the component manufacturer's recommendation for maximum temperature.

13-3 Construction Requirements. The pump, piping, and valves shall be suitable to withstand a minimum hydrostatic burst pressure of 100 psi (690 kPa) above the maximum system operating pressure.

13-4 Pump Intake Connections.

13-4.1* Each pump intake connection shall be of a sufficient size to permit the full rated performance of the pump and shall be equipped with a valve controllable at the pump operator's position. If an inlet is located at the pump operator's position, it shall be provided with a permanent label that states "Warning — Serious Injury or Death Could Occur if the Inlet(s) Is Supplied by a Pressurized Source When the Valve Is Closed."

13-4.2 Each external intake shall be equipped with National Hose threads, a removable or accessible strainer, and a bleeder valve to bleed off air or water from a hose connected to the intake.

13-4.2.1 All intakes shall be provided with closures suitable to withstand a hydrostatic burst pressure of 500 psig (3450 kPag). Intakes having male threads shall be equipped with caps; intakes having female threads shall be equipped with plugs. 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.

13-4.2.2 Closures for 3½-in. (89-mm) and smaller external intakes shall be secured to the apparatus with suitable chains or cables.

13-5* Pump Discharge Connections.

13-5.1 Each pump discharge shall be equipped with a valve controllable at the pump operator's position.

13-5.2 Any discharge outlets that are fed by lines from both the auxiliary pump and the main pump shall have check valves in both supply lines.

13-5.3* All discharge outlets shall be equipped with male National Hose threads. Adapter couplings with special threads or other means for hose attachment shall be permitted to be furnished on any or all outlets.

13-5.4 All discharge outlets, except outlets to which a hose will be preconnected, shall be equipped with caps or closures suitable to withstand a minimum hydrostatic burst pressure of 100 psig (690 kPag) over the maximum pump close-off pressure or 500 psi (3450 kPa), whichever is greater. Where adapters are furnished, the closures shall fit on the adapters. Caps or closures for outlets 3½ in. (89 mm) and smaller in size shall be secured to the apparatus with suitable chains or cables.

13-5.5 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 controllable at the pump operator's position.

13-6 Pump Operator's Position.

13-6.1 All gauges, discharge outlets, pump intakes, and controls located on the pump operator's panel for the auxiliary pump shall be illuminated to a minimum lighting level of 5 footcandles (54 lux).

13-6.2 All required markings shall be permanent, shall be capable of withstanding the effects of extreme weather and temperature, and shall be securely attached.

13-7 Pump Controls.

13-7.1 Provisions shall be made for quickly and easily placing the pump in operation. The control for the pump engagement mechanism shall be marked to indicate when the pump is properly engaged in pumping position.

13-7.2 With parallel/series centrifugal pumps, the positions for parallel operation (volume) and series operation (pressure) shall be clearly indicated. The control for changing the pump from series to parallel, and vice versa, shall be located on the pump operator's panel.

13-7.3 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.

13-7.4 All pump controls and devices shall be installed so as to be protected against mechanical damage or the effects of adverse weather conditions upon their operation.

13-7.5 A suitable, readily accessible, and marked drain valve(s) shall be provided to allow draining the pump and all water-carrying lines and accessories. The drain valve(s) shall be operational without the operator having to get under the apparatus.

13-7.6 A by-pass line of not less than ¼ in. (6.3 mm) in diameter, with a valve controllable at the pump operator's position, or an automatic-type control, shall be installed from the discharge manifold directly to the water tank or ground.

13-8 Pump Drive Systems.

13-8.1 Where the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or flywheel PTO, the provisions of 12-10.6 and 12-10.7 shall apply.

13-8-2 Where the pump is driven by a chassis transmission-mounted (SAE) PTO, a visible or audible warning device shall be provided on the pump operator's panel that is actuated when the temperature of the lubricant in the chassis transmission exceeds the transmission manufacturer's recommended maximum temperature.

13-8.3 Where a separate engine is used to drive the auxiliary pump, an amber indicator light shall be provided in the driving compartment that is energized when the pump engine ignition is energized. This light shall be marked "Pump Engine Ignition."

13-8.4* If a separate pumping engine is provided, it shall meet the requirements of 8-2.1.1, 8-2.1.2, 8-2.2, 8-2.3.1, 8-2.3.2, 8-2.4, 8-2.5, and Sections 9-4 and 9-5.

13-9 Engine Controls. 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. This shall be permitted to be the same throttle control that is used for the main fire pump.

13-10 Gauges and Instruments.

13-10.1 Master Pump Discharge Pressure Indicating Device. A master discharge pressure indicating device shall be provided. It shall read from zero to at least 300 psig (2070 kPag), but not less than 100 psi (690 kPa) higher than the maximum pressure that can be developed by the pump when it is operating with zero intake pressure.

13-10.1.1 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade 1A as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*. Numerals for master gauges shall be a minimum 0.25 in. (6.4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation and shock; and have internal mechanisms that do not require periodic lubrication.

13-10.1.2 If a digital pressure indicating device is used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

13-10.2 Discharge Outlet Instrumentation. If the apparatus is equipped with 1½-in. (38-mm) or larger discharge outlets that can only be supplied by the auxiliary pump, these discharge outlets shall be equipped with pressure indicating devices or flow meters. The pressure indicating device or flow meter display shall be located adjacent to the corresponding valve control with no more than 6 in. (150 mm) separating the pressure indicating device or flow meter bezel and the valve control centerline. Pressure indicating devices shall be connected to the outlet side of the valve. Flow meters shall display flow in not greater than 10 gpm (38 L/min).

13-10.2.1 Where an analog pressure gauge is used, the gauge shall have a minimum accuracy of Grade B as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*. Numerals for gauges shall be a minimum 5/32 in. (4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation, and shock; and have internal mechanisms that do not require periodic lubrication.

13-10.2.2 If a digital pressure indicating device is used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

13-10.3 All pressure indicating devices and flow meters shall be mounted and attached so they are protected from accidental damage and excessive vibration.

13-10.4 All pressure indicating devices and flow meters shall be capable of continuous operation to –40°F (–40°C) without damage.

13-11 Testing. The pump, piping, valves, and caps or plugs shall be hydrostatically tested to 100 psi (690 kPa) above the maximum system operating pressure, and the apparatus manufacturer shall certify the test results in writing.

Chapter 14 Water Transfer Pump and Associated Equipment

14-1* Application. If the apparatus is equipped with a water transfer pump, the provisions of this chapter shall apply.

14-2 Pumping System Capability.

14-2.1* The water transfer pump shall be mounted on the apparatus and have a minimum rated capacity of 250 gpm (950 L/min) at 50 psi (345 kPa) net pump pressure. The pump shall also be capable of pumping a minimum of 100 gpm (380 L/min) at 115 psi (793 kPa) net pump pressure. Power to drive the transfer pump shall be permitted to be provided by the same engine used to propel the apparatus or by a separate engine.

14-2.2 When dry, the pumping system shall be capable of taking suction and discharging water in not more than 45 seconds through 20 ft (6 m) of suction hose of the size required by the pump manufacturer and at a lift of 10 ft (3 m).

14-2.3 The completed pumping system shall be capable of developing a vacuum of 18 in. Hg (61 kPa) by means of the pump priming device and sustaining this for at least 5 minutes with a loss not to exceed 10 in. Hg (33.9 kPa). This shall be demonstrated with all intakes capped or plugged and all discharge caps removed

14-2.4* Pump Suction Capability. The pump manufacturer shall certify that the transfer pump is capable of pumping 100 percent of rated capacity at 50 psi (345 kPa) net pump pressure, from draft, through a single intake using 20 ft (6 m) of suction hose of the size required by the pump manufacturer and with a strainer attached, under conditions as stipulated below.

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

(b) Atmospheric pressure of 29.9 in. Hg (101.2 kPa) (corrected to sea level);

NOTE: At an altitude of 2000 ft (610 m), the actual (uncorrected) atmospheric pressure equivalent to the sea level reading of 29.9 in. Hg (101.2 kPa) is 27.8 in. Hg (94.1 kPa).

(c) Water temperature of 60°F (15.6°C);

(d) Lift of 10 ft (3 m).

14-3 Pumping Engine Requirements.

14-3.1 The apparatus manufacturer shall approve the use of the pumping engine for stationary pumping applications in fire apparatus of the type and the size being furnished.

14-3.2 The engine shall be capable of performing the pumping tests herein specified without exceeding the maximum rated speed of the engine as shown on the engine manufacturer's published horsepower curve.

14-3.3 Where the maximum rated speed of the pump driving source exceeds the maximum rated speed that the trans-

fer pump was designed for, an automatic means shall be provided to limit the pump driving source to the maximum designed speed of the pump.

14-3.4 If a separate engine is used to drive the pump, the engine shall meet the requirements of 14-3.4.1 through 14-3.4.3.

14-3.4.1 The pump engine shall be equipped with an electric starter, wired to the chassis battery system through the master disconnect switch with a starter button and ignition switch at the pump operator's position.

14-3.4.2 A pump engine amber indicator light shall be provided in the driving compartment and shall be energized when the pump engine ignition is energized. It shall be marked "Pump Engine Ignition."

14-3.4.3 The fuel supply for the transfer pump shall be taken from the onboard chassis fuel supply where possible.

14-4 Construction Requirements.

14-4.1* Wetted moving parts shall be constructed of, or clad with, a corrosion-resistant material.

14-4.2 The pump shall be subjected to a hydrostatic test of 50 psi (345 kPa) minimum over the pump's designed maximum operating pressure for 10 minutes. A certified document on this test shall be furnished to the purchaser.

14-4.3 The entire discharge and intake piping system, valves, drain cocks and lines, and intake and outlet closures, excluding the tank fill and tank to pump lines on the tank side of the valves in those lines, shall be suitable to withstand a minimum hydrostatic burst pressure of 300 psig (2070 kPag).

14-5 Pump Intake Connections.

14-5.1* An intake of the same or larger size as the required suction hose size shall be provided.

14-5.1.1 The intake shall have National Hose threads.

14-5.1.2 If the couplings on the suction hose carried on the apparatus are of a different size or have other means of hose attachment than the intakes, suitable adapters shall be provided on each appropriate intake.

14-5.1.3 If an inlet located at the pump operator's position is valved, it shall be provided with a permanent label that states "Warning — Serious Injury or Death Could Occur if Inlet(s) Is Supplied by a Pressurized Source When the Valve is Closed."

14-5.2 Each intake shall have a removable or accessible strainer inside the intake.

14-5.3 Any 3-in. (76-mm) or larger intake valve shall be a slow operating valve.

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

14-5.4 Valved intakes, where provided, shall be equipped with a 3/4-in. (19-mm) bleeder valve located in close proximity to the intake to bleed off air or water from a hose connected to the intake. The valve shall be operational without the operator having to get under the apparatus. If a valved appliance is attached to an intake, it shall be equipped with a 3/4-in. (19-mm) bleeder valve on each inlet.

14-5.5 Each intake shall be provided with a closure capable of withstanding a minimum hydrostatic burst pressure of 300 psig (2069 kPag). Intakes having male threads shall be equipped with caps; intakes having female threads shall be equipped with plugs. 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.

14-5.6 Closures for 3 1/2-in. (89-mm) and smaller intakes shall be secured to the apparatus with suitable chains or cables.

14-6 Pump Discharge Outlets.

14-6.1 Sufficient 2 1/2-in. (65-mm) or larger discharge outlets shall be provided to discharge the rated capacity of the pump at 50 psi (345 kPa) net pump pressure. There shall be at least one 2 1/2-in. (65-mm) outlet.

14-6.2 All 2 1/2-in. (65-mm) or larger outlets shall be equipped with male National Hose threads. Adapter couplings with special threads or other means for hose attachment shall be permitted to be furnished on any or all outlets.

14-6.3 All discharge outlets, except outlets to which a hose will be preconnected, shall be equipped with suitable caps or closures capable of withstanding 300 psig (2069 kPag). Where adapters are provided on the discharge outlets, the closures shall fit on the adapters. Closures for outlets 3 1/2 in. (89 mm) and smaller in size shall be secured to the apparatus with suitable chains or cables.

14-6.4 All outlets shall be equipped with valves that can be opened and closed smoothly and readily at any rated pressure. The flow regulating element of each valve shall not change its position under any condition of operation involving discharge pressures to the maximum operating pressure of the pump; the means to prevent a change in position shall be incorporated in the operating mechanism and shall be permitted to be manually or automatically controlled. Any 3-in. (76-mm) or larger discharge valve shall be a slow operating valve.

14-6.5 All 2 1/2-in. (65-mm) or larger discharge outlets shall be equipped with a drain or bleed-off valve having a minimum 3/4-in. (19-mm) pipe thread connection for draining or bleeding off pressure from a hose connected to the outlet.

14-6.6 All pump discharges shall have valves controllable at the pump operator's position. Secondary valves shall be permitted to be provided at the discharge outlet if required for special applications.

14-6.7 No discharge outlet larger than 2 1/2 in. (65 mm) shall be located at the pump operator's panel.

14-7 Pump Drains. A suitable, readily accessible, and labeled drain valve(s) shall be provided to allow draining the pump and all water-carrying lines and accessories. The drain valve(s) shall be operational without the operator having to get under the apparatus.

14-8 Pump Operator's Position.

14-8.1 There shall be an area where the pump controls, gauges, and other instruments are located. It shall be known as the pump operator's position or panel.

14-8.2 All gauges, discharge outlets, pump intakes, and controls shall be illuminated to a minimum lighting level of 5 footcandles (54 lux).

14-8.3 All required markings shall be of a type permanent in nature, capable of withstanding the effects of extreme weather and temperature, and shall be securely attached.

14-9 Pump Controls.

14-9.1 Provisions shall be made for placing the pump drive system in operation using controls and switches that are clearly identified and within convenient reach of the operator. Indicator and interlock systems shall be provided as required by this pump control section.

14-9.1.1 Where the apparatus is equipped with an automatic chassis transmission and the transfer pump is driven through the automatic transmission, an interlock system shall be provided to ensure that the pump drive system components are properly engaged in the pumping mode of operation so that the pumping system can be safely operated from the pump operator's position. (*See 14-10.2.*)

14-9.1.2 Where the pump is driven by the chassis engine and transmission retarders, engine compression brakes, or engine exhaust brakes are furnished, they shall be automatically disengaged for pumping operations. Where an automatic fan clutch is furnished, the fan shall be engaged for pumping operations.

14-9.2* Any control device used in the pumping system power train between the engine and the pump shall be equipped with a means to prevent unintentional movement of the control device from its set position.

Exception: Auxiliary manual pump shift override devices shall not require such means.

14-9.3 A nameplate 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 easily read from the driver's position.

14-9.4 Where the pump is driven by the chassis engine through a split shaft PTO, the driving compartment speedometer shall register when the pump shift has been completed and the pump is in gear.

14-9.5 Where the pump is driven by a split shaft PTO, and the chassis is equipped with either a manual or automatic shift chassis transmission, a green indicator light shall be located in the driving compartment. This indicator light shall be energized when the pump shift has been completed and shall be marked "Pump Engaged." Where an automatic chassis transmission is provided, a second green indicator light in the driving compartment and a green indicator light located at the pump operator's position shall be provided and energized when both the pump shift has been completed and the chassis transmission is engaged in pump gear. The light in the driving compartment shall be marked "OK to Pump." The light on the pump operator's panel shall be positioned adjacent to, and preferably above, the throttle control and shall be marked "Warning: Do Not Open Throttle Unless Light Is On." This light shall also be energized when the chassis transmission is in the neutral position and the parking brake is engaged.

14-9.6 Where an automatic chassis transmission is provided and the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and is used for stationary pumping with the chassis transmission in neutral, or for pump and roll with the chassis transmission in any forward or reverse gear, shift indicator lights shall be provided as follows:

(a) Two green indicator lights in the driving compartment. One of the lights shall be energized when the pump drive has been engaged and shall be marked "Pump Engaged." The second light shall be energized when both the pump drive has been engaged and the chassis transmission is in neutral and shall be marked "OK to Pump."

(b) One green and one red indicator light on the pump operator's panel. The green light shall be energized when the chassis transmission is in neutral and the parking brake is engaged. The green light shall be positioned adjacent to, and preferably above, the throttle and shall be marked "Warning: Do Not Open Throttle Unless Light Is On." The red light shall be energized when the chassis transmission is not in neutral and the ignition switch is activated and shall be located adjacent to, and preferably above, the throttle and shall be marked "Danger: Do Not Open Throttle."

14-9.7 Where a manual chassis transmission is provided and the pump is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and used for stationary pumping, a green indicator light that is energized when the pump is engaged shall be provided in the driving compartment, and shall be marked "Pump Engaged."

14-9.8 A priming device shall be provided and controlled from the pump operator's position. It shall be capable of meeting the requirements of 14-2.2 and of developing a vacuum of 18 in. Hg (61 kPa) at an altitude of 2000 ft (610 m). The priming device shall be capable of operating with biodegradable or nontoxic fluids.

14-9.9 All pump controls and devices shall be installed so as to be protected against mechanical damage or the effects of adverse weather conditions upon their operation.

14-10 Pump Engine Controls.

14-10.1 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.

14-10.2 Where the chassis engine drives the pump and electric or electronic engine throttle controls are provided, an interlock shall prevent advancement of the engine speed at the pump operator's panel unless the parking brake is engaged and the chassis transmission is in neutral; or the parking brake is engaged, the water pump is engaged and the chassis transmission is in pumping gear. The indicator lights located on the pump operator's panel that are specified in 14-9.5 and 14-9.6(b) are not required.

14-11 Gauges and Instruments.

14-11.1 A master discharge pressure indicating device shall be provided at the pump operator's position. It shall read from 30 in. Hg (110 kPa) vacuum to 200 psig (1380 kPag).

14-11.1.1 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade B as defined in ASME

B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element.* Numerals for master gauges shall be a minimum 5/32 in. (4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation, and shock; and have internal mechanisms that do not require periodic lubrication.

14-11.1.2 If a digital pressure indicating device is used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

14-11.2 All pressure indicating devices and flow meters shall be mounted and attached so they are protected from accidental damage and excessive vibration.

14-11.3 All pressure indicating devices and flow meters shall be capable of continuous operation to −40°F (−40°C) without damage.

14-12 Manufacturer's Predelivery Tests.

14-12.1* Pump Certification Tests. The apparatus shall be tested at the manufacturer's approved facility and certified by the contractor. The certification shall include at least the pumping test (*see 14-12.2*), the priming device tests (*see 14-12.3*), the vacuum test (*see 14-12.4*), the piping hydrostatic test (*see 14-12.5*), and the water tank to pump flow test (*see 14-12.6*).

14-12.2 Pumping Tests.

14-12.2.1 Conditions for Test.

14-12.2.1.1 The test site shall be adjacent to a supply of clear water at least 4 ft (1.2 m) deep, with the water level not more than 10 ft (3 m) below the center of the pump intake, and close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water when connected to the pump by 20 ft (6 m) of suction hose.

14-12.2.1.2* Tests shall be performed when conditions are as follows:

Air temperature:	0°F to 100°F (−18°C to 38°C)
Water temperature:	35°F to 90°F (2°C to 32°C)
Barometric pressure:	29 in. Hg (98.2 kPa), minimum (corrected to sea level)

14-12.2.1.3 Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests. If the chassis engine drives the pump, the electrical loads and conditions specified in 9-14.3.3 shall be applied during the pumping portion of this test.

14-12.2.1.4 All structural enclosures, such as floorboards, gratings, grills, and heat shields, not furnished with a means for opening them in normal service shall be kept in place during the tests.

14-12.2.2 Equipment.

14-12.2.2.1 Suction hose shall be of the appropriate size for the rated capacity of the pump.

14-12.2.2.2 A suction strainer that will allow flow with total friction and entrance loss not greater than that specified in Table 12-2.4.1(b) shall be attached to the suction hose.

14-12.2.2.3 Sufficient fire hose shall be provided to allow discharge of rated capacity to the nozzles or other flow measuring equipment without exceeding a flow velocity of 35 fps (10.7 mps) [approximately 500 gpm (1900 L/min) for 2½-in. (65-mm) hose].

14-12.2.2.4 Where nozzles are used they shall be smooth-bore; inside diameters shall be from ¾ in. to 2½ in. (19 mm to 65 mm).

14-12.2.2.5 All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element,* and shall be at least size 3½ per ASME B40.1, paragraph 3.1. The 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 150 psig (1035 kPag) for a compound gauge. The discharge pressure gauge shall have a range of 0 psig to 400 psig (0 kPag to 2758 kPag). Pitot gauges shall have a range of at least 0 psig to 160 psig (0 kPag to 1103 kPag). A mercury manometer shall be permitted to be used in lieu of a intake gauge. All gauges shall have been calibrated in the month preceding the tests. Calibrating equipment shall consist of a dead weight gauge tester or a master gauge meeting the requirements for Grade 3A or 4A gauges as defined in ASME B40.1 that has been calibrated by its manufacturer within the preceding year.

14-12.2.2.6 All test gauge connections shall include "snubbing" means, such as needle valves to damp out rapid needle movements.

14-12.2.2.7 Speed measuring means other than the engine speed tachometers in the driving compartment (*see 10-2.4*) shall be used to measure the rotational speed of the pump drive system such that the pump impeller shaft speed can be calculated. Such speed measuring means shall be accurate to within ± 50 rpm of actual speed.

14-12.2.3 Procedure.

14-12.2.3.1* 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. The engine, pump, transmission, and all parts of the apparatus shall exhibit no undue heating, loss of power, overspeed, or other defect during the entire test.

14-12.2.3.2 The pump shall be subjected to a 20-minute pumping test consisting of continuous pumping at rated capacity at 50 psi (345 kPa) net pump pressure. The pump shall not be stopped, unless it becomes necessary to clean the suction strainer. The pump capacity, discharge pressure, intake pressure, and engine speed shall be recorded every 10 minutes with a minimum of three readings. The average net pump pressure shall be calculated and recorded based on the average values for discharge and intake pressure.

14-12.3 Priming Device Tests.

14-12.3.1 With all openings to the pump closed, the primer shall be operated in accordance with the manufacturer's instructions. The maximum vacuum attained shall be at least 18 in. Hg (61 kPa). At altitudes above 2000 ft (610 m), the vacuum attained shall be permitted to be less than 18 in. Hg (61 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (305 m) of altitude above 2000 ft (610 m).

14-12.3.2 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. The interval from the time the primer is started until the time the pump is discharging water shall not exceed 45 seconds. This test shall be permitted to be performed in connection with priming the pump for the pumping test.

14-12.4 Vacuum Test. A vacuum test shall be performed and shall consist of subjecting the interior of the pump, with capped intake and uncapped discharge outlets, to a vacuum of 18 in. Hg (61 kPa) by means of the pump priming device. The vacuum shall not drop more than 10 in. Hg (33.9 kPa) in 5 minutes. The primer shall not be used after the 5-minute test period has begun. The engine shall not be operated at any speed greater than the no-load governed speed during this test.

14-12.5 Piping Hydrostatic Test. The pump and its connected piping system shall be hydrostatically tested to 250 psi (1725 kPa). The hydrostatic test shall be conducted with the tank fill line valve, the by-pass line valve, and the tank to pump valve closed. All discharge valves shall be open and the outlets capped. All intake valves shall be closed, and non-valved intakes shall be capped. This pressure shall be maintained for 3 minutes.

14-12.6 Water Tank to Pump Flow Test. A water tank to pump flow test shall be conducted as follows:

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

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

(c) The tank fill line and by-pass cooling line shall be closed.

(d) Hose lines and nozzles suitable for discharging water at the rated tank to pump flow rate shall be connected to one or more discharge outlets.

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

(f) The engine throttle shall be adjusted until the required flow rate −0/+ 5 percent is established (*see 15-3.2*). The discharge pressure shall be recorded.

(g) The discharge valves shall be closed and the water tank refilled. The by-pass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits.

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

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

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

Chapter 15 Water Tanks

15-1 Application. If the fire apparatus is equipped with a water tank, the provisions of this chapter shall apply.

15-2 Tank Construction.

15-2.1* All water tanks shall be constructed of noncorrosive material or other materials that are protected against corrosion and deterioration. They shall have a means to permit complete cleaning of the tank.

15-2.2* All water tanks, except those on mobile water supply fire apparatus, shall be constructed to be independent of the body and compartments and shall be equipped with a method for lifting the tanks out of the body.

15-2.3 Tanks shall be securely restrained and cradled, or cushioned and spring-loaded, to avoid stress when traveling over uneven terrain.

15-2.4* All water tanks shall be provided with baffles or swash partitions to form a containment or dynamic method of water movement control.

15-2.4.1 If a containment method of baffling is used, a minimum of two transverse or longitudinal vertical baffles shall be provided. There shall be a maximum distance of 48 in. (1220 mm) between any combination of tank vertical walls and baffles. Each baffle shall cover at least 75 percent of the area of the plane that contains the baffle.

15-2.4.2 If a dynamic method of partitioning is used, the tank shall contain vertical transverse and longitudinal partitions. The vertical partitions shall be secured to the top and bottom of the tank. The longitudinal partitions shall extend a minimum of 75 percent of the tank length. The partitions shall be arranged in such a manner that a vertical plane passed through each partition shall create cells for which no dimension shall exceed 48 in. (1220 mm).

15-2.5 One or more clean-out sumps that extend below the bottom of the tank with a 3-in. (76-mm) or larger removable pipe plug shall be provided.

15-2.6 An indicator shall be provided that shows the level or amount of water in the tank(s). If the apparatus is not equipped with a pump, the indicator shall be visible at the inlet valve position.

15-3 Tank to Pump Intake Line.

15-3.1 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.

15-3.2* If the water tank has a certified capacity of less than 500 gal (1900 L), the piping and valve arrangement shall be capable of delivering water to the pump at a minimum rate of 250 gpm (950 L/min). If the water tank has a certified capacity of 500 gal (1900 L) or greater, the piping and valve arrangement shall be capable of delivering water to the pump at a minimum rate of 500 gpm (1900 L/min) or the rated capacity of the pump, whichever is less. This flow shall be sustainable while pumping a minimum of 80 percent of the certified tank capacity with the apparatus on level ground.

15-3.3* An automatic means shall be provided in the tank to pump line that prevents unintentional back-filling of the water tank through the line.

15-3.4 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. 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.

15-4 Filling and Venting.

15-4.1* A convenient, covered fill opening designed to prevent spillage shall be provided and designed to allow the insertion of a 2½-in. (65-mm) hose with coupling. The cover shall be marked "Water Fill." An easily removable, readily cleaned screen shall be installed in the opening. The cover, or another device, shall open as a vent to release pressure buildup in the tank of more than 1 psig (6.9 kPag).

15-4.2* Adequate venting of the tanks shall be provided to allow water to be drawn from the tank at a rate at least equal to that required in 15-3.2. The overflow outlet shall be designed to direct any water to behind the rear axle so as not to interfere with rear tire traction.

15-4.3* If the apparatus is equipped with a pump, a valved tank fill line of at least 1 in. (25 mm) nominal inside diameter shall be provided. Where the tank is greater than 1000 gal (3785 L), the fill line shall be at least 2 in. (51 mm) nominal inside diameter. The valve shall be capable of regulating flow and controllable at the pump operator's position.

15-4.4* If the apparatus is designed to be a mobile water supply apparatus, an external fill connection directly to the tank shall be provided. This connection shall permit a minimum filling rate of 1000 gpm (3785 L/min) from sources external to the unit. This 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. Any 3-in. (76-mm) or larger valve shall be a slow operating valve.

15-5* Water Transfer. If the apparatus is designed to be a mobile water supply apparatus, single or multiple tank connections capable of allowing water to be transferred to the right, left, and rear of the vehicle from the tank to an external use shall be supplied. Each outlet shall be capable of emptying 90 percent of the tank capacity at a minimum average rate of 1000 gpm (3785 L/min) with the apparatus on level ground.

15-6* Water Tank Capacity Certification. The manufacturer shall certify the capacity of the water tank prior to delivery of the apparatus. This capacity shall be recorded on the manufacturer's record of construction (*see Section 2-14*), and the certification shall be provided to the purchaser when the apparatus is delivered.

Chapter 16 Aerial Devices

16-1* General Requirements.

16-1.1 If the apparatus is equipped with an aerial ladder, the aerial device and apparatus shall meet the requirements of Sections 16-2 through 16-6 and Sections 16-17 through 16-25.

16-1.2 If the apparatus is equipped with an elevating platform, the aerial device and apparatus shall meet the requirements of Sections 16-7 through 16-13 and Sections 16-17 through 16-25.

16-1.3 If the apparatus is equipped with a water tower, the aerial device and apparatus shall meet the requirements of Sections 16-13 through 16-25.

16-2 Aerial Ladder Requirements.

16-2.1 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 fire fighters and civilians from an elevated position to the ground.

16-2.2 The rated vertical height of an aerial ladder shall be at least 50 ft (15 m) and shall be measured in a vertical plane with the ladder at maximum elevation and extension from the outermost rung of the outermost fly section to the ground.

16-2.3 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.

16-2.4 Height and reach dimensions shall be taken with the aerial ladder mounted on a chassis meeting the aerial manufacturer's minimum recommended vehicle specifications, the vehicle on level ground, and the stabilizers deployed per manufacturer's instructions.

16-2.5 The ladder rungs shall be spaced on 14-in. (356-mm) centers and shall have a skid-resistant surface or covering. Where covering is provided, it shall be attached in such a manner as to be secure from twisting and shall cover at least 60 percent of the length of each rung. 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. Where rungs other than round are furnished, they shall have a cross-sectional area not less than 1.2 in.^{2} (775 mm^2), maximum outside dimensions of the cross-sectional area (height or width) of 3.2 in. (81 mm), including the skid-resistant surface or covering, and they shall have a minimum outside dimension of ¾ in. (19 mm), including the skid-resistant surface or covering. The minimum design load per 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.

16-2.6 There shall be a minimum of 18 in. (457 mm) width inside the aerial ladder between the rails measured at the narrowest point, excluding any mounted equipment.

16-2.7 Where a solid obstruction below the ladder is wider than 12 in. (305 mm), a minimum clearance of 7 in. (178 mm) between the centerline of the rung and the obstruction shall be provided. Where the solid obstruction below the centerline of the ladder is 12 in. (305 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. (178 mm), provided there is at least 6 in. (152 mm) of rung width and 7 in. (178 mm) of depth below the centerline of the rung on each side of the obstruction.

16-2.8 Top rails shall be provided on the ladder, shall have a minimum width of 1 in. (25 mm), and shall be at a minimum height of 12 in. (305 mm) above the centerline of the rungs.

16-2.9 Two folding steps with skid-resistant surfaces shall be provided on the ladder for the use of the ladder pipe-monitor operator. Each folding step shall have a minimum design load of 500 lb (227 kg) and shall be a minimum of 35 in.^{2} (225 cm^2) in area. A single step that has a minimum design load of 500 lb (227 kg) and a minimum area of 100 in.^{2} (645 cm^2) shall be permitted to be used in place of the two steps.

16-2.10 Provisions shall be made so that the personnel working on the ladder can attach fall protection harnesses.

16-2.11 The apparatus shall be equipped with skid-resistant steps or rungs that provide a path at any degree of elevation from the bottom rung of the aerial ladder to the ground. Steps, with the exception of the ground to the first step, shall be spaced on no more than 18-in. (366-mm) centers. Handrails shall also be provided within convenient reach at each step location.

16-2.12 The aerial ladder with a rated vertical height of 110 ft (34 m) or less, with stabilizers set, shall be capable of being raised from the bedded position to maximum elevation and extension and rotated 90 degrees in not over 120 seconds. Two or more of these functions shall be permitted to be performed simultaneously. Aerial ladders over 110 ft (34 m) in rated vertical height shall meet these requirements in not over 180 seconds.

16-3 Aerial Ladder Rated Capacity.

16-3.1 The rated capacity of the aerial ladder shall be a minimum load of 250 lb (114 kg) carried on the outermost rung of the outermost fly section with the aerial ladder placed in the horizontal position at maximum extension. The aerial ladder shall be capable of operating in any position while carrying its rated capacity on the outermost rung of the outermost fly section. If the aerial ladder has a permanently mounted water delivery system, the 250 lb (114 kg) rated capacity shall be determined without water in the system.

16-3.2 The rated capacity of the aerial ladder shall be a minimum load of 250 lb (114 kg) carried on the outermost rung of the outermost fly section with the aerial ladder at 45 degrees to the horizontal and at maximum extension while discharging water at rated capacity through the full range of monitor or nozzle movements as permitted by the aerial manufacturer.

16-3.3 Rated capacities in excess of 250 lb (114 kg) shall be stated in increments of 250 lb (114 kg) and shall be in addition to any fire-fighting equipment installed on the aerial ladder by the manufacturer.

16-3.4* If the aerial ladder is rated in multiple configurations, the manufacturer shall clearly describe these configurations, including the rated capacity of each, in both the operations manual and on a sign at the operator's control station.

16-4 Aerial Ladder Operating Position.

16-4.1* An aerial ladder operator's position shall be provided on the apparatus so that the operator is not in contact with the ground. A sign(s) shall be placed to warn the operator(s) of electrocution hazards.

16-4.2 Indicating devices that are suitably lighted, clearly marked, and conveniently arranged shall be visible from the operator's position to:

(a) Indicate rungs are aligned for climbing;

(b) Indicate the alignment of the aerial ladder with the travel bed; and

(c) Indicate elevation, extension, and rated capacities, or provide an equivalent load indicating system.

16-4.3* A weather-resistant two-way voice communication system shall be provided between the aerial ladder operator's position and the tip of the ladder. The speaker/microphone at the tip shall allow for hands-free operation.

16-5 Aerial Ladder Operating Mechanisms.

16-5.1 Elevation.

16-5.1.1 A power-operated system for elevating and lowering the aerial ladder under all the rated conditions of loading shall be provided. Where hydraulic components are utilized, they shall meet the requirements of Section 16-19. Provisions shall be made to prevent damage at the top and bottom limits.

16-5.1.2 An automatic locking device(s) shall be provided so that the desired elevated position can be maintained.

16-5.1.3 A locking device shall be provided that will retain the aerial ladder in the bed when the vehicle is in motion and will dampen the impact of the aerial ladder's base section on the ladder rest.

16-5.2 Rotation.

16-5.2.1* A power-operated turntable shall be provided that shall allow continuous rotation in either direction under all the rated conditions of loading. The turntable rotation bearing shall be accessible for lubrication and retorquing of bolts.

16-5.2.2 The turntable rotation mechanism shall be provided with an automatically applied brake or self-locking drive. It shall provide braking capacity with all power systems nonfunctioning to prevent turntable rotation under all rated conditions of loading.

16-5.3 Extension.

16-5.3.1 A power-operated system for extending and retracting the fly section(s) under all the rated conditions of loading shall be provided. Where hydraulic components are utilized, they shall meet the requirements of Section 16-19. An automatic locking device shall be provided so that the desired position of extension can be maintained.

16-5.3.2 Where a winch-type extension system or an extension system with a single extension cylinder and single set of extension cables is provided, ladder rung lock pawls shall be provided to prevent retraction movement of the sections in the event of power loss. These lock pawls shall align the rungs between sections. The control for the pawls shall be at the base of the ladder adjacent to the operator and

shall allow the operator to clearly determine the on and off position without it being necessary to see the pawls.

16-5.3.2.1 To prevent damage to the ladder caused by application of power when the pawls are locked, an automatic device shall be provided to prevent retraction of the ladder sections until the pawls have been released.

16-5.3.2.2 Provisions shall be made to prevent damage at full retraction or extension. Stops shall be provided to properly align the sections without damage to the ladder or to the cable mechanism when the ladder is retracted.

16-5.3.2.3 An automatic locking device shall be provided, in addition to pawls, so that the desired position of extension can be maintained.

16-5.4* If a secondary aerial ladder operator's position is located at the tip of the outermost fly section, the following shall apply:

(a) The lower control shall override the aerial tip control station.

(b) 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.

(c) The maximum speed of the ladder functions measured at the tip shall be as follows when operated from the tip control station:

1. Rotation at 2 ft/sec (0.6 m/sec), when fully extended at 0 degrees elevation;
2. Elevation and lowering at 1 ft/sec (0.3 m/sec);
3. Extension and retraction at $\frac{1}{2}$ ft/sec (0.15 m/sec).

(d) The step(s) for the tip operator shall be designed to keep the operator's feet from protruding through the outermost fly section. The fold-down step(s) shall be weight supporting before the tip controls are activated.

16-6 Aerial Ladder Water Delivery System.

16-6.1* Where a prepiped waterway is provided, the following shall be furnished:

(a) A telescoping pipe to a fly section or a nontelescoping pipe to the tip of the base section;

(b) A permanently attached monitor capable of flowing 1000 gpm (3785 L/min). If a power-operated monitor is provided, controls shall be at the aerial operator's position. Where more than one set of controls are provided, the set at the aerial operator's position shall be capable of overriding all others;

(c) A 1000-gpm (3785-L/min) nozzle;

(d) A preset relief valve capable of protecting the waterway system by relieving pressure through the dumping of water to the environment;

(e) flow meter, installed in the waterway, with a display on either the pump operator's panel or the aerial ladder operator's control panel;

(f) A $1\frac{1}{2}$-in. (38-mm) minimum drain valve at the low point of the waterway inlet system.

16-6.1.1 The monitor shall be capable of swiveling 135 degrees from a line parallel to the ladder and down. The horizontal traverse of the monitor shall be at least 45 degrees from each side of center but shall not exceed the aerial ladder manufacturer's recommendation.

16-6.1.2 The aerial ladder and its waterway system shall be capable of flowing 1000 gpm (3785 L/min) at 100 psi (690 kPa) nozzle pressure at full elevation and extension. 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 at a point below the waterway swivel shall not exceed 100 psi (690 kPa) at 1000 gpm (3785 L/min) flow with ladder at full horizontal extension.

16-6.1.3* The water system shall be supplied at ground level through an external inlet suitable to deliver the system flow. 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.

16-6.1.4* A permanently installed monitor/nozzle shall not present an obstacle to easy access to or from the tip of the ladder.

16-6.2* Where a prepiped waterway is not provided, the following equipment shall be furnished:

(a) A ladder pipe suitable for quickly attaching to the aerial ladder with $1\frac{1}{4}$-in. (32-mm), $1\frac{3}{8}$-in. (35-mm), and $1\frac{1}{2}$-in. (38-mm) tips;

(b) A suitable length(s) of 3-in. (76-mm) attack hose complying with the requirements of NFPA 1961, *Standard for Fire Hose*, to reach between the installed ladder pipe and the ground with at least 10 ft (3 m) of hose available at the ground with the ladder at full extension;

(c) One hose strap per ladder section;

(d) Halyards to control the ladder pipe from ground level.

16-6.2.1 A bracket for carrying the detachable ladder pipe shall be provided on the apparatus. This bracket shall have two metal rungs of the same spacing as the ladder rungs so that the ladder pipe clamps will not have to be readjusted to secure the pipe to the aerial ladder.

16-6.2.2* The horizontal traverse of the detachable ladder pipe shall not exceed the aerial ladder manufacturer's recommendations. The ladder pipe shall be capable of swiveling 135 degrees from a line parallel to the ladder and down.

16-7 Elevating Platform Requirements.

16-7.1 The elevating platform shall consist of an elevated tower of two or more booms or sections equipped with a passenger-carrying platform(s) assembly.

16-7.2 The rated vertical height of the elevating platform assembly shall be measured in a vertical plane from the top surface of the platform handrail to the ground, with the platform raised to its position of maximum elevation.

16-7.3 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.

16-7.4 Height and reach dimensions shall be taken with the elevating platforms mounted on a chassis meeting the elevating platforms manufacturer's minimum recommended vehicle

specifications, the vehicle on level ground, and the stabilizers deployed per manufacturer's instructions.

16-7.5 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 in not over 150 seconds. Two or more of these functions shall be permitted to be performed simultaneously.

16-7.6 The platform shall have a minimum floor area of 14 ft^2 (1.3 m^2) and shall be provided with a continuous guard railing, a minimum of 42 in. (1069 mm) and a maximum of 44 in. (1118 mm) high, on all sides. The railing shall be constructed so there are no horizontal or vertical openings below it greater than 24 in. (610 mm) in either dimension. There shall be a minimum of two gates providing access to the platform. Each gate shall be provided with a self-engaging latch. The use of a vertical-opening or inward-opening, self-closing gate or door for access to and from the platform shall be considered as meeting the continuous railing intent.

16-7.6.1 A kick plate of not less than 4 in. (100 mm) high shall be provided around the floor and shall be permitted to swing with the gate.

16-7.6.2 Steps and the floor of the platform shall be provided with skid-resistant surfaces.

16-7.6.3 Drain openings shall be provided to prevent water accumulation on the platform floor.

16-7.6.4 A heat reflective shield shall be provided on the front, sides, and bottom of the platform. If necessary, openings for the movement and operation of the water monitor shall be permitted in the front heat shield.

16-7.6.5 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. The system shall be controlled by a single, quick acting valve with an actuator accessible from the platform.

16-7.6.6 Provisions shall be made so that the personnel working on the platform can attach fall protection harnesses.

16-7.7 Where a breathing air system is provided, it shall supply breathing air for a minimum of two persons on the platform and shall meet the requirements of 16-7.7.1 through 16-7.7.7.

16-7.7.1 The system shall include storage for at least 400 ft^3 (11.3 m^3) of breathing air. The cylinder(s) shall be manufactured, installed, and used in accordance with the U.S. Department of Transportation (DOT) requirements as defined in Title 49, *Code of Federal Regulations* (CFR), Part 178, Subpart C, "Specifications for Cylinders."

16-7.7.2 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. The piping system shall be arranged with a high pressure regulator at the air supply that shall limit the air pressure in the piping up the aerial device to the pressure required to supply 125 psi (862 kPa) at the outlet point. All piping, valves, and components shall be fabricated of corrosion-resistant materials and shall be sized to ensure an adequate supply of air at the platform. A pressure relief valve set to relieve the pressure at 1½ 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.

16-7.7.3 All valves, pressure regulators, and gauges shall be protected from accidental damage that could occur through normal fire service use of the aerial device. The piping or hose system between the air cylinder(s) and the platform shall be installed so as to prevent damage due to abrasion, bending, pinching, or exposure to excessive heat.

16-7.7.4 Suitable holders shall be provided for the storage of the breathing air equipment when it is not in use.

16-7.7.5 A low air warning system shall be provided that shall monitor the air volume and shall provide an audible warning at both the upper and lower control stations when the air volume is at or below 20 percent.

16-7.7.6 The quality of the breathing air shall meet the requirements of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*.

16-7.7.7 All components of the system that the breathing air will be in contact with shall be cleaned of oil, grease, contaminants, and foreign material.

16-8 Elevating Platform Rated Capacity.

16-8.1 The rated capacity of the elevating platform shall be a minimum of 750 lb (340 kg), with no water in the water delivery system, in any position of operation. 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, in any position of operation.

16-8.2 The elevating platform shall be capable of delivering a minimum of 1000 gpm (3785 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.

16-8.3 All rated capacities shall be stated in increments of 250 lb (114 kg) and shall be in addition to any fire-fighting equipment installed on the elevating platform by the manufacturer.

16-8.4 If the elevating platform is rated in multiple configurations, the manufacturer shall clearly describe these configurations, including the rated capacity of each, in the operations manual and on the signs at the operator's control stations.

16-9 Elevating Platform Operating Positions.

16-9.1 There shall be two control stations, one to be known as the platform control station, and the other as the lower control station. All operational controls shall be operable from both of these positions. The lower control station shall be located so as to facilitate observation of the platform while operating the controls.

16-9.2* Provisions shall be made so the lower control station operator is not in contact with the ground. A sign(s) shall be placed to warn the operator(s) of electrocution hazards.

16-9.3 Provisions shall be made for lower station controls to override the platform station controls.

16-9.4* A weather-resistant two-way voice communication system shall be provided between the platform control station and the lower control station. The speaker/microphone at the platform control station shall allow for hands-free operation.

16-10 Elevating Platform Operating Mechanisms.

16-10.1 Power-operated elevating and extending devices shall be provided. They shall be so designed and provided with adequate power to allow multiple movements of the elevating platform booms or sections simultaneously under all rated conditions of loading. Where hydraulic components are utilized, they shall meet the requirements of Section 16-19. An automatic locking device(s) shall be provided so that the desired elevated position can be maintained. Provisions shall be made to prevent damage at top and bottom limits.

16-10.2 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.

16-10.3 Turntable.

16-10.3.1 A power-operated turntable shall be provided that shall allow continuous rotation in either direction under all the rated conditions of loading. The turntable rotation bearing shall be accessible for lubrication and retorquing of bolts.

16-10.3.2 The turntable rotation mechanism shall be provided with an automatically applied brake or self-locking drive. It shall provide braking capacity with all power systems nonfunctioning to prevent turntable rotation under all rated conditions of loading.

16-10.4 A locking device shall be provided that will retain the elevating platform booms or sections in the bed when the vehicle is in motion.

16-11 Ladders on the Elevating Platform.

16-11.1 If the raising and extending booms or sections incorporate a ladder or ladder sections, the ladder shall meet the requirements of 16-2.1, 16-2.5 through 16-2.8, 16-2.10, 16-2.11, and 16-4.2.

16-11.2 The transition step between the top rung of the ladder and the platform shall not be greater than 18 in. (457 mm).

16-12 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.

16-12.1 The water delivery system shall be capable of delivering 1000 gpm (3785 L/min) at 100 psi (690 kPa) nozzle pressure with the elevating platform at rated vertical height. Friction loss (total system loss less head loss) between the monitor outlet and a point below the waterway swivel shall not exceed 100 psi (690 kPa) at 1000 gpm (3785 L/min) flow.

16-12.2 One or more permanently installed monitors with nozzles capable of discharging 1000 gpm (3785 L/min) shall be provided on the platform. They shall be supplied by the permanent water system. The monitors 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. The horizontal and vertical traverse of the monitors shall not exceed the elevating platform manufacturer's recommendation.

16-12.2.1* A slow operating valve shall be provided at the base of any monitor.

16-12.2.2 If a hose connection is provided, it shall be a minimum 2½-in. (65-mm) nominal diameter valved connection.

16-12.3* The water system shall be supplied at ground level through an external inlet suitable to deliver the system flow requirement. 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.

16-12.4 A flow meter 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.

16-12.5 A preset relief valve capable of protecting the waterway system by relieving pressure through the dumping of water to the environment shall be provided.

16-12.6* A 1½-in. (38-mm) minimum drain valve shall be provided at the low point of the waterway system. Additional drains shall be provided to drain any portions of the waterway that do not drain to the low point of the system.

16-13 Water Tower Requirements.

16-13.1 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.

16-13.2 The rated vertical height of the water tower assembly shall be measured in a vertical plane from the discharge end of the nozzle to the ground, with the nozzle raised to its position of maximum elevation.

16-13.3 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.

16-13.4 Height and reach dimensions shall be taken with the water tower mounted on a chassis meeting the water tower manufacturer's minimum recommended vehicle specifications, the vehicle on level ground, and stabilizers deployed in accordance with the manufacturer's instructions.

16-14 Water Tower Rated Capacity.

16-14.1 The water tower shall be capable of delivering a minimum water stream of 1000 gpm (3785 L/min) at 100 psi (690 kPa) from the tower nozzle with the booms or sections and nozzle positioned in any configuration permitted by the manufacturer. The rated capacity shall include the weight of the charged waterway and the manufacturer's maximum nozzle reaction force.

16-14.2 If the water tower is rated in multiple configurations, the manufacturer shall clearly describe these configurations, including the rated capacity of each, in the operations manual and on the sign at the operator's control station.

16-14.3 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 in not over 105 seconds. Two or more of these functions shall be permitted to be performed simultaneously.

16-15 Water Tower Operating Mechanisms.

16-15.1 Power-operated elevating and extending devices shall be provided. They shall be so designed and provided with adequate power to allow multiple movements of the water tower booms or sections simultaneously under all rated conditions of loading. Where hydraulic components are utilized, they shall meet the requirements of Section 16-19. An automatic locking device(s) shall be provided so that the desired elevated position can be maintained. Provisions shall be made to prevent damage at top and bottom limits.

16-15.2 A lock shall be provided that will retain the water tower booms or sections in the bed when the vehicle is in motion.

16-15.3 A power-operated turntable shall be provided that shall allow continuous rotation in either direction under all the rated conditions of loading. The turntable rotation bearing shall be accessible for lubrication and retorquing of bolts.

16-15.4 The turntable rotation mechanism shall be provided with an automatically applied brake or self-locking drive. It shall provide braking capacity with all power systems nonfunctioning to prevent turntable rotation under all rated conditions of loading.

16-16 Water Tower Water Delivery System.

16-16.1 A permanently installed monitor with an automatic variable flow nozzle capable of a discharge range of at least 300 gpm to 1000 gpm (1136 L/min to 3785 L/min) shall be provided at the top of the water tower and supplied by a permanent water system. The monitor shall be powered so as to allow the operator(s) to control its aimed direction. The monitor, as distinct from the supporting boom, shall provide for rotation through at least 45 degrees either side of center. The monitor shall also provide for elevation and depression of the nozzle through at least 30 degrees above and 135 degrees below the centerline of the boom. The horizontal and vertical traverse of the monitor shall not exceed the water tower manufacturer's recommendation. If a variable pattern spray nozzle is provided, a control shall be provided at the operator's position to select the desired stream pattern.

16-16.2 A permanent water system shall be installed capable of delivering 1000 gpm (3785 L/min) at 100 psi (690 kPa) nozzle pressure with the water tower and nozzle positioned in any configuration permitted by the manufacturer. For water towers with a rated vertical height of 110 ft (33.5 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 (690 kPa) at a flow of 1000 gpm (3785 L/min). A flow meter 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.

16-16.3* The water system shall be supplied at ground level through an external inlet suitable to deliver the system flow requirement. 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.

16-16.4 A preset relief valve capable of protecting the waterway system by relieving pressure, through the dumping of water to the environment, shall be provided. Such dumping shall be via a system of piping terminating in an area facing away from the operator's position. The discharge end of the piping shall not have a threaded connection.

16-16.5* A $1\frac{1}{2}$-in. (38-mm) minimum drain valve shall be provided at the low point of the waterway system.

16-17 Control Devices.

16-17.1 Controls shall be provided at the driver's position to transfer power to the aerial device. A visual signal shall be provided at the driver's position to indicate when the operating mechanisms are engaged.

16-17.2 An interlock shall be provided that prevents operation of the aerial device until the chassis spring 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.

16-17.3 A power-operated governed engine speed control shall be provided to limit the operating speed of the aerial device apparatus engine to within normal operating parameters as determined by the manufacturer and this standard.

16-17.3.1 An interlock shall be provided that allows operation of the engine speed control only after the chassis spring brakes have been set and the transmission is in neutral.

16-17.3.2 Where the apparatus is equipped with a fire pump, any high idle speed control shall be automatically disengaged when the fire pump is operating.

16-17.4* An interlock system shall be provided to prevent rotating the aerial device until the stabilizer(s) is in a configuration to meet the stability requirements of Section 16-21. The interlock system shall also prevent the movement of the stabilizers unless the aerial device is in the travel position.

16-17.5 Controls, suitably lighted, clearly marked, and conveniently arranged shall be provided at the operator's position in order to:

(a) Elevate and lower the aerial device;
(b) Extend and retract the aerial device, if applicable;
(c) Rotate the aerial device in either direction; and
(d) Operate the intercom.

16-17.5.1 A method shall be provided to prevent unintentional movement of the aerial device.

16-17.5.2 Controls 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.

16-17.5.3 All controls shall be arranged so they can be easily operated by an operator with a gloved hand without disturbing any other control(s).

16-17.6 Where a three-lever system is used to control the basic functions of the aerial device, the levers shall be distinctively 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. (*See Figure 16-17.6.*)

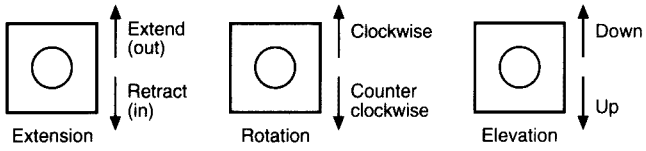


Figure 16-17.6 Control lever arrangement.

16-17.6.1 The aerial device shall extend when the extension control is pushed up or forward (away from the operator).

16-17.6.2 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 (away from the operator). Otherwise, the rotational control handle shall move in the direction of rotation.

16-17.6.3 The aerial device shall lower when the elevation control is pushed up or forward (away from the operator).

16-17.7 Where a multifunction control lever is furnished, it shall move in the direction of the function it controls where possible.

16-17.8 All controls regulating the movement of the aerial device shall automatically return to the neutral position upon release by the operator.

16-17.9 When electric over hydraulic aerial device controls are incorporated, a readily accessible, manual means of overriding the electric controls shall be provided.

16-18 Safety.

16-18.1* If the operator's position is on the turntable, the turntable platform shall be provided with a railing at least 42 in. (1067 mm) high. The railing design shall be capable of withstanding a 225-lb (102-kg) force applied at any point from any direction without permanent deformation.

16-18.2 Where the aerial device includes moving cylinders or other moving parts, these shall be arranged so as to provide adequate hand clearance, or suitable hand guards shall be provided to prevent injury to the operator.

16-18.3 Lighting shall be provided at the base of the aerial device and shall be arranged to illuminate the aerial device in any position of operation.

16-18.4 A spotlight of not less than 75,000 candlepower shall be provided on the apparatus by which the operator shall be able to observe the effect of the stream from the ladder pipe or monitor nozzle.

16-18.5 Provisions shall be made so that in the event of failure of the normal operating power source, an auxiliary source of power shall be readily available. The auxiliary power source shall be capable of returning the aerial device to a road travel position.

16-18.6 Where the operation of the aerial device is accomplished by hydraulic means, the system shall be equipped with appropriate devices to prevent motion of the aerial device in the event of any hydraulic hose failure.

16-18.7 Where the operation of the aerial device is accomplished by other than hydraulic means, the system shall be designed to prevent motion of the aerial device in the event of a power failure.

16-18.8 All components used to stabilize the apparatus that the aerial device is mounted on shall be designed to prevent instability in the event of a hydraulic hose failure or a power failure.

16-18.9 Where the design of the aerial device incorporates a "knuckle," the knuckle shall either be equipped with position lights or continuously illuminated by boom lights. The knuckle shall be painted with reflective paint or provided with reflective striping.

16-19 Hydraulic System.

16-19.1 The nonsealing moving parts of all hydraulic components whose failure could result in motion of the aerial device shall have a minimum bursting strength of four times the maximum operating pressure to which the component is subjected.

16-19.1.1 Dynamic sealing parts of all hydraulic components whose failure could result in motion of the aerial device shall not begin to extrude or otherwise fail at pressures at or below two times the maximum operating pressure to which the component is subjected.

16-19.1.2 Static sealing parts of all hydraulic components whose failure could result in motion of the aerial device shall have a minimum bursting strength of four times the maximum operating pressure to which the component is subjected.

16-19.2 All hydraulic hoses, tubing, and fittings, shall have a minimum bursting strength of at least three times the maximum operating pressure to which the components are subjected.

16-19.3 All other hydraulic components shall have a minimum bursting strength of at least two times the maximum operating pressure to which the components are subjected.

16-19.4 The hydraulic system shall be provided with an oil pressure gauge at the lower operating position.

16-19.5 A means shall be provided for readily checking and filling the hydraulic reservoir. The fill location shall be conspicuously marked "Hydraulic Oil Only." The manufacturer shall provide proper instructions for checking and filling the hydraulic reservoir.

16-19.6 The hydraulic system components shall be capable of maintaining, under all operating conditions, proper oil cleanliness and temperature to comply with the component manufacturer's recommendations. The system shall have adequate cooling for continuous water pump operation of not less than 2½ hours.

16-19.7 An hourmeter shall be provided that records any time the aerial device hydraulic system is engaged.

16-20 Structure.

16-20.1* 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. This is equivalent to a 2:1 safety factor.

16-20.2 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. This is equivalent to a 5:1 safety factor.

16-20.3 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 normal operating conditions. The factor of safety for the wire rope shall remain above 2:1 during any extension or retraction system stall. The minimum ratio of the diameter of wire rope used to the diameter of the sheave used shall be 1:12.

16-21 Stabilization.

16-21.1* The following stability requirements shall be met by the apparatus that the aerial device is mounted on when that apparatus is in a service ready condition, but with all normally removable items such as water, hose, ground ladders, loose equipment, etc., removed. Items mounted on the aerial device by the manufacturer shall remain mounted.

16-21.1.1 The aerial device shall be capable of sustaining a static load 1½ 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. If having stabilizers extended to a firm footing is part of the definition of the configuration, they shall be extended for the purpose of determining whether the apparatus meets this stability requirement.

16-21.1.2 The aerial device shall be capable of sustaining a static load 1⅓ 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 downward in the direction most likely to cause overturning. If having the stabilizers extended to a firm footing is part of the definition of the configuration, they shall be extended to provide leveling for the purpose of determining whether the apparatus meets this stability requirement. If other facilities, such as a means of turntable leveling, are provided to minimize the effect of the sloping surface, then those facilities shall be permitted to be utilized for the purpose of determining whether the apparatus meets this stability requirement.

16-21.1.3* None of the stability tests shall produce instability of the apparatus or cause permanent deformation of any components.

16-21.2 Stabilizers shall be provided, if required to meet the stability requirements of 16-21.1.

16-21.2.1 If the stabilizer system is power operated, the controls shall be arranged so that the operator can view the stabilizers in motion. An audible alarm of not less than 87 dba at any position the stabilizer can be in, shall sound when a stabilizer is moving.

16-21.2.2 Where the rated vertical height of the elevating platform is 110 ft (34 m) or less, the stabilizers shall be deployed in not more than 90 seconds from the stored position to the operating position.

16-21.2.3 The ground contact area for each stabilizer shall be such that a unit pressure of not greater than 75 psi (517 kPa) will be exerted over the ground contact area when the apparatus is fully loaded and the aerial device is carrying its rated capacity in every position permitted by the manufacturer. This shall be permitted to be accomplished with stabilizer pads in conjunction with the permanently mounted stabilizer shoes to meet the loading requirement of 75 psi (517 kPa). The stabilizer shoe shall be capable of swiveling in at least one direction. If the shoe swivels in one direction only, it shall swivel on an axis parallel to the longitudinal axis of the apparatus.

16-21.2.4 All stabilizers that protrude beyond the body of the apparatus shall be striped or painted with reflective material so as to indicate a hazard or obstruction.

16-21.2.5 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.

16-22 Quality Control.

16-22.1 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.

16-22.2 The quality control program shall include 100 percent nondestructive testing of all critical structural components of the aerial device. The manufacturer shall determine the types of nondestructive testing (NDT) to be conducted. The procedures used for NDT shall comply with the appropriate standards defined in 16-22.4. All NDT procedures shall be fully documented with respect to the extent of the examination, the method of testing, and the inspection techniques. All testing shall be performed by ASNT Level II NDT technicians certified in the test methods used, or by ASNT Level I technicians under the supervision of an on-site Level II technician, all of whom have been certified in the test methods used. All NDT testing shall be done in accordance with ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel.*

16-22.3 Welds for all structural load supporting elements shall be performed by certified welders under the guidelines of AWS D1.1, *Structural Welding Code — Steel*; AWS D1.3, *Structural Welding Code — Sheet Steel*; and AWS D1.2, *Structural Welding Code — Aluminum*. Welding performed by machines shall be considered equivalent to welding performed by certified welders.

16-22.4 The manufacturer and the installer shall establish applicable welding quality assurance procedures for all weldments. Methods of nondestructive testing shall be described in the manufacturer's quality assurance procedures and shall be as recommended by AWS B1.10, *Guide for*

the Nondestructive Inspection of Welds. The manufacturer shall designate the welds to be examined, the extent of examination, and the type of testing.

16-22.5 Nondestructive Testing Procedure.

16-22.5.1 All ultrasonic inspections shall be conducted in accordance with the following ASTM standards:

(a) ASTM E 114, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method*;

(b) ASTM E 797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*.

16-22.5.2 All magnetic particle inspections shall be conducted in accordance with ASTM E 709, *Standard Guide for Magnetic Particle Examination*.

16-22.5.3 All liquid penetrant inspections shall be conducted in accordance with ASTM E 165, *Standard Test Method for Liquid Penetrant Examinations*.

16-22.5.4 All radiographic inspections shall be conducted in accordance with ASTM E 1032, *Standard Method for Radiographic Examination of Weldments*.

16-22.5.5 All electrical conductivity measurements shall be conducted in accordance with ASTM E 1004, *Standard Test Method for Electromagnetic (Eddy-Current) Measurements of Electrical Conductivity*.

16-22.5.6 All hardness readings shall be conducted in accordance with the following ASTM standards:

(a) ASTM E 6, *Standard Terminology Relating to Methods of Mechanical Testing*;

(b) ASTM E 10, *Standard Test Method for Brinell Hardness of Metallic Materials*;

(c) ASTM E 18, *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*;

(d) ASTM E 92, *Standard Test Method for Vickers Hardness of Metallic Materials*;

(e) ASTM B 647, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gauge*;

(f) ASTM B 648, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor*.

16-22.5.7 All acoustic emission inspections shall be conducted in accordance with the following ASTM standards:

(a) ASTM E 569, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation*;

(b) ASTM E 650, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*.

16-23 Signs.

16-23.1 Legible, permanent signs that provide operational directions, warnings, and cautions shall be installed in positions readily visible to the operator(s).

16-23.1.1 Operational direction signs shall describe the function of each control and provide operating instructions.

16-23.1.2 Warning and caution signs shall indicate hazards inherent in the operation of the aerial device. These hazards shall include, but shall not be limited to:

(a) Electrical hazards involved where the aerial device does not provide protection to the personnel from contact with, or near proximity to, an electrically charged conductor;

(b) Electrical hazards involved where the aerial device does not provide protection to ground personnel who might contact the vehicle when in contact with energized electrically charged conductors;

(c) Hazards from stabilizer motion;

(d) Hazards that can result from failure to follow manufacturer's operating instructions.

16-23.2 Permanent labels shall disclose the following information relative to the aerial device:

(a) Make;

(b) Model;

(c) Insulated or noninsulated;

(d) Serial number;

(e) Date of manufacture;

(f) Rated capacity;

(g) Rated vertical height;

(h) Rated horizontal reach;

(i) Maximum hydraulic system pressure, if applicable;

(j) Hydraulic oil requirements (change quantity and type), if applicable.

16-24 Certification Tests. The completed apparatus with the aerial device shall be tested at the manufacturer's approved facility and certified by an independent testing organization approved by the purchaser.

16-24.1 The aerial device shall be inspected and tested in accordance with the requirements of NFPA 1914, *Standard for Testing Fire Department Aerial Devices*, including all nondestructive testing, prior to being subjected to the tests defined in 16-24.2 through 16-24.4.

16-24.2 The apparatus the aerial device is mounted on shall be placed on a firm, level surface. If having the stabilizers extended is part of the configuration, the stabilizers shall be deployed in accordance with the manufacturer's recommendations. A load of 1 1/2 times the rated capacity as specified by the manufacturer 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. If the manufacturer specifies a rated capacity while flowing water, then one times the water load and the worst case nozzle reaction shall be added to the stability test weights. The apparatus shall show no signs of instability. For a water tower, the stability test shall include 1 1/2 times the weight of the water in the system and 1 1/2 times the maximum nozzle reaction force when it is in the position of least stability.

16-24.3 The apparatus the aerial device is mounted on shall be placed on a firm surface sloping downward at 5 degrees in the direction most likely to cause overturning. If having the stabilizers extended is part of the configuration, the stabilizers shall be deployed in accordance with the manufacturer's recommendations. A load of 1 1/3 times the rated capacity shall be suspended from the tip of the aerial ladder, the platform of the elevating platform, or the tip of the water tower when it is in the position of least stability. The apparatus shall show no signs of instability.

16-24.4 Aerial Device Water System Test.

16-24.4.1 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 provided to the purchaser. 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 (690 kPa) with 1000 gpm (3785 L/min) flowing and the water system at full extension.

16-24.4.2 A flow test shall be conducted to determine that the water system is capable of flowing 1000 gpm (3785 L/min) at 100 psi (690 kPa) nozzle pressure with the aerial device at full elevation and extension. 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. The intake pressure to the fire pump shall not exceed 20 psi (138 kPa).

16-25* Manufacturer's Predelivery Test. If the aerial device is equipped with a permanent water delivery system, the manufacturer shall conduct the following test prior to delivery of the apparatus. The piping for the waterway system, including the monitor, shall be hydrostatically tested at the maximum operating pressure required to flow 1000 gpm (3785 L/min) at 100 psi (690 kPa) nozzle pressure at maximum elevation and extension.

Chapter 17 Foam Proportioning Systems

17-1* Application. If the fire apparatus is equipped with a foam proportioning system, it shall comply with the applicable sections of this chapter.

17-2* Requirements by Type of Foam Proportioning System.

17-2.1* Eductor System. An eductor foam proportioning system shall meet the requirements of 17-3.1 through 17-3.6, 17-3.8, 17-3.9, and Sections 17-4, 17-5, 17-6, 17-9, and 17-10.

17-2.2* Self-Educting Master Stream Nozzle. A self-educting master stream nozzle shall meet the requirements of Sections 17-3, 17-4, 17-6, 17-9, and 17-10.

17-2.3* Intake-Side System. An intake-side foam proportioning system shall meet the requirements of Sections 17-3, 17-4, 17-5, 17-6, 17-9, and 17-10.

17-2.4* Around-the-Pump System. An around-the-pump foam proportioning system shall meet the requirements of Sections 17-3, 17-4, 17-5, 17-6, 17-9, and 17-10.

17-2.5* Balanced Pressure System. A balanced pressure foam proportioning system shall meet the requirements of Sections 17-3 through 17-10.

17-2.6* Direct Injection Systems. A direct injection foam proportioning system shall meet the requirements of Sections 17-3, 17-4, 17-5, 17-6, 17-7, 17-9, and 17-10.

17-2.7* Water Powered Direct Injection Foam Proportioning System. A water motor or water turbine foam proportioning system shall meet the requirements of Sections 17-3, 17-4, 17-5, 17-6, 17-7, 17-9, and 17-10.

17-3 Design and Performance Requirements of a Foam System.

17-3.1 The proportioning system shall be capable of proportioning foam concentrate(s) in accordance with the foam concentrate manufacturer's recommendations for the type of foam concentrate used in the system over the system's design range of flow and pressures. The foam proportioning system water flow characteristics and the range of proportioning ratio(s) shall be specified by the purchaser.

17-3.2 The apparatus shall be capable of supplying the power required by the foam proportioning system in addition to the requirements of the other power-dependent systems installed on the apparatus.

17-3.3* Components that are continuously wetted with foam concentrate shall be constructed of materials that will not be damaged in form, fit, or function, when exposed to foam concentrates, including the adverse effects of corrosion, formation of harmful solids, deterioration of gaskets and seals, binding of moving parts, and the deterioration of the foam concentrate caused by contact with incompatible materials.

17-3.4 The foam proportioning components that can be flushed with water after use shall be constructed of materials that do not corrode after being flushed with water and allowed to dry. These components shall also be constructed of materials resistant to deterioration by foam concentrates.

17-3.5 The foam concentrate supply line shall be noncollapsible.

17-3.6 A means shall be provided to prevent water backflow into the foam proportioning system and the foam concentrate storage tank.

17-3.7 A minimum of one strainer or filter shall be provided on the foam concentrate supply side of the foam proportioner to prevent any debris that might affect the operation of the foam proportioning system from entering the system. The strainer assembly shall consist of a removable straining element, housing, and retainer. The strainer assembly shall allow full flow capacity of the foam supply line.

17-3.8 If the foam proportioning system injects foam concentrate on the discharge side of the water pump, a means shall be provided to automatically prevent foam concentrate and foam solution from flowing back into the water pump or water tank.

17-3.9 A foam concentrate system flush line(s) shall be provided as required by the foam system manufacturer. A means shall be provided in the flush line(s) to prevent water backflow into the foam concentrate tank or water tank during the flushing operation. Where the foam proportioning system is connected to more than one foam concentrate storage tank, provisions shall be made to flush all common lines to avoid contamination of dissimilar foam concentrates.

17-4 Controls for Foam Systems.

17-4.1* The foam proportioning system operating controls shall be located at the pump operator's position and shall clearly identified.

17-4.2 Foam proportioning systems that require flushing after use shall be provided with readily accessible controls

that enable the operator to completely flush the system with water according to the manufacturer's instructions.

17-4.3 Foam proportioning systems that incorporate foam concentrate metering valves shall have each metering valve calibrated and marked to indicate the rate(s) of the foam concentrate proportioning available as determined by the design of the system.

17-4.4 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 in a manual mode.

17-5 Foam System Pressure Indicating Devices, Flow Meters, and Indicators.

17-5.1 All pressure indicating devices, flow meter displays, and indicators (e.g., fluid level indicators) shall be located so that they are readily visible from the pump operator's position. All pressure indicating devices or flow meter displays shall be mounted in a manner that protects the pressure indicating device or display from physical damage and excessive vibration.

17-5.2 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade B as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*. Numerals for master gauges shall be a minimum of $^{5}/_{32}$ in. (4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation and shock; and have internal mechanisms that do not require periodic lubrication.

17-5.3 If digital pressure indicating devices are used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

17-5.4 All pressure indicating devices and flow meters shall be capable of continuous operation to −40°F (−40°C) without damage.

17-5.5 A gauge(s) shall be provided for balanced pressure foam proportioning systems that simultaneously indicates water pressure and foam concentrate pressure.

17-6 Atmospheric Foam Concentrate Tank. If the foam proportioning system incorporates an atmospheric foam concentrate tank, 17-6.1 through 17-6.12 shall apply.

17-6.1 The foam concentrate tank or tanks shall be constructed of noncorrosive materials or other materials that are protected against corrosion or deterioration and that will not be adversely affected by the foam concentrate to be stored in the tank.

17-6.2 All foam concentrate tanks shall be provided with sufficient swash partitions so that the maximum dimension perpendicular to the plane of any partition shall not exceed 36 in. (915 mm). The swash partition(s) shall extend from wall to wall and cover at least 75 percent of the area of the plane of the partition.

17-6.3* The foam concentrate tank shall be provided with a fill tower or expansion compartment having a minimum area of 12 in.^{2} (7742 mm^2) and having a volume of not less than 2 percent of the total tank volume. The fill tower opening shall be protected by a completely sealed airtight cover. The cover shall be attached to the fill tower by mechanical means. The fill opening shall be designed to incorporate a $^{1}/_{4}$-in. (6-mm) removable screen and shall be located so that foam concentrate from a 5-gal (19-L) container can be dumped directly to the bottom of the tank to minimize aeration without the use of funnels or other special devices.

17-6.4 The fill tower shall be equipped with a pressure/vacuum vent that enables the tank to compensate for changes in pressure or vacuum when filling or withdrawing foam concentrate from the tank. The pressure/vacuum vent shall not allow atmospheric air to enter the foam tank except during operation or to compensate for thermal fluctuations. The vent shall be protected to prevent foam concentrate from escaping or directly contacting the vent at any time. The vent shall be of sufficient size to prevent tank damage during filling or foam withdrawal.

17-6.5 The foam concentrate tank shall not be equipped with an overflow pipe or any direct opening to the atmosphere.

17-6.6* The foam concentrate tank(s) shall be designed and constructed to facilitate complete interior flushing and cleaning as required.

17-6.7 A minimum $^{1}/_{2}$-in. (13-mm) valved drain shall be provided at the lowest point of any foam concentrate tank. The drain shall be piped to drain directly to the surface beneath the apparatus without contacting other body or chassis components.

17-6.8* The foam concentrate tank shall be constructed and installed to be independent of the apparatus body.

17-6.9 The foam concentrate discharge system design shall prevent the siphoning of foam.

17-6.10* A label or visible permanent marking that reads "Foam Tank Fill" shall be placed at or near any foam concentrate tank fill opening. A label shall be placed at or near any foam concentrate tank fill opening that specifies the type(s) of foam concentrate the system is designed to use, any restrictions on the types of foam concentrate that can be used with the system, and a warning message that reads "Warning: Do Not Mix Brands and Types of Foam."

17-6.11 The foam concentrate tank outlet connection shall be designed and located to prevent aeration of the foam concentrate and shall allow withdrawal of 80 percent of the foam concentrate tank storage capacity under all operating conditions with the vehicle level.

17-6.12 The foam concentrate tank inlet connection, if provided, shall prevent aeration of the foam concentrate under all operating conditions.

17-7* Foam Concentrate Pump. If the foam proportioning system is equipped with a foam concentrate pump, 17-7.1 through 17-7.5 shall apply.

17-7.1 The foam concentrate pump shall operate without cavitation when delivering maximum rated flow.

17-7.2 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 17-9.3.

17-7.3 Drive train components that transmit power to the foam concentrate pump shall be in accordance with the apparatus manufacturer's design performance provided on the rating plate required in 17-9.3.

17-7.4 A means to relieve excess pressure in the foam concentrate pumping system shall be provided to protect the foam concentrate pump from damage.

17-7.5* Foam concentrate pumps that are intended to be supplied from an external source of foam concentrate shall be provided with an external valved intake and discharge connection.

17-8 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, 17-8.1 through 17-8.8 shall apply.

17-8.1 If the tank is charged with a compressed gas, the tank shall be of welded construction and designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the rated pressure.

17-8.2 All pressure tanks and associated piping shall be designed to a minimum of 1½ times maximum working pressure and shall be tested to the design pressure after installation.

17-8.3 The pressure vessel tank shall be protected against corrosion from the foam concentrate or water stored in the tank.

17-8.4 If the tank is equipped with a gravity fill (has a fill cap), the fill opening shall be a minimum 2-in. (51-mm) inside diameter.

17-8.4.1 The fill cap shall be equipped with nontapered threads and a compressible gasket.

17-8.4.2 Special wrenches or tools required to tighten the fill cap shall be supplied by the manufacturer and shall be securely mounted adjacent to the fill cap.

17-8.4.3 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.

17-8.5 A minimum ½-in. (13-mm), manually operated, valved vent shall be provided on all pressure vessel tanks.

17-8.6 If the tank is charged with a compressed gas, an approved ASME relief valve, properly set, shall be furnished on the tank to prevent tank pressure from exceeding 110 percent of the maximum allowable working pressure.

17-8.7 A minimum ½-in. (13-mm), manually operated, valved drain connection shall be provided on all pressure vessel tanks.

17-8.8 A gauge indicating the internal pressure of the pressure vessel shall be provided and located at the operator's position.

17-9 Labels, Nameplates, and Instructions.

17-9.1 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.

17-9.2 A nameplate that is marked clearly with the identification and function shall be provided for each control, gauge, and indicator related to the foam proportioning system.

17-9.3* A label shall be provided on the pump operator's panel that identifies the type(s) of foam concentrate(s) that the foam proportioning system is designed to use. It shall also state the minimum/maximum foam proportioning rate(s) at the minimum/maximum rated system flow and pressure.

17-9.4 Two copies of an operations and maintenance manual shall be provided. They shall include a complete diagram of the system together with operating instructions and details outlining all recommended maintenance procedures.

17-10* Foam Proportioning System Accuracy. The accuracy of the foam proportioning system shall be tested by the apparatus manufacturer prior to delivery of the apparatus. If the manufacturer's rated proportioning ratio is below 3 percent, the foam system shall proportion foam concentrate within –0 percent/+40 percent of the manufacturer's rated proportioning ratio across the manufacturer's stated range of water flow and pressure. If the manufacturer's rated proportioning ratio is at or above 3 percent, the foam system shall proportion foam concentrate within –0 percent/+40 percent of the manufacturer's rated proportioning ratio or 1 percentage point, whichever is less, across the manufacturer's stated range of water flow and pressure.

Chapter 18 Compressed Air Foam Systems (CAFS)

18-1* Application. If the fire apparatus is equipped with a compressed air foam system (CAFS), it shall comply with the applicable sections of this chapter.

18-2 General Requirements.

18-2.1* A foam proportioning system shall be used and shall comply with the applicable requirements of Chapter 17.

18-2.2 The total CAFS rating shall be expressed in terms of matched air and water flow. The air shall be expressed in standard cubic feet per minute (SCFM) and shall be based on the continuous flow capacity of the compressed air source(s) at a minimum of 125 psig (862 kPag).

18-2.3 The design of a CAFS on a fire apparatus shall allow the operator to engage the CAFS and produce the desired consistency of foam in the same relative time and ease as it takes to engage the water pump and begin flowing water.

18-2.4 The apparatus shall be capable of supplying power for operating the CAFS at its rated capacity in addition to all other power-dependent systems installed on the apparatus.

18-2.5* On CAFS, the water pump and air pressures shall be automatically balanced up to the rated pressure of the air compressor within ± 5 percent.

18-3 Compressed Air Source.

18-3.1 The compressed air source operating in clean environment conditions shall be designed to provide a continuous rated supply for 6 hours duration without needing adjustment, addition of lubrication, or changing of air filters.

18-3.2 The compressed air source shall be equipped with an air pressure relief valve that meets the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 2. The outlet of the relief device shall be routed to an area that does not expose personnel to air blasts or cause the creation of dust.

18-3.3 The compressed air source shall be equipped with moisture drain valves.

18-3.4 If a holding, surge, or separator tank is provided, it shall be designed, fabricated, and stamped in accordance with the requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1, for the required pressure.

18-4* Air Mixing.

18-4.1 The proportioning system's air to foam solution ratio shall be accurate within ± 10 percent of the desired air ratio at the rated flow and pressure.

18-4.2 An automatic means shall be provided to prevent the backflow of all liquids and gases. This shall include the backflow of water or foam solution into the compressed air source, air into the water pump, and both water and air into the foam proportioning equipment.

18-4.3 A means of mixing air and foam solution shall be provided on CAFS. The air and foam solution mixing system shall provide homogeneous mixing of the compressed air and foam solution.

18-5* Compressed Air System Piping. The discharge plumbing shall be configured to minimize the use of elbows or abrupt turns.

18-6 Air Source Controls.

18-6.1 All compressed air source controls shall be located at the pump operator's position and shall be clearly identified.

18-6.2 Air compressor systems that require flushing after use shall be provided with readily accessible controls that allow the operator to completely flush the system with water according to the manufacturer's instructions.

18-7 Foam System Pressure Indicating Devices, Flow Meters, and Indicators.

18-7.1 The displays of all pressure indicating devices, flow meters, and indicators shall be located so they are readily visible from the pump operator's position. All pressure indicating devices or flow meters shall be mounted in a manner that protects the pressure indicating devices or display from physical damage and excessive vibration.

18-7.2 Where an analog pressure gauge is used, it shall have a minimum accuracy of Grade B as defined in ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*. Numerals for master gauges shall be a minimum of $^{5}/_{32}$ in. (4 mm) high. There shall be graduation lines of at least every 10 psi (69 kPa), with major and intermediate graduation lines emphasized and minimum figure intervals every 100 psi (690 kPa). Analog pressure gauges shall be vibration and pressure pulsation dampened; resistant to corrosion, condensation and shock; and have internal mechanisms that do not require periodic lubrication.

18-7.3 If digital pressure indicating devices are used, the digits shall be at least 0.25 in. (6.4 mm) high. Digital pressure indicating devices shall display pressure in increments of not more than 10 psi (69 kPa).

18-7.4 All pressure indicating devices and flow meters shall be capable of continuous operation to –40°F (–40°C) without damage.

18-7.5 Flow meter displays shall be located at the pump operator's position and shall indicate the airflow in standard cubic feet per minute and indicate the water flow in gallons per minute. Flow meters shall be rated to 500 psig (3447 kPag) hydrostatic burst pressure if located on the pressure side of the system.

18-7.6* A pressure indicating device shall be provided for the compressed air source.

18-8 Nameplates and Instruction Plates.

18-8.1 A nameplate that is marked clearly with the identification and function of each control, gauge, and indicator related to the compressed air foam system shall be provided.

18-8.2 A rating plate shall be provided at the pump operator's position that gives the rated continuous flow capacity of the compressed air source at 125 psig (862 kPag).

18-8.3 An instruction plate shall be provided at the pump operator's position that states:

(a) Open and close valves slowly.
(b) Do not run with just air/water.
(c) Shut off air when foam tank is empty.
(d) Be prepared for high nozzle reactions — open nozzle slowly.

18-9* Manufacturer's Predelivery Tests. The manufacturer shall conduct the following tests prior to delivery of the apparatus.

18-9.1 Capacity Rating Test.

18-9.1.1 The operation of the water pump and the compressed air source shall be tested simultaneously to determine the integrity of the system and to ensure that there is adequate power available to operate these components of the CAFS. The compressed air source shall be operated at its flow capacity at a minimum 125 psig (862 kPag), and the water pump shall discharge 2 gal (7.6 L) of water at 125 psi (862 kPa) net pump pressure for every one SCFM of compressed air discharge. The discharge shall be through at least two separate discharge openings, one discharging air only and the other discharging water only.

18-9.1.2 One or more lines of fire hose of sufficient diameter shall be provided to allow discharge of the required amount of water from the pump to a nozzle or other flow-measuring equipment without exceeding a flow velocity of 35 ft/sec (10.7 m/sec) [approximately 500 gpm (1900 L/min) for $2^{1}/_{2}$-in. (65-mm) hose]. The discharge shall be measured using a smoothbore nozzle and pitot tube or other equipment such as flow meters, volumetric tanks, or weigh tanks. Test gauges shall meet the requirements of 12-13.2.2.4, and all test gauge connections shall include "snubbing" means, such as needle valves to damp out rapid needle movements, unless the gauges are liquid-filled.

18-9.1.3* The airflow rate shall be measured using a pressure and temperature compensated flow-measuring device. The airflow shall be measured in standard cubic feet per minute (SCFM) at a minimum of 125 psig (862 kPag). The airflow-measuring device shall have been calibrated for accuracy within the previous 3 months. The air discharge outlet shall have nothing attached directly to it except the test device(s).

18-9.1.4 The water pump and the compressed air source shall be started and the rated flows and pressures as specified in 18-9.1.1 shall be maintained. The system shall be run for 1 hour. Readings of the airflow rate and pressure, and the water pump pressure and discharge rate shall be taken at least every 10 minutes.

18-9.1.5 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.

18-9.2* Standby Run Test. One 200-ft (61-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. A quarter-turn valve of the same nominal size as the hose shall be installed at the discharge end. The hose shall be secured immediately behind the valve at the discharge end to prevent uncontrollable movement when the valve is opened. Operating as a CAFS, with gauge air output at 125 psig (862 kPag), a foam flow shall be established in the hose line. With the water tank at the ½ full level, the valve at the discharge end of the hose shall be shut no faster than in 3 seconds and no slower than in 10 seconds. The engine(s) speed shall be maintained for 10 minutes without discharging water, air, or foam solution from the CAFS and without operator intervention. A by-pass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits. At the end of 10 minutes, the valve shall be reopened no faster than in 3 seconds and no slower than in 10 seconds. Any damage to the system that affects its rated performance characteristics or the lack of a fire stream immediately upon opening the hose line shall constitute failure of this test.

Chapter 19 Line Voltage Electrical Systems

19-1* Application. Where any part of a line voltage electrical system is provided as a fixed installation, the applicable requirements of this chapter shall apply.

19-2 General Requirements.

19-2.1* The maximum voltage between any conductor and any other conductor or an earth ground shall not exceed 250 volts ± 10 percent.

19-2.2 Any fixed line voltage power source producing alternating current (ac) line voltage shall produce electric power at 60 cycles ± 5 cycles.

19-2.3 Except where superseded by the requirements of this chapter, all components, equipment, and installation procedures shall conform to NFPA 70, *National Electrical Code®* (herein referred to as the *NEC*). Where the requirements of this chapter differ from those in the *NEC*, the requirements in this chapter shall apply.

19-2.4* Line voltage electrical system equipment and materials included on the apparatus shall be listed and installed in accordance with the manufacturer's instructions. All products shall be used only in the manner for which they have been listed.

19-2.5 Location Ratings.

19-2.5.1 Any equipment used in a dry location shall be listed for dry locations.

19-2.5.2 Any equipment used in a wet location shall be listed for wet locations.

19-2.5.3 Any equipment used in an under-body or under-chassis 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.

19-3 Grounding and Bonding.

19-3.1* Grounding. Grounding shall be in accordance with Section 250-6 (*Portable and Vehicle Mounted Generators*) of the *NEC*. Ungrounded systems shall not be used. Only stranded or braided copper conductors shall be used for grounding and bonding.

19-3.1.1 An equipment grounding means shall be provided in accordance with Section 250-91 (*Grounding Conductor Material*) of the *NEC*.

19-3.1.2 The grounded current carrying conductor (neutral) shall be insulated from the equipment grounding conductors and from the equipment enclosures and other grounded parts. The neutral conductor shall be colored white or gray in accordance with Section 200-6 (*Means of Identifying Grounding Conductors*) of the *NEC*.

19-3.1.3 Any bonding screws, straps, or buses in the distribution panel board or in other system components between the neutral and equipment grounding conductor shall be removed and discarded.

19-3.2 Bonding.

19-3.2.1 The neutral conductor of the power source shall be bonded to the vehicle frame. The neutral bonding connection shall only occur at the power source.

19-3.2.2 In addition to the bonding required for the low voltage return current, each body and driving or crew compartment enclosure shall be bonded to the vehicle frame by a copper conductor. This conductor shall have a minimum amperage rating of 115 percent of the name plate current rating of the power source specification label as defined in Section 310-15 (*Ampacities*) of the *NEC*. A single conductor, properly sized to meet the low voltage and line voltage requirements shall be permitted to be used.

19-4 Power Source General Requirements. The following requirements shall apply to all line voltage power sources.

19-4.1 All power source system mechanical and electrical components shall be sized to support the continuous duty nameplate rating of the power source.

19-4.2 The power source shall be shielded from contamination that will prevent the power source from operating within its design specifications.

19-4.3 Guards shall be provided to protect personnel from moving parts and any surface with a temperature of 131°F (55°C) or more.

19-4.4 The power source shall have adequate ventilation to prevent heating of the system above the manufacturer's recommended limits.

19-4.5 Access shall be provided to permit both routine maintenance and removal of the power source for major servicing. The mounting brackets and power source shall not interfere with the routine maintenance of the apparatus.

19-4.6 The instrumentation shall be permanently mounted at an operator's panel. The instruments shall be located in a plane facing the operator so they are readily visible under normal operating conditions. Gauges, switches, or other instruments on this panel shall be labeled to indicate their function.

19-4.7 Instrumentation.

19-4.7.1 If the power source is rated at less than 8 kW, a "power on" indicator light shall be provided.

19-4.7.2* If the power source is rated at 8 kW or larger, the following instrumentation shall be provided at the operator's panel:

(a) Voltmeter;
(b) Amperage meters for each leg;
(c) Frequency (cycle) meter;
(d) Power source hourmeter.

19-4.8 Instructions that provide 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.

19-4.9 Operation.

19-4.9.1 Provisions shall be made for quickly and easily placing the power source into operation. The control shall be marked to indicate when it is correctly positioned for power source operation.

19-4.9.2 Any control device used in the drive train shall be equipped with a means to prevent the unintentional movement of the control device from its set position.

19-4.10 A power source specification label shall be permanently attached to the apparatus near the operator's control station. The label shall provide the operator with the information detailed in Figure 19-4.10.

Operational Category	Nominal Rating
Rated Voltage(s) and Type (ac or dc)	
Phase	
Rated Frequency [at rated voltage(s)]	
Rated Amperage	
Continuous Rated Watts	
Power Source Engine Speed	

Figure 19-4.10 Power source system specification label.

19-4.11 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.

19-5 Additional Power Source Requirements. The following requirements are specific to the defined type of line voltage power source.

19-5.1* Direct Drive (PTO) Generators. The generator shall comply with Article 445 (*Generators*) of the *NEC*.

19-5.1.1* The main propulsion engine shall have a governor capable of maintaining the engine speed within the limits required by the generator to meet the frequency control specifications.

19-5.1.2* An interlock shall prevent PTO engagement unless the parking brake is engaged. 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 while the generator is operating.

19-5.1.3 The transmission's PTO port and PTO, or the split shaft PTO, and all associated drive shaft components shall be rated to support the continuous duty torque requirements of the generator's full rated load as defined on the power source specification label.

19-5.1.4 A nameplate 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 easily be read from the driver's position.

19-5.1.5 Where the generator is driven by a split shaft PTO, a green indicator light shall be located in the driving compartment. This indicator light shall be energized when the PTO shift has been completed and shall be marked "PTO Engaged." Where an automatic chassis transmission is provided, a second green indicator light located in the driving compartment and a green indicator light located on the operator's panel shall be energized when both the PTO shift has been completed and the chassis transmission is engaged in the correct gear. The light in the driving compartment shall be marked "Generator PTO Operational." The light at the operator panel shall be marked "Generator PTO Engaged."

19-5.1.6 Where an automatic chassis transmission is provided and the generator is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO and is used for power generation with the chassis transmission in neutral, shift indicator lights shall be provided as defined in (a) and (b) below:

(a) A green indicator light shall be located in the driving compartment. The light shall be energized when the PTO drive has been engaged and shall be marked "Generator PTO Engaged."

(b) A green indicator light shall be located on the operator's panel. The green light shall be energized when both the PTO drive has been engaged and the chassis transmission is in neutral. The green light shall be marked "Generator PTO Engaged."

19-5.1.7 Where the chassis engine drives the generator through a converter driven transmission mounted (SAE) PTO and is used for power generation with the chassis transmission in neutral, the transmission torque converter shall be in the converter lock-up mode when the PTO generator is engaged.

19-5.1.8 Where a manual chassis transmission is provided and the generator is driven by a transmission-mounted (SAE) PTO, front-of-engine crankshaft PTO, or engine flywheel PTO, a green indicator light shall be located in the driving compartment. The light shall be energized when the PTO drive has been engaged and shall be marked "Generator PTO Engaged."

19-5.2* Hydraulically Driven Generators. The generator shall comply with Article 445 (*Generators*) of the *NEC*.

19-5.2.1* A means shall be provided to activate the hydraulic generator system.

19-5.2.2 If the hydraulic pump is to be supported by or mounted to any structural member or if the mounting brackets are attached to the structural members of the vehicle, vibration isolators shall be provided.

19-5.2.3 If the engine speed is not automatically controlled, a system shall be provided to automatically disconnect the power supply if the system voltage falls below 90 percent of the name plate voltage measured at the terminals of the power source.

19-5.2.4 Hydraulic Components.

19-5.2.4.1 A hydraulic system filter and strainer shall be provided. They shall be located in a readily accessible area.

19-5.2.4.2 Hydraulic hoses shall meet the hydraulic pump manufacturer's recommendations for pressure, size, vacuum, and abrasion resistance.

19-5.2.4.3* Hydraulic fittings shall meet the hydraulic pump manufacturer's recommendations for pressure, size, and the type of hose used.

19-5.2.4.4* Where the hydraulic hose comes into contact with other surfaces, the hose shall be protected from chaffing.

19-5.3* Fixed, Auxiliary Engine-Driven Generators. The generator shall comply with Article 445 (*Generators*) of the *NEC*.

19-5.3.1 Fixed, auxiliary engine-driven generators shall:

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

(b) Have the exhaust outlet piped to the exterior and located so exhaust is directed away from any operator positions.

19-5.3.2 Fuel System.

19-5.3.2.1 Fuel lines shall be protected from chaffing at all wear points.

19-5.3.2.2 If the fuel source is shared with the apparatus engine, a separate fuel pickup system shall be provided. The pickup tube arrangement shall ensure that the generator cannot utilize more than 75 percent of the fuel tank's capacity.

19-5.3.3 Exhaust System.

19-5.3.3.1* The exhaust piping and discharge shall be located or shielded to prevent thermal damage to the apparatus or equipment. Where parts of the exhaust system are exposed so that they are likely to cause injury to operating personnel, suitable protective guards shall be provided.

19-5.3.3.2 Silencing devices shall be provided and shall not create exhaust backpressure that exceeds the limits specified by the engine manufacturer.

19-5.4* Belt-Driven Generators or Alternators Supplying a Dedicated Invertor.

19-5.4.1 A means shall be provided to engage and disengage the generator.

19-5.4.2 A voltmeter shall be provided at the operator's panel for all sizes of systems of this type.

19-5.4.3 The belt drive system shall be rated to drive the generator or alternator at the system performance label rating.

19-5.5 Line Voltage Systems Derived from Apparatus Low Voltage Power Supply Systems.

19-5.5.1* Where a line voltage power source derives its input energy from the apparatus low voltage electrical system, the system shall be installed in strict compliance with the requirements of Chapter 9.

19-5.5.2 A means shall be provided to advance engine speed to obtain the power stated on the power source nameplate rating. This control shall work in coordination with other engine speed controls and interlocks as required in this standard.

19-6* Portable Generator Installations. The generator shall comply with Article 445 (*Generators*) of the *NEC*.

19-6.1 Any portable generator that can be operated while mounted on the vehicle shall:

(a) Be installed so fumes, vapors, heat, excessive noise, and vibrations do not enter interior driving or crew compartments or damage the generator during operation;

(b) Have the exhaust outlet located so exhaust is directed away from any operator station located on the apparatus and shall be properly guarded to protect the operator.

19-6.2 If the portable generator is remotely mounted, it shall have a remote operator's control station that shall provide for starting and stopping the generator and monitoring the same instrumentation as is required for fixed power sources.

19-6.3 Wiring for Portable Generator Installations. Wiring installed for the purpose of facilitating the distribution of power from a portable generator installation shall conform to the following additional requirements.

19-6.3.1 Circuit conductors shall be appropriately sized in relation to the system performance specification label rating and shall be protected by an overcurrent device commensurate with their amp capacities.

19-6.3.2 There shall be a single output connector cable with all of the conductors in the cable sized to carry a minimum of 115 percent of the nameplate amperage. If there is not an overcurrent protection device at the power source, this cable shall not exceed 72 in. (1830 mm) in length and shall be connected to an overcurrent protection device. The size of the main overcurrent protection device shall equal

the nameplate amperage rating 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.

19-6.4 If a connecting plug is required, it shall be appropriately sized and conform to NEMA configurations for plugs.

19-7 Line Voltage Supplied from an External Source.

19-7.1* If the apparatus is equipped with a fixed power inlet (shoreline inlet), it shall be a permanently mounted, flanged surface inlet (male-recessed-type receptacle with cover) sized in accordance with the anticipated load and wired directly to the system or device to be powered, or to a transfer switch where required by 19-7.2.

19-7.2 Transfer Switch Applications.

19-7.2.1 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.

19-7.2.2* Transfer equipment, including transfer switches, shall operate such that all ungrounded conductors of one source of supply are disconnected before any ungrounded conductors of the second source are connected.

19-7.3 The apparatus shall have a label permanently affixed at or near the power inlet that indicates the following:

Shore Power Inlet

Type of Line Voltage (120/240) _____
Current Rating in Amps _____

NOTE: If the power inlet is for dc or other than single-phase ac, it shall be so marked.

19-8 Overcurrent Protection. Manually resetable overcurrent devices shall be installed to protect the line voltage electrical system components.

19-8.1 Power Source Protection. A main overcurrent protection device shall be provided that is either incorporated in the power source or is connected to the power source by a power supply assembly.

19-8.1.1 The size of the main overcurrent protection device shall not exceed 100 percent of the nameplate amperage rating 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.

19-8.1.2 If the main overcurrent protection device is subject to road spray, the unit shall be housed in a Type 4 rated enclosure.

19-8.2 Power Supply Assembly. 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 144 in. (3658 mm) in length.

19-8.2.1 All power supply assembly conductors, including neutral and grounding conductors, shall have an equivalent amperage rating and shall be sized to carry not less than 115 percent of the amperage of the nameplate current rating of the power source.

19-8.2.2 For fixed power supplies, all conductors in the power supply assembly shall be Type THHW, THW, or USE stranded conductors enclosed in nonmetallic liquidtight flexible conduit rated for a minimum of 194°F (90°C).

19-8.2.3 For portable power supplies, conductors located between the power source and the line side of the main overcurrent protection device shall be Type SO or Type SEO with suffix WA flexible cord, rated for 600 volts at 194°F (90°C).

19-8.3 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 Section 240-3 (*Protection of Conductors*) of the *NEC*.

19-8.3.1 Any panelboard shall have a main breaker when the panel has six or more individual branch circuits.

19-8.3.2 Each overcurrent protection device shall be marked to identify the function of the circuit it protects.

19-8.3.3 Dedicated circuits shall be provided for any large appliance or device (air conditioning units, large motors, etc.) that require 60 percent or more of the rated capacity of the circuit to which it is connected. The circuit shall serve no other purpose.

19-8.4 Panel Boards. Unless all line voltage power connections are made through receptacles on the power source with integrated overcurrent protection, all fixed power sources shall be hardwired to a permanently mounted panelboard.

19-8.4.1 The panel shall be readily visible and located so that there is unimpeded access to the panelboard controls.

19-8.4.2 All panelboards shall be suitable for use in their intended location.

19-9 Wiring Methods. Fixed wiring systems shall be limited to the following:

(a) Metallic or nonmetallic liquidtight flexible conduit rated at not less than 194°F (90°C); or

(b) Type SO or Type SEO cord with a WA suffix, rated at 600 volts at not less than 194°F (90°C).

19-9.1 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:

(a) Separated by a minimum of 12 in. (305 mm) from exhaust piping or properly shielded; and

(b) Separated from fuel lines by a minimum of 6 in. (152 mm) distance.

19-9.2 A means shall be provided to allow "flexing" between the cab, body, and other areas or equipment whose movement would stress the wiring.

19-9.3 Electrical cord or conduit shall be supported within 6 in. (152 mm) of any junction box and at a minimum of every 24 in. (610 mm) of run. Supports shall be made of nonmetallic materials or corrosion protected metal. All supports shall be of a design that does not cut or abrade the conduit or cable and shall be mechanically fastened to the vehicle.

19-9.4 Only fittings and components listed for the type of cable or conduit being installed shall be used.

19-9.5 Splices shall be made only in a listed junction box.

19-9.6 Additional Requirements for Type SO or Type SEO Cable Installations.

19-9.6.1 Where Type SO or Type SEO cable is installed in a compartment, it shall be installed on the ceiling surface, or shall be enclosed in a minimum of 16 MSG metal conduit or enclosure.

19-9.6.2 Where Type SO or Type SEO cable is installed in areas other than a compartment, it shall be provided with a polymeric convoluted wire loom to help prevent mechanical abrasion. The loom shall have a flammability rating of VW-1 as defined in UL 62, *Standard for Flexible Cord and Fixture Wire*, have a minimum temperature rating of 289°F (143°C) and be made from a nonabsorbent material.

19-9.6.3 Where Type SO or Type SEO cable penetrates a metal surface, rubber or plastic grommets or bushings shall be installed.

19-9.7 Wiring Identification.

19-9.7.1 All line voltage conductors located in the main panel board shall be individually and permanently identified. The identification shall reference the wiring schematic or indicate the final termination point.

19-9.7.2 When prewiring for future power sources or devices, the unterminated ends shall be labeled showing function and wire size.

19-10 Wiring System Components.

19-10.1 Only stranded copper conductors with an insulation rated for at least 194°F (90°C) shall be used. Conductors in Type SO or Type SEO cord shall be sized in accordance with Table 400-5(A) of the *NEC*. Conductors used in conduit shall be sized in accordance with Section 310-15 (*Ampacities*), of the *NEC*. Aluminum or copper-clad aluminum conductors shall not be used.

19-10.2 Boxes. All boxes shall conform to and be mounted in accordance with Article 370 (*Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings*) of the *NEC*.

19-10.2.1 All boxes shall be accessible using ordinary hand tools. Boxes shall not be permitted behind welded or popriveted panels.

19-10.2.2 The maximum number of conductors permitted in any box shall be in accordance with Section 370-16 (*Number of Conductors in Outlet, Device, and Junction Boxes, and Conduit Bodies*) of the *NEC*.

19-10.3* All wiring connections and terminations shall provide a positive mechanical and electrical connection. Connectors shall be installed in accordance with the manufacturer's instructions. Wire nuts or insulation displacement and insulation piercing connectors shall not be used.

19-10.4* Switches. 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.

19-10.4.1 All switches shall be marked with the function of the switch.

19-10.4.2* Circuit breakers used as switches shall be "switch rated" (SWD) or better.

19-10.4.3 Switches shall simultaneously open all associated line voltage conductors.

19-10.4.4 Switching of the neutral conductor alone shall not be permitted.

19-10.4.5 Line voltage circuits controlled by low voltage circuits shall be wired through properly rated relays in listed enclosures. All nongrounded current-carrying conductors shall be controlled by the relay.

19-10.5 Receptacles and Inlet Devices.

19-10.5.1 Wet Locations.

19-10.5.1.1* 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 Section 210-7 (*Receptacles and Cord Connections*) of the *NEC*.

19-10.5.1.2* All receptacles located in a wet location shall be not less than 24 in. (610 mm) from the ground. Receptacles on "off-road" vehicles shall be a minimum of 30 in. (762 mm) from the ground.

19-10.5.2 All receptacles located in a dry location shall be of the grounding type. Receptacles shall be not less than 30 in. (762 mm) above the interior floor height.

19-10.5.3 The face of any wet location receptacle shall be installed in a plane from vertical to not more than 45 degrees off vertical. No receptacle shall be installed in a face-up position.

19-10.5.4 All receptacles shall be marked with the type of line voltage (120 volts or 240 volts) and the current rating in amps. If the receptacles are dc or other than single phase, they shall be so marked.

19-10.5.5* Listing. All receptacles and electrical inlet devices shall be listed to UL 498, *Standard for Safety Attachment Plugs and Receptacles*, or other appropriate performance standards. Receptacles used for dc voltages shall be rated for the appropriate dc service.

19-11 Cable Reels. All cable reels shall be rated for continuous duty and installed to be easily accessible for removal, cord access, maintenance, and servicing.

19-11.1 The power rewind cable reel spool area shall be visible to the operator during the rewind operation, or the reel spool shall be encapsulated to prevent cable from spooling off the reel.

19-11.2 Rollers shall be provided, where required, to prevent damage to the cable at reel spools or compartment openings.

19-11.3 Rewind Provision.

19-11.3.1 Manually operated reels shall have a hand crank.

19-11.3.2 Power rewind type reels shall have the control in a position where the operator can safely observe the rewinding operation.

19-11.3.3 The rewind control or crank shall not be over 72 in. (1830 mm) above the operator's standing position. The

rewind control shall be marked for function and shall be guarded to prevent accidental operation.

19-11.4* The reel shall be designed to hold 110 percent of the capacity needed for the intended cable length. The wire size shall be in accordance with *NEC* Table 400-5(A), "Allowable Ampacity for Flexible Cords and Cables."

19-11.5* Electrical cable shall be Type SO or Type SEO with a WA suffix or equivalent.

19-11.6* Labeling. A label shall be provided in a readily visible location adjacent to any permanently connected reel. It shall indicate the following:

(a) Current rating;
(b) Current type;
(c) Phase;
(d) Voltage;
(e) Total cable length.

19-11.7 Remote Power Distribution Box. Where a power distribution box is hardwired to the end of a cable stored on a fixed cable reel or other fixed storage means, the following requirements shall apply.

19-11.7.1 The remote power distribution box shall be listed for use in a wet location.

19-11.7.2* The distribution box shall be:

(a) Protected from corrosion;
(b) Capable of being carried with a gloved hand; and
(c) Designed to keep the exterior electrical components above 2 in. (51 mm) of standing water.

19-11.7.3* Inlets, receptacles, circuit breakers, or GFCI devices shall not be mounted on the top surface of the horizontal plane.

19-11.7.4 Branch circuit breakers shall be installed in the remote power distribution box if the overcurrent device protecting the feed cable to the box is too large to protect the wiring supplying the devices plugged onto the distribution box.

19-11.7.5* Remote power distribution boxes shall have a light on the box to indicate the power is on. The light shall be visible in a 360-degree plane from a minimum of 200 ft (61 m) in complete darkness. The light shall be mechanically protected to prevent damage.

19-11.7.6 The hardwired portable cord connection to the box shall have strain relief and meet the intended usage requirements.

19-12 Scene Lighting Systems. Where fixed scene lights are supplied, the following requirements shall apply.

19-12.1 All scene lights shall be provided with a lens or equivalent means to prevent damage from water spray and shall be listed for wet location usage.

19-12.2 If the light is adjustable, a handle shall be provided. The design of the light shall not allow the temperature of the handle to exceed 131°F (55°C).

19-12.3 The manufacturer of the device shall type certify that the scene light has been tested and complies with the vibration testing requirements of SAE J575, *Test Methods and Equipment for Lighting Devices and Components for Use on Vehicles Less Than 2032 mm in Overall Width.*

19-13 Power-Operated Light Mast.

19-13.1* General.

19-13.1.1 The mast shall be designed to sustain the intended tip load with at least a 125 percent safety factor.

19-13.1.2 The mast shall withstand a minimum of a 50-mph (81-kmph) wind in a raised, unguyed position.

19-13.2 Installation and Operational Requirements.

19-13.2.1 The mast shall be capable of being raised in not over 2 minutes.

19-13.2.2 Where the installation precludes the operator from visually seeing the light in its nested position, a means shall be provided to allow the operator to properly align the light for nesting when the operator is at the operator's position.

19-13.2.3* A means shall be provided to reduce the likelihood of electrocution of the operator due to contact with power lines.

19-13.2.4 A means shall be provided to prevent operations that could cause damage to the power supply conductors.

19-13.2.5 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 to prevent injury to equipment or personnel.

19-13.2.6 A secondary means of control shall be provided to allow for emergency lowering of the mast.

19-13.2.7 Where the tower is powered by the vehicle air brake supply, the air supply reservoir and piping shall comply with the requirements of the Federal Motor Vehicle Safety Standard (FMVSS) No. 121, *Air brake systems.*

19-13.2.8* An automatic deenergizing 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.

19-13.2.9 The hazard warning light required in Section 9-11 shall be illuminated whenever the light tower is not in the stowed position.

19-13.2.10 The operational envelope of the mast shall be automatically illuminated whenever the mast assembly is being raised, lowered, or rotated.

19-13.3 Labeling.

19-13.3.1 Essential mast operational instructions and warning labels shall be provided at the operator's position.

19-13.3.2 A label shall be provided at the operator's position to indicate:

(a) Extended tower height from the ground;
(b) Bulb replacement data.

19-14 Electrical System Testing.

19-14.1* The wiring and associated equipment shall be tested by the apparatus manufacturer or the installer of the line voltage system.

19-14.2 The wiring and permanently connected devices and equipment shall be subjected to a dielectric voltage withstand test of 900 volts for 1 minute. The test shall be conducted between live parts and the neutral conductor, and between live parts and the vehicle frame with any switches in

the circuit(s) closed. This test shall be conducted after all body work has been completed. The dielectric tester shall have a 500 VA or larger transformer, with a sinusoidal output voltage that can be verified.

19-14.3* Electrical polarity verification shall be made of all permanently wired equipment and receptacles to determine that connections have been properly made.

19-14.4 Operational Test. The apparatus manufacturer shall perform the following operation test and shall certify that the power source and any devices that are attached to the line voltage electrical system are properly connected and in working order.

19-14.4.1* The prime mover shall be started from a cold start condition and the line voltage electrical system loaded to 100 percent of the nameplate rating. The following information shall be recorded:

(a) The cranking time until the prime mover starts and runs, if applicable;

(b) The voltage, frequency, and amperes at continuous full rated load;

(c) The prime mover oil pressure, water temperature, transmission temperature, hydraulic temperature, and the battery charge rate, as applicable;

(d) The ambient temperature and altitude.

19-14.4.2* The power source shall be operated at 100 percent of its nameplate voltage for a minimum of 2 hours. Testing at unity power factor is acceptable, provided that rated load tests at rated power factor have been conducted and certified by the power source manufacturer. The conditions specified in 19-14.4.1(b) and (c) shall be recorded at least every ½ hour during the test.

Exception: Line voltage electrical systems that are category certified in accordance with 19-14.5 shall be permitted to be operationally tested for a minimum of 15 minutes with data collected at the start, the midpoint, and the end of the test.

19-14.4.3 Where the line voltage power is derived from the vehicle's low voltage system, the minimum continuous electrical load as defined in Chapter 9 shall be applied to the low voltage electrical system during the operational test. Any termination of line voltage power by the low voltage load management system shall be noted and the duration of the periods of line voltage power source shutdown shall be recorded.

19-14.4.4 Vehicle support systems that are required to maintain the power source in operation shall remain within their required operational parameters.

19-14.4.5 The results of the tests listed in this section shall be supplied to the purchaser at the time of delivery.

19-14.5 Category Certification of Line Voltage Electrical Systems. Apparatus manufacturers installing multiple systems of the same design shall be permitted to category certify their system. To be so certified, systems shall be required to be substantially identical in all major respects including that they are the same in construction and load, are installed in the same volume compartment, and have the same volume of airflow over the unit. The manufacturer shall indicate that such system has been previously tested and is category certified in the test report given to the purchaser.

Chapter 20 Command and Communications

20-1 General. If the apparatus is equipped with a separate communications area, or if it is used as a totally dedicated command vehicle, it shall meet the requirements of this chapter.

20-2* Location.

20-2.1* The command center shall be enclosed within a vehicle crew area or body.

20-2.2* The size of the command center located in a body shall be a minimum of 25 ft^2 (2.3 m^2) of floor space.

20-2.3 If there is only a single access door, there shall be a secondary means of escape.

20-3* Climate Control. The command area shall be provided with a heater capable of maintaining the temperature at a minimum of 60°F (16°C) with the vehicle's doors closed. 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 vehicle's doors closed.

20-4* Noise Levels. When the vehicle is stopped with major operational components in operation, the noise levels in the command area shall not exceed 80 dba.

20-5 Lighting Levels.

20-5.1 The command area shall have a switch control at the door entry area for general entry lighting or automatic dome lighting.

20-5.2* Lighting levels during command operations shall provide a continuous 100 lumens per square foot in the command area.

20-6 Command Working Surfaces and Countertop.

20-6.1* Horizontal working surfaces shall be smooth, with corners and edges provided that will not cause injury or damage when rubbed up against. The surface shall be supported or constructed to support the weight of a person.

20-6.2 Chair level work surfaces shall be 28 in. to 30 in. (711 mm to 762 mm) above the floor. Stand-up work surfaces shall be 36 in. to 40 in. (914 mm to 1016 mm) above the floor.

20-7 Seating in Command Center.

20-7.1* If seating is provided in the command center and that same seating is used during mobile operations (moving over the highway), the seat(s) shall comply with Section 10-1.

20-7.2 Storage shall be provided for all seating that is not permanently mounted in the vehicle so the seating can be stored in such a way as to protect all passengers while the vehicle is in motion. A clearly visible label shall be attached to each nonpermanently mounted seat indicating the seat is not to be used while the vehicle is in transit and is to be properly stored during that time.

20-8* Cabinets and Equipment Storage. Cabinets for the storage of equipment shall be designed and engineered to properly contain the equipment during periods of transit.

20-9 Wall, Ceiling, and Floor Surfaces.

20-9.1* The interior surfaces of command areas shall be free of sharp corners, projections, and edges. The interior surfaces shall be designed to sustain normal usage expected in a command area.

20-9.2 Floor surfaces shall be capable of being routinely cleaned. Floor mats or coverings shall be durable and removable for cleaning.

20-9.3 Dry-type grease boards, cork boards, chalk-type boards, or similar bulletin- or command-type wall surfaces shall be securely bolted in place, easily maintainable, and replaceable.

20-10 Communications and Electrical Consoles.

20-10.1* The communications equipment shall be installed in accordance with the component manufacturer's instructions and manuals.

20-10.2 Installation of radio and communications equipment shall conform to Federal Communications Commission (FCC) standards and requirements.

20-10.3 If a radio or electrical console is provided, it shall be enclosed on all sides to afford protection to equipment mounted in it. The front surface shall be hinged or bolted in place. Additional hinged or removable panels shall be provided for as required for access to equipment.

20-11* Computer Equipment and Installation.

20-11.1 All computer equipment shall be installed in a manner to reduce shock, vibration, and mechanical injury. During transit, computer equipment shall be stored in cabinets or securely mounted on work surfaces with quick release straps or other means.

20-11.2 Outlets specifically for computer use, whether 12 volt or 120 volt, shall be tested by the manufacturer to ensure they meet the computer manufacturer's requirements and shall be specially labeled for their usage and power output.

20-12 Video Equipment and Installation.

20-12.1 The purchaser shall detail the exact video equipment that is to be mounted on, and used with, the apparatus.

20-12.2 The storage of video equipment shall be in enclosed cabinets, with appropriate padding to prevent mechanical injury. Quick release straps shall hold the equipment in its designated storage area.

20-12.3 If a monitor is provided, it shall be securely mounted to prevent damage during transit.

20-12.4 If the equipment is to be externally mounted, appropriate mounting bracket(s) and outlet plugs shall be installed as necessary to accommodate the outside mounting of video equipment. Roof access ladders, steps, and safety railings shall be installed as required by Chapter 11.

Chapter 21 Air Systems

21-1 Application. Where a breathing air system or a utility air system is mounted on fire apparatus, the following shall apply. This chapter does not apply to compressed air foam systems (CAFS).

21-2* Provisions Applying to All Air Systems.

21-2.1 Compressor and booster supplied systems shall be capable of operating in any ambient temperature between 32°F and 110°F (0°C and 43°C). Cascade systems shall be capable of operating in any ambient temperature between 0°F and 125°F (–18°C and 52°C).

21-2.2 The air system shall be capable of withstanding storage at temperatures between 0°F and 125°F (–18°C and 52°C) without damage.

21-2.3 The air system shall be designed so it can be stored and operated in environments with relative humidity up to and including 100 percent.

21-2.4 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.

21-2.5 Assembly and Installation Practices.

21-2.5.1 Installation of low voltage electrical components shall meet the requirements of Chapter 9, and installation of line voltage electrical components shall meet the requirements of Chapter 19.

21-2.5.2 Surfaces over 142°F (61°C) shall be covered with a thermal insulating material or suitably guarded to protect the operator unless such protection affects the operation of the component. In those cases, a label shall be provided that states "Caution: Hot Surfaces When Operating."

21-2.5.3 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.

21-2.5.4 All screws, pins, bolts, or other fasteners whose failure would create a hazardous condition for personnel or equipment shall be equipped with locking devices. Safety wire, self-locking nuts, cotter pins, lock-washers, and liquid-locking compounds shall be acceptable.

21-2.6 Breathing Air Systems.

21-2.6.1 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 to be encountered during actual air system operation.

21-2.6.2 Discharge air from a compressor shall pass through a purification system prior to distribution.

21-2.6.3 Prior to the initial air quality test and commissioning, the breathing air system shall be purged with sufficient quantities of pure air or nitrogen to remove moisture and other contaminants.

21-2.7 General Piping and Installation.

21-2.7.1 All pneumatic fittings, tubing, and hoses shall be rated for the maximum allowable working pressure that could be encountered, with a test safety factor of not less than 3 to 1.

21-2.7.2 All pneumatic fittings, tubing, and hoses shall be corrosion resistant or treated to resist corrosion.

21-2.7.3 No threaded close nipples shall be used. Plugs shall be bar stock type with hex heads.

21-2.7.4 All piping and tubing shall be blown clean with clean, dry air before it is installed.

21-2.7.5 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.

21-2.7.6 Pipes or tubes installed, but not connected, shall have the ends closed with threaded caps or plugs to prevent the entry of foreign material.

21-2.7.7 All rigid piping compressed air lines shall be secured to a rigid body or chassis component at a minimum of every 16 in. (400 mm) and within 4 in. (100 mm) on each side of a coupling or elbow. Rigid piping shall run in an orderly manner with a minimum of bends and elbows. The piping installation shall provide room for maintenance and repairs with easy access panels provided where applicable.

21-2.8 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. The hose shall be installed in a manner that permits removal of the hose without removal of major vehicle components or vehicle mounted equipment.

21-2.9 Parts.

21-2.9.1 Gauges, instruments, and valves shall be located and oriented for maximum visibility. Any instrument that is to be used as a basis for manual control shall be visible from the manual controlling device.

21-2.9.2 Pressure gauges or other devices shall not be mounted directly on lines where excessive vibration is likely to be present. With the exception of direct connected process instruments (e.g., pressure gauges), instruments shall not use instrument piping or electrical conduit for support.

21-2.9.3 Any gauge shall be capable of reading at least 10 percent but not greater than 50 percent higher than any safety relief valve settings on lines supplying those gauges.

21-2.10 Maintainability. 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:

(a) The design shall be such that faults can be isolated to access removable assemblies or components.

(b) Fuses, if used, shall be readily accessible.

(c) The physical arrangement of components shall be such that they can be inspected, serviced, calibrated, and, if necessary, adjusted without removing them and with minimum disturbance to other parts.

(d) The design shall be such that inspection, service, and replacement can be accomplished using a minimum of special tools and support equipment. If special tools are required, they shall be supplied by the manufacturer.

(e) Adequate test points shall be provided to facilitate malfunction isolation and the connection of calibration instrumentation.

21-2.11 Instructions, Labeling, and Manuals.

21-2.11.1 All major components and accessories shall be clearly identified and labeled. Appropriate caution and warning labels shall be affixed where necessary to advise the users how to safely operate and adjust the equipment.

21-2.11.2 Knobs, gauges, valves, and other equipment shall be clearly marked as to function and operation.

21-2.11.3 The manufacturer of the air system shall provide schematics or drawings that document the system and its operation. Any symbols used shall be described in a key chart on the drawing. All schematics and drawings shall be delivered with the fire apparatus. The following information shall be shown:

(a) The general arrangement of the system;

(b) The electrical wiring and controls;

(c) The air control panel surface showing all controls, gauges, valves, outlets, and other specified equipment;

(d) The piping system showing all valves, gauges, controls, cylinders or vessels, piping, and specified equipment.

21-2.11.4 Two complete manuals that document the operation and maintenance of the system shall be provided. Nomenclature for switches, controls, and indicators shall be consistent with that used on the schematics and diagrams required in 21-2.11.3 and on equipment nameplates. The manuals shall include, but not necessarily be limited to, the following:

(a) An illustrated parts lists;

(b) A schedule of maintenance and adjustment checks;

(c) A lubrication schedule;

(d) Troubleshooting information to enable a technician to locate trouble and to make repairs or adjustments to the equipment;

(e) Step-by-step procedures for starting, operating, and stopping the equipment.

21-3* Breathing Air Compressor.

21-3.1 The purchaser shall determine the working pressure and capacity required from the compressor and state those requirements in the purchase specifications.

21-3.2 Compressor Intake.

21-3.2.1* The air intake shall be located where it will not be contaminated by the exhaust of the vehicle or the exhaust of the gasoline or diesel engines used to power the compressor or other components on the apparatus.

21-3.2.2 If an extended air intake pipe is used, it shall be installed in accordance with the compressor manufacturer's specifications.

21-3.3 Cooling.

21-3.3.1 The compressor shall be installed in the vehicle in accordance with the compressor manufacturer's specifications and in a manner that does not inhibit cooling efficiency.

21-3.3.2 The compressor shall be either air-cooled or water-cooled.

21-3.3.3 The temperature of the compressed air shall not exceed 25°F (14°C) above ambient when measured at the discharge nozzle of the compressor aftercooler.

21-3.4 A relief valve shall be provided after each stage of compression.

21-3.5 If interstage condensate traps are provided by the compressor manufacturer, they shall be plumbed to a common automatic drain system.

21-3.6 Compressor Controls.

21-3.6.1 All compressors shall have switches that activate audible and visual alarms, shut down the compressor, and prevent automatic restart when any of the following conditions occur:

(a) Low oil level or low oil pressure;

(b) Discharge air temperature is higher than recommended by the manufacturer;

(c) Moisture in the compressed air at the purification system outlet exceeds 24 ppm;

(d) Carbon monoxide level within the processed air exceeds 10 ppm.

21-3.6.2 All compressors shall be equipped with:

(a) An air pressure switch that controls the maximum operating pressure;

(b) Interstage pressure gauges after each compression stage;

(c) Final stage pressure gauge;

(d) An oil pressure gauge on pressure lubricated compressors or an oil level indicator or device on nonpressure oil-type compressors;

(e) An electric, nonresettable hourmeter(s).

21-3.6.3 Compressors with electric motors shall be equipped with:

(a) Magnetic motor starter with motor overload protection;

(b) Protective control to prevent automatic restart after power loss has been restored.

21-3.6.4 Compressors with gasoline and diesel engines shall be equipped with:

(a) A means to allow the engine to be started, idled, and run with the compressor disengaged or unloaded;

(b) An electric, nonresettable hour meter to record engine operating hours.

21-3.7 The compressor and driver assembly shall be mounted to a subassembly with shock mounts to provide vibration-dampening. The compressor frame shall have provision for safe handling or lifting. Frames for compressors with vee belt drives shall include a means to adjust the vee belt tension.

21-3.8 The air compressor shall have a standard nameplate, securely affixed in a conspicuous location, showing the name and address of the manufacturer, serial number and model number, the date of manufacture, and the rated capacity.

21-4 Purification System. If the compressed air system is to supply breathing air, a purification system that meets the requirements of 21-4.1 through 21-4.7 shall be installed.

21-4.1 If the processed air is to be used for fire fighting, the purification system shall produce breathing air that meets the requirements of Grade D breathing air as specified by CGA G-7.1, *Commodity Specification for Air*, and NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*.

21-4.2 If the processed air 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*.

21-4.3 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. The purification system shall be equipped with purifier cartridges and filter elements. The design of the purification system shall permit replacement of the mechanical separator filter and the purifier cartridges without disconnecting piping or other components.

21-4.4 A relief valve shall be provided in the purification system, set no higher than 10 percent above the maximum allowable working pressure.

21-4.5 A mechanical separator shall be provided and shall be piped to the automatic drain system. A check valve shall be installed between the mechanical separator and the remainder of the purification system.

21-4.6 The mechanical separator and the purifier housings shall be designed for a 3:1 safety factor at their maximum allowable working pressure. The mechanical separator and the purifier housings shall be corrosion resistant or treated to resist corrosion. An upstream valve and pressure gauge shall be installed ahead of the purifier to control and monitor depressurization before service.

21-4.7 A pressure regulator valve (back pressure regulator or minimum pressure valve) with a minimum setting of 2000 psi (13,790 kPa) shall be installed in the purification system downstream of the mechanical separator and purifier housings. A piping connection shall be provided downstream of the pressure regulator valve to provide an air sample for the air quality monitors. A line valve shall be installed on the purifier outlet to isolate the purifier from the remainder of the system during inspection, maintenance, and repairs.

21-5 Air Storage Systems.

21-5.1 Air tanks (DOT tanks or ASME pressure vessels) shall comply with Title 29, *Code of Federal Regulations* (CFR), paragraph 1910.169, "Air Receivers."

21-5.2 Transportable air tanks shall comply with Title 49, *Code of Federal Regulations* (CFR), paragraph 178.37, or Title 29, *Code of Federal Regulations* (CFR), paragraph 1910.169. Relief valves shall be furnished in compliance with ASME *Boiler and Pressure Vessel Code*, Section VIII.

21-5.3 Valves installed on air tanks shall meet the requirements of the Compressed Gas Association regarding pressure and usage with compressed air.

21-5.4 Air tanks shall be permanently stamped or identified in accordance with DOT or ASME regulations.

21-5.5 The manufacturer's test date (month and year) identified on each air tank shall be current within 12 months of the apparatus delivery date.

21-5.6 Air tanks shall be clearly marked "High Pressure _____ PSI Breathing Air."

21-5.7 Air Tank Mounting.

21-5.7.1 Air tanks shall be securely mounted in an arrangement that will hold the tanks in all types of mobile use, including rough roads and terrain. 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. The protective device(s) shall not prevent access for operation and inspection.

21-5.7.2 The air tank mounting shall facilitate removal of air tanks for inspection, testing, or service. Under no circumstances is an air tank to be located in an inaccessible location. Air tanks shall be so installed that all openings and associated piping are accessible. Air tanks shall be supported with sufficient clearance to permit a complete inspection of external surfaces. The air tank location shall be away from any heat-producing devices such as the generator engine or exhaust.

21-5.8 Air Tank Valve Control and Monitoring.

21-5.8.1 A valve(s) shall be provided to control airflow into and out of the storage system (if applicable).

21-5.8.2 A separate inlet connection shall be provided to permit refilling the storage system from a remote source. 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 chain and "pin hole" to release leaking pressure when not in use. A check valve or a line valve shall be provided on the inlet connection.

21-5.8.3 Gauges shall be provided for monitoring pressures from the air storage system or individual air tanks specified by the authority having jurisdiction.

21-6* Air Booster Systems.

21-6.1 Line valves shall be provided at the air control panel or on air booster to control the booster inlet air supply line and the booster discharge airflow. A pressure gauge shall be provided on the supply line and the discharge line from the booster.

21-6.2 A safety valve or high pressure switch shall be installed on the discharge side of the air booster. The pressure setting on this valve or switch shall not exceed the maximum allowable working pressure of the booster, the booster's distribution piping, or the air system components.

21-7 Air Supply Regulation.

21-7.1* The following arrangement shall be provided at any location in the air system where the air pressure is over 300 psig (2068 kPag) and it is necessary to regulate the air pressure.

(a) One air pressure gauge marked "Supply Pressure" between the air supply line valve and the pressure regulator;

(b) One slow operating air supply valve on the intake supply line;

(c) One adjustable pressure regulator equipped with a device to prevent inadvertent or accidental adjustment;

(d) One air pressure gauge downstream of the pressure regulator;

(e) One pressure relief valve preset at not over 10 percent above the pressure regulator output setting;

(f) A warning label shall be installed next to the pressure regulator to indicate the setting of the relief valve.

21-7.2 Controls and instruments shall be located on an air control panel.

21-7.3 A label that warns against setting the regulator to an excessive pressure shall be installed adjacent to any hand-adjustable regulator.

21-8 Air Control Panel.

21-8.1 The air control panel and system piping arrangement for a compressor supplied breathing air system shall allow the operator to perform the following functions:

(a) Fill the storage system directly from the compressor/purification system.

(b) Fill SCBA cylinders directly from the compressor/purification system.

(c) Fill SCBA cylinders directly from the storage system/air booster.

(d) Utilize the "cascade method" or "bulk fill method" of filling SCBA cylinders, as desired.

(e) By-pass filling of the storage system to "top-off" SCBAs directly from the compressor/purification system.

(f) Regulate the maximum SCBA fill pressure.

(g) Meter airflow to control the SCBA fill rate.

(h) Take an air sample to check air quality (at panel or at end of air reel hose, if applicable).

21-8.2 The air control panel and system piping arrangement for a cascade system shall allow the operator to perform the following functions:

(a) Fill the storage system directly from a remote air compressor.

(b) Fill SCBA cylinders directly from a remote air compressor.

(c) Fill SCBA cylinders directly from the storage system/air booster.

(d) Utilize the "cascade method" of filling SCBA cylinders.

(e) Regulate the maximum SCBA fill pressure.

(f) Meter airflow to control the SCBA fill rate.

(g) Take an air sample to check air quality (at panel or at end of air reel hose, if applicable).

21-8.3 Gauges, valves, and other controls shall be marked to indicate their use, normal pressure, and operating instructions.

21-9 SCBA Fill Station.

21-9.1 An area shall be provided to retain SCBA cylinders during refilling. If a fragmentation tube is provided, it shall be designed to direct all material away from operator in the event of a cylinder failure.

21-9.2 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. A valve(s) on a fill line(s) shall be a slow operating valve. The SCBA fill hose shall have a retaining device on the system to prevent injury to the operator if the fill valve is opened when the fill line is not connected to a cylinder.

21-9.3 A separate bleeder and flow restriction device shall be provided on each SCBA fill hose.

21-10 Air Hose Reels.

21-10.1* 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 3 to 1.

21-10.2 The air 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 3 to 1.

21-10.3 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).

21-10.4 The air hose reel shall have a minimum of 1/2 in. (13 mm) I.D. fluid path with a full flow style swivel joint and an appropriate hose connection sized to match the intended hose size.

21-10.5 The reel shall be labeled for its intended use and indicate the following:

(a) Utility air or breathing air;
(b) Operating pressure;
(c) Total hose length;
(d) Hose size (ID).

21-10.6 Air Supply to Air Reel.

21-10.6.1 The following equipment shall be provided on the intake air supply line to the reel where the air supply pressure is up to 150 psig (1034 kPag):

(a) One air pressure gauge;
(b) One slow operating air supply valve;
(c) One check valve.

21-10.6.2 The following equipment shall be provided on the intake air supply line to the reel where the air supply pressure is between 151 psig (1041 kPag) and 300 psig (2068 kPag):

(a) One air pressure gauge upstream of the air pressure regulating device;
(b) One slow operating air supply valve;
(c) One adjustable pressure regulator equipped with a device to prevent inadvertent or accidental adjustment;
(d) One downstream pressure gauge [0 psi to 500 psi (0 kPa to 3448 kPa) range].

21-10.6.3 The following equipment shall be provided on the intake air supply line to the reel where the air supply pressure is over 300 psig (2068 kPag):

(a) One air pressure gauge upstream of the air pressure regulating device;
(b) One slow operating air supply valve;
(c) One adjustable pressure regulator equipped with a device to prevent inadvertent or accidental adjustment;
(d) One downstream pressure gauge;
(e) One preset pressure relief valve set at not over 10 percent above maximum working pressure.

21-10.7 The inlet to an air hose reel with an operating pressure of over 300 psig (2068 kPag) shall have a flow limiting device, such as a velocity type valve, or a manually adjustable orifice type valve. The device shall be adjusted to restrict excessive flow and located or covered to prevent readjustment. The metering device shall not be used for normal shutoff valve purposes.

21-10.8 The final assembler of the air hose reel assembly and installation shall test the completed system to determine the actual airflow (cfm), air pressure (psi), and duration at the noted pressure and airflow. A permanent label shall be installed adjacent to the air reel controls to indicate the maximum airflow (cfm), air pressure range (psi), and duration.

21-10.9 Air Reel Installation.

21-10.9.1 Reels installed in concealed locations shall be easily accessible for maintenance and servicing, hose access, and reel removal.

21-10.9.2 The hose reel spool area shall be visible to the rewind operator.

21-10.9.3 Rollers and guides shall be installed, where necessary to prevent damage to the hose at the reel spool or compartment openings, and to allow easy deployment and rewinding of the hose.

21-10.9.4 Reels shall be installed in such a manner as not to expose the operator to the rewind components.

21-10.9.5 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.

21-10.9.6 Switches for power rewind type reels shall be located in a position that allows the operator to safely rewind the hose. The rewind control shall be not over 72 in. (1830 mm) above the operator's standing position. The rewind control shall be labeled for function and suitably guarded to prevent accidental activation.

21-10.10* Low Pressure Breathing Air Reel.

21-10.10.1 The regulation of the output pressure from the breathing air reel shall be at the reel or at an air control panel.

21-10.10.2 No shutoff valves or flow control valves shall be installed downstream of the pressure regulator except at the end of the hose.

21-10.10.3 The low pressure breathing air supply shall be equipped with a low air pressure audible warning device on the air supply.

21-11 Air Hose.

21-11.1* All air hose and couplings shall be certified by the hose manufacturer for its intended use 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 to 1.

21-11.2 Where the hose is attached to an air reel, it shall be done in a manner that allows for its removal.

21-11.3 The discharge end of any high pressure breathing air hose shall have a slow operating valve with a right-hand female thread appropriate for the air cylinders to be refilled

and a removable threaded dust plug attached with a chain. The discharge end of other types of air hose shall have a slow operating valve and a threaded connection or a quick disconnect type connection.

21-11.4 The ends of the hose shall be color coded or labeled to designate the operating pressure of the hose. If color coding is used, coding shall be as follows:

Blue — utility air hose up to 300 psig (2068 kPag);
White — breathing air hose up to 300 psig (2068 kPag);
Yellow — breathing air hose from 301 psig to 3000 psig (2075 kPag to 20 685 kPag);
Red — breathing air hose over 3000 psig (20 685 kPag).

21-11.5 Low pressure breathing air hose shall be a minimum 1/4 in. (6 mm) inside diameter with a maximum hose length of not more than 300 ft (91 m).

21-11.6 Utility air hose shall be of a flexible type, with a scuff abrasion-resistant outer covering. The hose shall be oil resistant and shall be compatible with oil, alkalis, kerosene, paraffin, grease, and salt solutions.

21-11.7 The hose connections for utility air hose shall not be the same as for low pressure breathing air hose or high pressure air hose.

21-12* Low Pressure Utility Air Supply. Where the air reel or air outlets 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.

21-13 Remote Breathing Air Systems. Remote breathing air systems for aerial ladders, elevating platforms, pump panels, or other remote locations shall comply with 21-13.1 through 21-13.7.

21-13.1 A breathing air system shall be designed to supply breathing air for a minimum of two personnel at the specified location.

21-13.2 The system shall include storage for at least 400 ft^3 (11.3 m^3) of breathing air. The cylinder(s) shall be manufactured, installed, and used in accordance with the U.S. Department of Transportation (DOT) requirements as defined in Title 49, *Code of Federal Regulations*, Section 178, Subpart C.

21-13.3 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. The piping system shall be arranged with a high pressure regulator at the air supply that shall limit the air pressure in the piping to that required to produce 125 psig (862 kPag) at the outlet point. All piping, valves, and components shall be fabricated of corrosion-resistant materials and shall be sized to ensure an adequate supply at the point of use. A pressure relief valve set to relieve the pressure at 1 1/2 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.

21-13.4 All valves, pressure regulators, and gauges shall be protected from accidental damage. The piping or hose system between the air cylinder(s) and point of use shall be installed to prevent damage due to abrasion, bending, or pinching.

21-13.5 Suitable holders shall be provided for the storage of the breathing air equipment when it is not in use.

21-13.6 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. On aerial devices, this shall be provided at both the upper and lower control stations.

21-13.7 The contractor shall deliver the apparatus with air at least 100 psig (690 kPag) of breathing air in the system.

21-14* Testing. The complete system shall be tested by the installer. Test results shall be submitted to purchaser at the time of delivery.

21-14.1 If the air system includes a compressor, the system shall be tested to ensure it meets or exceeds the requirements for air quality and output.

21-14.2 If the air system has an air purification component, the discharge air shall be tested to ensure it is of the proper grade and that the following contaminants are within acceptable levels:

(a) Carbon monoxide;
(b) Carbon dioxide;
(c) Moisture;
(d) Oil;
(e) Odor.

Chapter 22 Winches

22-1 General. If a chassis mounted winch is installed on the apparatus, it shall meet the requirements of this chapter and SAE J706, *Rating of Winches*.

22-2 Rating.

22-2.1* The winch shall have a minimum single line pull rating of 6000 lb (26.7 kN).

22-2.2 The winch shall have a minimum wire rope length of 100 ft (30 m). The wire rope shall be of a type and size recommended by the winch manufacturer. The wire rope assembly, including all hardware such as clevises, hooks, and snatch blocks provided for attachment to the winch, shall have a breaking strength greater than the line pull capacity of the winch.

22-3 Electric Powered Winches.

22-3.1 Controls.

22-3.1.1* Control of the electric motor shall be by means of a handheld switch with forward, neutral and reverse positions. The switch shall be located at the end of a minimum 25 ft (7.6 m) electrical cord that plugs into a receptacle near the winch location. Alternately, the switch shall be permitted to be located on a handheld transmitter of a Federal Communications Commission approved radio frequency winch control device.

22-3.1.2 A free-spooling clutch shall be provided in addition to the remote-control device if the winch is not visible to the operator.

22-3.2 Power Supply. Dedicated power and ground circuits shall be utilized. Wiring shall be sized in accordance with the manufacturer's installation instructions and 9-2.1 of this standard.

22-4 Hydraulic Winches.

22-4.1 All hydraulic hoses shall be designed for hydraulic pressures encountered for the specified hydraulic components. Hoses shall be wire-braided type, with a female swivel on one end.

22-4.2 Hydraulic Tanks.

22-4.2.1 The hydraulic fluid tank shall be of sufficient size to prevent overheating of the fluid or cavitation of the hydraulic pump at its maximum output level.

22-4.2.2 The tank shall permit visual checking of the fluid level and easy refilling. The fill point shall have a label permanently attached near the fill point stating the hydraulic oil quantity and type.

22-4.2.3 A drain plug shall be installed to permit complete draining of the tank.

22-4.2.4 A tank return line diffuser shall be installed in the tank. A tank swash partition shall be installed in the tank between the suction and return lines.

22-4.2.5 A vent shall be supplied and shall be designed to prevent dirt and moisture from entering the tank.

22-4.3 The system shall be equipped with necessary filters and strainers to keep the hydraulic fluid within the cleanliness requirements necessary for good operation of the hydraulic system.

22-4.4* The winch shall be equipped with clutch assembly to permit free-spooling and quick removal of cable. This control shall be easily accessible, without reaching under the apparatus. If the winch is installed under the vehicle, it shall be remotely controlled.

22-4.5 Driving Compartment Controls.

22-4.5.1 The hydraulic pump engagement controls shall be located in the driving compartment and shall be labeled as to their purpose and use.

22-4.5.2 A red light shall be installed in the driving compartment to indicate when the winch drive system is engaged.

Chapter 23 Referenced Publications

23-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

23-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1992 edition.

NFPA 1914, *Standard for Testing Fire Department Aerial Devices*, 1991 edition.

NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*, 1994 edition.

NFPA 1961, *Standard for Fire Hose*, 1992 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1993 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, 1992 edition.

NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components*, 1995 edition.

23-1.2 Other Publications.

23-1.2.1 ANSI Publication. American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI Z535.4, *Product Safety Signs and Labels*, 1991.

23-1.2.2 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME *Boiler and Pressure Vessel Code*, Section VIII, Division 1 and Division 2, 1995.

ASME B40.1, *Gauges — Pressure Indicating Dial Type — Elastic Element*, 1991.

23-1.2.3 ASNT Publication. American Society for Nondestructive Testing, Inc., 4153 Arlingate Plaza, Columbus, OH 43228.

ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel*, 1991.

23-1.2.4 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B 647, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gauge*, 1984.

ASTM B 648, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor*, 1978.

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

ASTM E 6, *Standard Terminology Relating to Methods of Mechanical Testing*, 1989.

ASTM E 10, *Standard Test Method for Brinell Hardness of Metallic Materials*, 1993.

ASTM E 18, *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*, 1994.

ASTM E 92, *Standard Test Method for Vickers Hardness of Metallic Materials*, 1982.

ASTM E 114, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method*, 1995.

ASTM E 165, *Standard Test Method for Liquid Penetrant Examinations*, 1995.

ASTM E 569, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation*, 1985.

ASTM E 650, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*, 1985.

ASTM E 709, *Standard Guide for Magnetic Particle Examination*, 1995.

ASTM E 797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*, 1994.

ASTM E 1004, *Standard Test Method for Electromagnetic (Eddy-Current) Measurements of Electrical Conductivity*, 1991.

ASTM E 1032, *Standard Method for Radiographic Examination of Weldments*, 1992.

23-1.2.5 AWS Publications. American Welding Society, Inc., 550 N.W. Lejunne Road, P.O. Box 351040, Miami, FL 33135.

AWS B1.10, *Guide for Nondestructive Inspection of Welds*, 1986.

AWS D1.1, *Structural Welding Code — Steel*, 1994.

AWS D1.2, *Structural Welding Code — Aluminum*, 1990.

AWS D1.3, *Structural Welding Code — Sheet Steel*, 1989.

23-1.2.6 Compressed Gas Association Publications. Crystal Gateway 1, Suite 501, 1235 Jefferson Davis Highway, Arlington, VA 22202.

G-7, *Compressed Air For Human Respiration*, 1990.

G-7.1, *Commodity Specification for Air*, 1989.

23-1.2.7 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J156, *Fusible Links*, 1994.

SAE J348, *Standard for Wheel Chocks*, 1990.

SAE J541, *Voltage Drop for Starting Motor Circuits*, 1989.

SAE J551, *Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHZ)*, 1990.

SAE J553, *Circuit Breakers*, 1992.

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

SAE J575, *Test Methods and Equipment for Lighting Devices and Components for Use on Vehicles Less than 2032 mm in Overall Width*, 1992.

SAE J578, *Color Specification*, 1995.

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

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

SAE J690, *Certificates of Maximum Net Horsepower for Motor Trucks and Truck Tractors*, 1965.

SAE J706, *Rating of Winches*, 1990.

SAE J833, *Human Physical Dimensions*, 1989.

SAE J845, *360 Degree Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles*, 1992.

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

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

SAE J1127, *Battery Cable*, 1995.

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

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

SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, 1986.

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

SAE J1517, *Driver Selected Seat Position*, 1990.

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

SAE J1849, *Emergency Vehicle Sirens*, 1989.

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

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

23-1.2.8 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 62, *Standard for Safety Flexible Cord and Fixture Wire*, 1991.

UL 498, *Standard for Safety Attachment Plugs and Receptacles*, 1991.

23-1.2.9 U.S. Government Publications. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

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

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

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

No. 121, *Air brake systems.*

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

No. 209, *Seat belt assemblies.*

No. 210, *Seat belt assembly anchorages.*

No. 302, *Flammability of interior materials.*

Title 49, *Code of Federal Regulations*, Part 178C, "Specifications for Cylinders."

Title 49, *Code of Federal Regulations* , 178.37, Specification 3AA, "Seamless Steel Cylinders Made of Definitely Prescribed Steels"; or 3AAX, "Seamless Steel Cylinders Made of Definitely Prescribed Steels of Capacity Over 1000 Pounds of Water Volume."

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

23-1.2.10 TRA Publication. The Tire and Rim Association, Inc., 3200 West Market Street, Akron, OH 44313.

TRA *Yearbook*.

Appendix A Explanatory Material

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

A-1-1 The term "new" as applied in this standard is intended to refer to the original construction of a fire apparatus. It is not intended that this standard be applied retroactively to existing apparatus. However, if major renovations are made to an existing piece of apparatus, it is suggested that the apparatus be brought into line with this standard as closely as possible.

A-1-3 The purchase of new fire apparatus involves a major investment and should be treated as such. Fire apparatus are complex mechanical equipment that should not be purchased in a haphazard manner. A purchase should be made only after a detailed study of the fire department's apparatus needs, taking into consideration other equipment the department owns or plans to buy.

The local fire chief and fire department staff know the conditions under which the apparatus will be used. However, competent advice should also be obtained from knowledgeable and informed sources such as other experienced fire service personnel, trade journals, training instructors, maintenance personnel, and fire equipment and component manufacturers. The fire insurance rating authority should also be consulted.

The study should look not only at current operations and risks protected but also at how these might change over the life of the fire apparatus.

Writing the Specifications. This standard provides the minimum technical requirements that new fire apparatus are expected to meet. It is recognized that many purchasers will desire additional features of operation over and above these minimum requirements. The requirements in this standard, together with the appendix material, should be carefully studied. Details, such as anywhere that the apparatus being specified must exceed the minimum requirements or where a specific arrangement is desired, should be carefully defined in the specifications for the apparatus. This might include special performance requirements, defining the number of seats and the seating arrangement for fire fighters riding on the apparatus, or the provision of space for extra hose or equipment the apparatus will be required to carry.

The first consideration in the design of a fire apparatus are the "fixed equipment" components. These major "support function" components could represent the concentrated and heaviest load elements of the vehicle. It is vital these elements be laid out in the early initial designs and situated on the vehicle to provide for the following:

(a) Good load distribution;

(b) Balance (both front to rear, and right to left);

(c) Low center of gravity.

These fixed components could be located in exterior compartments or the interior of the vehicle to be "functional" and organized in a layout to be "user friendly" in emergency applications. Specifically, the following fixed equipment are examples of this:

(a) Electrical generators;

(b) Water tanks, fire pumps, and other fire-fighting equipment;

(c) Air cascade or compressors;

(d) Reels of all types.

A major support function of any fire apparatus, no matter the type, is the "portable equipment." This is why this document places so much emphasis on final GVWR and carrying capacity of the completed vehicle, which includes both fixed and portable equipment.

The listings of portable and fixed equipment is so variable, depending upon the mission of the vehicle, the fire department must measure and weigh their "specific" equipment.

The fire department should classify the equipment as follows:

(a) "Existing" equipment to be carried;

(b) "Proposed" new equipment to be carried;

(c) "Future expansion" equipment that might be carried in the future.

In this way, an adequate GVWR of the chassis can be provided to ensure the vehicle will not be overloaded in the future.

After determining the list of present, proposed, and future portable equipment, the fire department should analyze the "actual" cubic foot space necessary for the portable equipment. The following factors that will increase required cubic foot of storage and size of body should be considered:

(a) Compartment door and box pan interference;

(b) Mounting implications;

(c) Compartment shelving;

(d) Slide trays;

(e) Components of body as compartment flanges, notches, and other interferences that affect removal of equipment from body;

(f) Ventilation of generator, air compressor, or other equipment.

The actual usable space in compartments also should be considered, in addition to the individual cubic feet for each item of equipment to be carried.

Where local operating conditions necessitate apparatus of unusual design, the purchaser needs to define carefully the special requirements in the specifications. Height, width, under-vehicle clearance, wheel base, turning radius, length, etc., might occasionally need special attention. For example, a community with many narrow, winding streets should have apparatus capable of readily negotiating switchbacks without delay.

This standard is designed to ensure sound equipment that is capable of good performance, with inclusion of restrictive features only where needed to specify minimum requirements. The tests are an important feature and the results should be carefully analyzed to ensure that the completed apparatus meets the specified performance.

Since the passage of Public Law 89-563, the National Traffic and Motor Vehicle Safety Act of 1966, the federal government has adopted certain motor vehicle safety standards applicable to all manufacturers of trucks, including fire apparatus. It is unlawful for a manufacturer to deliver a truck not in compliance with these federal standards. These federal safety standards are frequently changed, and their provisions make the incorporation of certain features and devices mandatory. Apparatus manufacturers face substantial penalties for infraction of these rules and, therefore, cannot build to specifications that would require them to perform unlawfully or to delete required items or to include any that are illegal.

Additional requirements are placed on both apparatus and engine manufacturers by the Clean Air Act, which is enforced by the Environmental Protection Agency. These EPA standards have resulted in major changes in the performance of many engines. Neither the engine manufacturer nor the apparatus manufacturer are permitted to modify engines once they are certified to EPA standards. Because of the EPA standards, it is often necessary to install larger engines than might have been previously used in order to obtain the same apparatus performance.

Many apparatus purchasers find it desirable to provide for an interim inspection at the apparatus assembly plant. The advantages of such a provision include the opportunity to evaluate construction prior to final assembly and painting. The specifications should detail the particulars of such an inspection trip.

The chief of the fire department (or a designated representative) normally exercises the acceptance authority following satisfactory completion of tests and inspections for compliance with purchase specifications. The specifications should provide details of delivery expectations, including the desired training, the required acceptance tests, and who is responsible for the various costs associated with the delivery and acceptance.

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

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

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

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

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

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

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

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

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

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

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

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

Before signing a contract, the purchaser should make certain that the successful bidder has a complete and thorough understanding of the specifications. If there are any disagreements, these should be resolved in writing and made part of the contract. If any changes are agreed upon, they

should be stated in writing and be signed by both parties. The contract should not be signed until the fire chief (or a designee) and the purchasing authority are satisfied.

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

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

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

A-1-5 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-5 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-5 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-5 Net Pump Pressure. Where operating from a hydrant, the net pump pressure is typically less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psig (1034 kPag) and the intake (suction) gauge reads 20 psig (138 kPag), the net pump pressure equals 130 psi (896 kPa). Where operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge reads 145 psig (1000 kPag) and the intake (suction) gauge reads 10 in. of mercury (Hg) (34 kPag) vacuum, the net pump pressure will be 150 psi (1034 kPa) (1 in. Hg = 0.5 psi = 3.38 kPa).

A-2-5.1 The engine compartment and the underside of the vehicle are not considered areas of normal nonmaintenance operation.

A-2-8.2 The distribution of the weight between the front and rear wheels should be a major consideration, as improper design will seriously affect the handling characteristics of the vehicle. Too little weight on the front wheels can cause a front-end skid and, over bumpy roads, could cause the front of the vehicle to veer from side to side. At the very least, it will be difficult to keep the vehicle under control. Too much weight on the front wheels will reduce the traction of the rear wheels and may result in a rear-end skid or difficulty in traveling over unpaved roads or in mud.

A-2-9 The temperature conditions, either hot or cold, within which the vehicle will be used or stored should be considered in the design of the vehicle. If the vehicle 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 unit is to be used or stored in subfreezing conditions, special system drains, engine heaters, or other special components might be required to prevent damage or to allow continued use.

A-2-9.1 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 (610 m), the manufacturer needs to know the operating elevation to provide an engine that will deliver proper performance. (*See Section 1-3.*)

A-2-9.2 Although the purchaser must specify grades in excess of 6 percent (*see Section 1-3*), 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 than prolonged stationary operations. Apparatus might require special lubrication systems for engines and other modification to ensure the apparatus will not be damaged by operation on the increased grades.

A-2-10(b) Although this standard recognizes the need for the vehicle to be able to accelerate to high speed while traveling on public roads, caution should be taken as to how fast the vehicle will travel. Consideration should be given to limiting the maximum speed the vehicle can obtain for safety.

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

A-2-10(c) The purchaser should specify the performance required on grades in excess of 6 percent. The occasional exposure to excessive grades is different than if it is 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 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-2-11.1 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-2-11.5 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 pass along these documents to the purchaser. The purchaser should specify if multiple copies of these documents are required.

A-2-13 Where the point of delivery is over 2000 ft (610 m) of elevation and a fire pump is provided, the pumping engine overload test described in 12-13.3 should be performed to ensure that the engine will develop adequate power at point of delivery. This test should be performed with the pump supplied from draft per Table 12-2.4.1(a), with the net pressure maintained at 165 psi (1138 kPa).

A-3-5 Additional compartmentation might be required to accommodate the size, shape, and weight of special equipment. Any special equipment to be carried on the apparatus should be identified in the specifications so the apparatus manufacturer can ensure the equipment will be properly accommodated within the design of the apparatus.

A-3-6 The purchaser should consider specifying some type of cover for the hose compartment. Hinged or removable covers might be desirable.

A-3-7.1 Where there are no ladder trucks in service, pumpers should normally be equipped with a 35-ft (10.7-m) extension ladder instead of the minimum 24-ft (7.3-m) extension ladder. It might be desirable to standardize on the 35-ft (10.7-m) extension ladder, regardless of available ladder truck service.

A-3-7.2 The size of the suction hose specified in Table 12-2.4.1(a) relates to pump certification only. Other sizes of suction hose, compatible with local operations, could be used and should be specified if they are desired.

A-3-8.1 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 (61 m) of 2½-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 2½-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 departments needs.

A-3-8.2 The requirements of service in different communities will necessitate additions to the equipment required. The operational objective is to arrive at the scene of the emergency with the necessary equipment for immediate life safety operations and emergency control.

The mandatory equipment required to be carried on the pumper fire apparatus weighs approximately 600 lb (272 kg). This leaves a remaining capacity of approximately 1400 lb (635 kg) for storage of optional equipment while staying within the allowance of 2000 lb (908 kg). The purchaser should advise the contractor if equipment in excess of 2000 lb (908 kg) is to be carried so the contractor can provide a chassis of sufficient size. (*See Sections 1-3 and 8-1.*)

The following list of additional equipment is recommended to be carried on pumper fire apparatus. The equipment list provided does not detail each item sufficiently for purchasing purpose. The purchaser should clarify the detailed specifications for these items.

One fire service claw tool;

One smoke ejector, 5000 ft^3/min (142 m^3/min) minimum capacity. If electrically driven, suitable adapter cord should be supplied to fit standard house "U" ground outlets and extension cords and outlets on generators used in fire departments;

One crowbar [36 in. (1 m) minimum] with brackets;

One pair insulated bolt cutters with 7/16-in. (11-mm) minimum cut;

One Halligan-type tool with brackets;

One 2½-in. (65-mm) hydrant valve (screw-type gate);

One double-gated reducing leader wye, sized to fit hose used in department;

Two shovels (1 pointed and 1 scoop);

Four hose straps;

One 125-ft (38-m) length of utility rope having a breaking strength of at least 5000 lb (2268 kg);

One 3000-W (minimum) portable generator;

Two 500-W portable lights;

Two cord reels with minimum 200-ft (61-m) cord on each, connections compatible with lights, generator, and smoke ejector;

One portable pump;

Toolbox with hammers, wrenches, screwdrivers, and other assorted tools;

Master stream appliance; 1000 gpm (3785 L/min) minimum;

Foam delivery equipment compatible with onboard foam system;

One hose clamp.

A-4-4 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.

A-4-5 It should be recognized that apparatus of 500 gpm (1900 L/min) rated pump capacity or more normally require more than 300 ft (91 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 (91-m) load provides only 150-ft (46-m) lines from the two outlets of a 500-gpm (1900-L/min) apparatus. Experience has shown that, with large capacity pumps, 600 ft to 1000 ft (183 m to 305 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 (1900 L/min).

The purchaser should consider specifying some type of cover for the hose compartment. Hinged or removable covers might be desirable.

A-4-6.2 The size of the suction hose specified in Table 12-2.4.1(a) relates to pump certification only. Other sizes of

suction hose, compatible with local operations, could be used and should be specified if they are desired.

A-4-7.2 The requirements of service in different communities will necessitate additions to the equipment required. The operational objective is to arrive at the scene of the emergency with the necessary equipment for immediate life safety operations and emergency control.

The mandatory equipment required to be carried on the initial attack fire apparatus weighs approximately 350 lb (159 kg). This leaves a remaining capacity of approximately 550 lb (249 kg) for storage of optional equipment while staying within the allowance of 900 lb (408 kg) for the smallest GVWR chassis. The purchaser should advise the contractor if equipment in excess of the allowance in Table 8-1 is to be carried so the contractor can provide a chassis of sufficient size. (*See Sections 1-3 and 8-1.*)

The following list of additional equipment is recommended to be carried on initial attack fire apparatus. The equipment list provided does not detail each item sufficiently for purchasing purpose. The purchaser should clarify the detailed specifications for these items.

One 6-lb (2.7-kg) flathead axe;
One fire service claw tool;
One 8-ft (2.4-m) or longer pike pole;
One smoke ejector, 5000 ft^3/min (142 m^3/min) minimum capacity. If electrically driven, suitable adapter cord should be supplied to fit standard house "U" ground outlets and extension cords and outlets on generators used in fire departments;
One 10-ft (3-m) folding ladder and mounting brackets; The ladder should meet the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*;
One crowbar [36 in. (1 m) minimum] with brackets;
One pair insulated bolt cutters with $^7/_{16}$-in. (11-mm) minimum cut;
One Halligan-type tool with brackets;
One $2^1/_2$-in. (65-mm) hydrant valve (screw-type gate);
Two shovels (1 pointed and 1 scoop);
Two hose straps;
One 125-ft (38-m) length of utility rope having a breaking strength of at least 5000 lb (2268 kg);
One 3000-W (minimum) portable generator;
Two 500-W portable lights;
Two cord reels with minimum 200-ft (61-m) cord on each, connections compatible with lights, generator, and smoke ejector;
Toolbox with hammers, wrenches, screwdrivers, and other assorted tools;
Foam delivery equipment compatible with onboard foam system;
One hose clamp.

A-5-4 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.

A-5-5.1 The purchaser might want to specify the location and the arrangement of the hose storage area to allow carrying the hose preconnected to the tank inlet.

The purchaser should consider specifying some type of cover for the hose compartment. Hinged or removable covers might be desirable.

A-5-6 The size of the suction hose specified in Table 12-2.4.1(a) relates to pump certification only. Other sizes of suction hose, compatible with local operations, could be used and should be specified if they are desired.

A-5-6.1 It might be desirable to use other than screw couplings with mobile water supply apparatus operations. Several types of quick connect couplings are available. If such couplings are used, sufficient adapters should be specified by the purchaser. If a floating or low level-type strainer is desired, it should be specified by the purchaser to fit the suction hose normally used to draft from a portable tank.

A-5-7.1.2 The purpose of a mobile water supply apparatus does not include attack fire fighting. However, if a pump is provided, the provisions of handlines will allow limited fire-fighting capability, particularly in protecting the apparatus if this becomes necessary.

A-5-7.2.1 The requirements of service in different communities will necessitate additions to the equipment required. The operational objective is to arrive at the scene of the emergency with the necessary equipment for immediate life safety operations and emergency control.

The mandatory equipment required to be carried on the mobile water supply fire apparatus weighs approximately 700 lb (318 kg). This leaves a remaining capacity of approximately 300 lb (136 kg) for storage of optional equipment while staying within the allowance of 1000 lb (454 kg). The purchaser should advise the contractor if equipment in excess of 1000 lb (454 kg) is to be carried so the contractor can provide a chassis of sufficient size. (*See Sections 1-3 and 8-1.*)

The following list of additional equipment is recommended to be carried on mobile water supply apparatus. The equipment list provided does not detail each item sufficiently for purchasing purpose. The purchaser should clarify the detailed specifications for these items.

One fire service claw tool;
One crowbar [36 in. (1 m) minimum] with brackets;
One pair insulated bolt cutters with $^7/_{16}$-in. (11-mm) minimum cut;
One Halligan-type tool with brackets;
One $2^1/_2$-in. (65-mm) hydrant valve (screw-type gate);
Two shovels (pointed long handle);
Four hose straps;
One 125-ft (38-m) length of utility rope having a breaking strength of at least 5000 lb (2268 kg);
One portable pump;
One low level strainer for use with portable tanks;
Toolbox with hammers, wrenches, screwdrivers, and other assorted tools;
One 1500-gal (5678-L) minimum collapsible, portable tank;
One water transfer device to be used between portable tanks.

A-6-5 Additional compartmentation may 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 properly accommodate the equipment within the design of the apparatus.

A-6-6.1 If the aerial fire apparatus is to carry hose, the purchaser needs to specify the amount and size of hose to be carried, and any special requirements for the location in which it is to be carried.

A-6-7 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. This standard provides for only one 35-ft (10.7-m) and one 24-ft (7.3-m) extension ladder. 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. It should be recognized, however, that as requirements for additional ground ladders are added, space for other equipment can become limited.

A-6-8.1 Axes and pike poles are now available with wood, fiberglass, or plastic handles. The fire department should specify which material it desires the handle to be made of.

The requirements of service in different communities will necessitate additions to the equipment required. The operational objective is to arrive at the scene of the emergency with the necessary equipment for immediate life safety operations and emergency control.

The mandatory equipment required to be carried on the aerial fire apparatus weighs approximately 1000 lb (454 kg). This leaves a remaining capacity of approximately 1500 lb (681 kg) for storage of optional equipment while staying within the allowance of 2500 lb (1135 kg). The purchaser should advise the contractor if equipment in excess of 2500 lb (1135 kg) is to be carried so the contractor can provide a chassis of sufficient size. (*See Sections 1-3 and 8-1.*)

The following list of additional equipment is recommended to be carried on aerial fire apparatus. The equipment list provided does not detail each item sufficiently for purchasing purpose. The purchaser should clarify the detailed specifications for these items.

Three portable floodlights (500 W);
Two shovels (round point);
Two electric cord reels with 200 ft (61 m) of 12-gauge, 3-wire cable. Connectors should be compatible with lights, smoke ejectors, and onboard generators;
Three 2-wire to 3-wire adapters;
One smoke ejector, 5000 ft^3/min (142 m^3/min) minimum capacity. If electrically driven, suitable adapter cord should be supplied to fit standard house "U" ground outlets and extension cords and outlets on generators used in fire departments;
Two 10-ton (9072-kg) hydraulic jacks;
Two 20-ton (18 144-kg) hydraulic jacks;
One pair insulated wire cutters capable of cutting No. 6 gauge wire;
Four additional salvage covers, at least 12 ft × 18 ft (3.6 m × 5.5 m);
Two floor runners, at least 3 ft × 18 ft (1 m × 5.5 m);
Four mops;
Four brooms;
Four squeegees with handles;
Two mop wringers, with buckets;
One roll 15-lb (6.8-kg) tar paper or plastic sheeting at least 8 mil thick;
Twelve (12) standard sprinkler heads (assorted temperatures and types);
Two claw hammers, each with assorted nails.
One heavy-duty stapler;
Six sprinkler stops or wedges;
One set of sprinkler head wrenches for the type of heads carried;
Two pairs safety goggles;
One power saw (chain or heavy-duty rotary type);
Four assorted hand saws;
One portable thermal cutting unit designed for cutting metal;
One rescue-type tool with extension rams and assorted lengths of chain;
One set air bags;
One deodorizer unit, power operated;
One water pickup vacuum;
Assorted rolls of tape (duct tape, electrical tape, cellophane tape, etc.);
One pneumatic rescue cushion;
One stokes basket;
One gas shutoff wrench;
One submersible-type pump;
Two pair lineman's gloves with leather glove protectors;
Four bale/mattress hooks;
Two four-tine forks;
Two blankets;
One block and tackle;
One life gun with ammunition;
One water shutoff wrench.

A-7-3 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.

A-7-4.2 The size of the suction hose specified in Table 12-2.4.1(a) relates to pump certification only. Other sizes of suction hose, compatible with local operations could be used and should be specified if they are desired.

A-7-5 The mandatory equipment required to be carried on a special service fire apparatus weighs approximately 200 lb (91 kg). This leaves a remaining capacity of approximately 1800 lb (817 kg) for storage of optional equipment while staying within the allowance of 2000 lb (908 kg) for the smallest GVWR chassis. The purchaser should advise the contractor if equipment in excess of the allowance in Table 8-1 is to be carried so the contractor can provide a chassis of sufficient size. (*See Sections 1-3 and 8-1.*)

Special service fire apparatus can be designed to provide a wide variety of support functions (rescue, command, hazardous material containment, air services, electrical generation and floodlighting, and transportation of support equipment and personnel). Because of this variety, the required list of equipment is minimal and the purchaser needs to review the functions and operations the apparatus will be expected to support and develop an appropriate equipment list.

Two lists below are provided for consideration where a vehicle is to support rescue operations and hazardous materials containment operations. The equipment lists provided do not detail each item sufficiently for purchasing purpose. Purchaser should clarify the detailed specifications for these items.

The equipment on the following list should be considered when deciding what to carry on a rescue apparatus.

500 ft (150 m) of plastic "emergency scene" or equal crowd control tape;
Forty-eight (48) 30-minute road flares;
Twelve (12) road hazards traffic control devices;
One 6-lb (2.7-kg) flathead axe;
One 6-lb (2.7-kg) pickhead axe;
One 6-ft (2-m) pike pole or plaster hook;
One 8-ft (2.4-m) or longer nonconductive pike pole;
One crowbar [36 in. (1 m) minimum] with brackets;
One pair insulated bolt cutters with $^{7}/_{16}$-in. (11-mm) minimum cut;
One Halligan-type tool with brackets;
Two shovels (1 pointed and 1 scoop);
Two 12-lb (5.4-kg) sledgehammers;
Two Class I life safety harnesses meeting the requirements of NFPA 1983, *Standard on Fire Service Life Safety Rope and System Components*;
150 ft (46 m) of two-person life safety rope meeting the requirements of NFPA 1983;
150 ft (46 m) of one-person life safety rope meeting the requirements of NFPA 1983;
One 150-ft (46-m) length of utility rope having a breaking strength of at least 5000 lb (2268 kg);

One box of tools to include the following:
One hacksaw with three blades,
One keyhole saw;
One 18-in. (457-mm) pipe wrench;
One hammer;
One pair tin snips;
One pair pliers;
One pair lineman's pliers;
Assorted types and sizes of screwdrivers;
Assorted adjustable wrenches;
Assorted combination wrenches;

Two salvage covers, each a minimum of 12 ft × 14 ft (3.7 m × 4.3 m);

One 4000-W (minimum) portable generator;

Two 500-W portable lights;

Two cord reels with minimum 125 ft (38 m) of 10-gauge, 3-wire cable on each with connections that are compatible with lights and generator;
One smoke ejector, 5000 ft^3/min (142 m^3/min) minimum capacity. If electrically driven, suitable adapter cord should be supplied to fit standard house "U" ground outlets and extension cords and outlets on generators used in fire departments;
Two 10-ton (9072-kg) hydraulic jacks;
Two 20-ton (18 144-kg) hydraulic jacks;
One roll 15-lb (6.8-kg) tar paper or plastic sheeting at least 8 mil thick;
Two pairs safety goggles;
One power saw (chain or heavy-duty rotary type);
Four assorted hand saws;
One portable cutting device;
Resuscitator equipment with oxygen administration capability and spare cylinders. The equipment should be compatible with the performance of cardiopulmonary resuscitation;
One powered rescue tool capable of cutting and spreading with associated accessory equipment;
Shoring of various sizes and lengths;
One 10-ft (3-m) and one 15-ft (4.5-m) log chain with hooks;
One minimum 4-ton (3629-kg) hydraulic porta-power kit;
One set air bags;
Assorted rolls of tape (duct tape, electrical tape, cellophane tape, etc.);
One stokes basket;
One gas shutoff wrench;
Two pair lineman's gloves with leather glove protectors;
Two blankets;
One block and tackle.

Equipment on the following list should be considered if the primary mission of the apparatus is hazardous material containment.

One U.S. DOT *Emergency Response Guidebook* (current edition);
One U.S. Coast Guard "CHRIS" manual or equivalent reference guide;
One American Association of Railroads/B.O.E *Emergency Action Guide* or equivalent reference guide;
One NFPA *Hazardous Materials Guide* or equivalent reference guide;
Two pairs of binoculars;
One gas detection instrument per OSHA standards;
One radiation monitoring instrument;
One pH test kit;
One colorometric chemical detector tube kit with 20-chemical minimum detection capability;
Six vapor-protective suits meeting the requirements of NFPA 1991, *Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies*;
Twelve (12) liquid splash-protective suits meeting the requirements of NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies*;
Twenty-four (24) pairs of disposable boot covers;
Twenty-four (24) pairs of disposable glove liners or inner gloves;
Forty-eight (48) pairs of disposable chemical protective gloves — gloves should be of three different materials as a minimum;
Six additional self-contained breathing apparatus complying with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters;*
One spare SCBA cylinder for each SCBA;
Ten traffic cones, 18 in. (0.5 m) minimum height;
Four rolls 1000-ft × 3-in. (305-m × 76-mm) banner tape;
Two rolls 6-mil minimum 10-ft × 100-ft (3-m × 31-m) plastic sheeting;
Two rolls 2-in. (51-mm) wide duct tape;
Two decontamination containment pools;
One decontamination shower;
Two 50-ft (15-m) lengths of heavy-duty garden hose with adapters for connection to a fire pump;
Two spray nozzles with garden hose thread;
Four 30-gal (114-L) open top containers, with sealed covers;
Four long handle scrub brushes;
Twenty 50-gal (190-L) capacity, heavy-duty garbage bags;
One assortment decontamination solution;
Four round point shovels;
Four portable explosionproof hand lights with mounting brackets;
Four non-spark, plastic, square point shovels;

One 6-lb (2.7-kg) flathead axe or forcible entry tool;
Two street brooms;
Two floor squeegees with handles;
One 6-lb (2.7-kg) sledge hammer;
Two non-spark bung wrenches;
One gas shutoff wrench;
One pair 24-in. (610-mm) bolt cutters;
One drum upender;
One non-spark 28-in. (710-mm) crowbar;
One plug and patch kit;
One tool box (wrenches, sockets, screwdrivers; minimum 100 units);
Six MC #306/DOT #406 dome clamps;
400 pads 18 in. × 18 in. × 3/8 in. (457 mm × 457 mm × 9.5 mm) hydrophobic polypropylene-type absorbents;
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;
Four 10-ft (3-m) sorbent booms;
50 lb (22.7 kg) dry "lime" in ruptureproof 5-gal (19-L) containers;
One manually operated product transfer pump with minimum 15-gpm (57-L/min) capacity and appropriate hoses;
One 55-gal (208-L) drum (UN-1A2);
One 85-gal (322-L) drum (UN-1A2).

A-8-1 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 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.

One of the most critical factors is the size of the water tank. Water weighs approximately 8⅓ 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 (1900-L) tank and its water about 2½ tons (2268 kg).

If the finished apparatus is not to be overloaded, the purchaser should provide the contractor with the weight of equipment to be carried if it is in excess of the allowance shown in Table 8-1. (*See Section 1-3.*)

Overloading 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 transmissions, clutches, and brakes. Overloading can also seriously affect handling characteristics, making steering particularly difficult.

Fire apparatus should be able to perform its intended service under adverse conditions that may require operation off paved streets or roads. Chassis components should be selected with the rigors of service in mind.

A-8-1.1 A weight of 250 lb (114 kg) for a fully equipped fire fighter is used elsewhere in NFPA standards. The 200 lb (91 kg) per person used here does not include the weight of SCBA and tools carried by a fire fighter, as the weight of this equipment is accounted for elsewhere.

A-8-2.1 The standard does not contain any minimum for size of engine as the size of the engine must be chosen to correspond with the conditions of design and service.

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

A-8-2.1.1 The maximum no-load governed speed is established by the engine manufacturer as a safe limit of engine speed. The governor or electronic fuel control system should prevent the engine from exceeding the safe speed. Most engine manufacturers allow a plus tolerance of 2 percent for maximum no-load governed speed.

A-8-2.1.3 A shutdown beyond the control of the pump operator during fire-fighting operations can result in loss of water flow from the pump that could severely endanger personnel. Automatic fuel line safety shutoff as required by DOT regulations is not considered an automatic engine shutdown.

A-8-2.1.4 An increase in engine speed provides increased alternator output, increased engine cooling, increased air conditioner output, and increased output or performance from other devices which derive their power from the chassis engine. The intent 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-8-2.2.1 Where a regular production model commercial chassis is used, it is recommended that the heavy-duty radiator option be included when such is available. Radiators with bolted top and bottom tanks and removable side braces, if available, are considered preferable. Optional features that might be desirable include a coolant conditioner, radiator sight gauges, and automatic radiator shutters any of which if used should be of a type approved by the engine manufacturer.

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

A-8-2.3.1 Full flow oil filters are mandatory with some diesel engines.

A-8-2.4.1 A manual emergency engine shutdown might be provided, in addition to the normal engine shutoff switch. It could be of the type that will close off either the air supply or the exhaust gas flow of the engine. The activation mechanism should be provided with a guard and marked "Emergency Shutdown." Provisions to prevent restarting of the engine without a special reset procedure should be included.

A-8-2.4.1.1 The extent to which air inlet protection is required could depend on specific fire department operations. Caution must be used as air intake filters might affect the engine manufacturer's air restriction requirements.

A-8-2.4.1.2 To prevent engine shutdown due to fuel contamination, dual filters in parallel, with proper valving so that each filter can be used separately, might be desired. The purchaser should specify if dual filters are desired. Installation of two or more pumps should be designed so that failure of one pump will not nullify the performance of the others. It should be remembered that commercial vehicles are designed for over-the-road operation, and the fuel system and battery are at least partially cooled by the flow of air resulting from the motion.

A-8-2.4.1.3 With the use of diesel engines, the concern for vapor lock common with gasoline engines does not exist, and electric fuel pumps are not usually compatible for connection in series with a diesel engine fuel system. As a result, when an electric fuel pump is specified with a diesel engine it is arranged as a fuel priming pump only. When not properly labeled or when the control valves are not properly set, the auxiliary priming system can cause the diesel engine to lose its prime. In addition, operation of a priming pump during diesel engine operation can boost fuel inlet pressure to the engine's fuel system. This could cause erratic engine behavior and loss of engine speed control. Control systems for priming pumps should allow only momentary operation and prevent the operation of the pump while the engine is operating.

A-8-2.5 Emissions from exhaust discharge pipes should be directed away from any fire-fighting tools since such emissions contain an oily substance that could make the tools difficult to handle and possibly dangerous to use.

A-8-3.1.2 Service brake and parking brake systems are required to be independent and separate systems so that any failure of one braking system will not prevent stoppage of the vehicle through use of the other system.

A-8-3.1.4 Adequate braking capacity is essential for the safe operation of fire apparatus. While this subject is normally covered in state highway regulations, it should be noted that fire apparatus might have a special problem as compared with normal vehicles of the same gross vehicle weight. Fire apparatus could be required to make successive brake applications in a short period of time when attempting to respond to alarms with minimum loss of time. Thus, the problem of brake "fade" and braking capacity could be critical unless the brakes provided take into account the service requirements. Air actuated brakes are recommended for fire service vehicles of over 25,000 lb (11,350 kg) GVWR.

Where air brakes are provided, it is important that they be of a quick buildup type with dual tanks and a pressure regulating valve. The rated compressor capacity should be not less than 12 ft^3/min (0.34 m^3/min) for this class of service. Air brakes require attention to guard against condensation in the air lines, such as might occur in areas subject to changes in climate affecting the moisture content of the air. Automatic moisture ejection of suitable nonfreezing type is recommended. Air pressure drop should be limited to normal air losses. The presence of the following conditions indicates the need for immediate service:

(a) Air brake pressure drop of more than 2 psi (13.8 kPa) in 1 minute for single vehicles or more than 3 psi (20.7 kPa) in 1 minute for vehicle combinations, with the engine stopped and the service brakes released.

(b) Air pressure drop of more than 3 psi (20.7 kPa) in 1 minute for single vehicles or more than 4 psi (27.6 kPa) in 1 minute for vehicle combinations, with the engine stopped and the service brakes fully applied.

A-8-3.1.5 There have been occurrences of the driver becoming disabled while driving a fire apparatus. The purchasers might want to specify the placement of the parking brake control to a location where it can be reached from the officers seat or require a second control so the officer could stop the vehicle if the driver becomes disabled.

A-8-3.1.7 Purchasers of apparatus with a GVWR of 31,000 lb (14,061 kg) or greater should consider equipping the apparatus with an auxiliary braking system. Fire apparatus commonly make repeated stops from high speeds which 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, are operating 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 drive-line retarders. Some auxiliary braking devices should be disconnected when the apparatus is operated on slippery surfaces. Follow the auxiliary braking device manufacturers recommendations for proper instructions.

A-8-3.2.1 Fire departments with vehicles that could be subject to continuous long mileage driving need to specify tire rating for continuous operation in place of intermittent operation.

A-8-3.2.3 The angle of approach or departure affects the road clearance of the vehicle when going over short steep grades such as would be found in a driveway entrance, crossing a high-crowned road at right angles, or in off-road service. Too low an angle of approach or departure will result in scraping the apparatus body. In those cases where equipment is stored below the body, the angle of approach or departure should be measured to a line below the equipment.

A-8-3.3 Where automatic transmissions are used, the power takeoff applications could present problems, especially when dual PTO drives are required. In some instances, the PTO drive can only be engaged in torque converter range with resultant chances of overheating with prolonged use. If high engine rpm occurs, there is the possibility, if the vehicle is accidentally left in gear, of the output torque overcoming the parking brake and moving the vehicle. Proper operational instructions are essential with automatic transmissions.

A-8-3.4.1 Where a large capacity fuel tank is desired, as in the case of apparatus designed for rural service, the capacity should be specified by the purchaser.

A-8-3.4.2 It is not a recommended practice to add a second tank to a commercial vehicle where the original tank is too small, since such tanks are seldom designed for dual tank use. Where large fuel capacity is required, over 50 gal (190 L), dual tanks designed for the purpose are acceptable. In such circumstances, it is undesirable for a pump operator to be required to open or close valves manually to provide additional fuel supply to the engine, and, further, there should be a

free flow from both tanks so that fuel will not remain unused in any tank for long periods. The tanks should be arranged with check valves in the line with free flow to a mutual feed line. It is also desirable that the fuel gauge be so installed that the operator can immediately determine the amount of fuel still remaining in the fuel system without mental addition of various fuel tank capacities.

A-8-3.5 If the purchaser wants the hooks or rings to be accessible without having to open compartment doors, the specifications should state that fact.

A-9-1 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-9-2.1 The 125 percent requirement for wiring and circuits is intended to provide end users a minimum amount of extra electrical circuit capacity. It is not the intent to have the final stage manufacturer replace the standard OEM chassis manufacturer's wiring to meet the 125 percent requirement. It is also not the intent of this requirement to have electrical accessories purchased by the apparatus manufacturer rewired to meet the 125 percent requirement. Electrical device manufacturer supplied wiring can be used to the point where it connects to apparatus manufacturer's installed wiring.

A-9-2.6 It is the intent of this section 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, this section 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-9-3.1 The minimum alternator size is developed using the loads required to meet the minimum continuous electrical load. Most apparatus will actually have loads exceeding the minimum requirements of this standard. The purchaser should review the maximum current output of the alternator verses the load study supplied for the apparatus from the manufacturer for on-scene and responding modes.

A-9-3.2(g) The purchaser needs to analyze the electrical loads that must be maintained to fulfill the mission of the apparatus and to define those loads for the manufacturer of the apparatus. The purchaser needs to understand, however, that there is a limit to the output capacity of an alternator system on the apparatus's engine and this standard requires that the apparatus be capable of maintaining the minimum continuous electrical load under the conditions defined in 9-3.1. When that load is exceeded and larger alternators are not available, the purchaser and the manufacturer need to work together to determine how to reduce the minimum continuous electrical load to that which can be sustained under the conditions defined in 9-3.1.

A-9-3.3 The unexpected shutdown of a fire apparatus at a fire can place fire fighters in mortal danger and seriously impact the fire attack. With computer controlled engines and transmissions as well as electric valves and other controls, an electrical system failure could result in an immediate and total shutdown of the apparatus. The low voltage monitoring system is intended to provide an early warning of an impending electrical failure and provide enough time to permit operator intervention.

A-9-3.5.1 Reduced crew sizes have forced the apparatus operator to assume many new fire ground tasks besides that of operating apparatus. Even if the operator is at the apparatus, he 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' electrical system, they are shed in an order least likely to affect emergency operations. Optical warning devices in excess of the minimum required in this standard can and should be load managed.

A-9-4 Batteries on fire apparatus should be larger than those used on commercial vehicles because in addition to starting the vehicle, they must provide the supplemental energy to power high amperage, intermittent operation devices such as mechanical sirens and electric rewind hose reels.

Batteries usually have two ratings: "Cold Cranking Amperes," which determines the size engine that can be started, and "Reserve Capacity," which provides a measure of the total power that can be provided at a much lower, constant rate of discharge. Fire apparatus batteries should be sized to have enough cold cranking amperage and reserve capacity to restart the engine after being substantially discharged.

A-9-4.4.2 Overheating of a battery will cause rapid deterioration and early failure; evaporation of the water in the battery electrolyte can also be expected. Batteries in commercial chassis are often installed to take advantage of the cooling effect of the flow of air from motion in over-the-road operation and could be subject to overheating when the apparatus is operated in a stationary position, such as during pumping operations.

A-9-4.5 The power cord from the onboard charger or battery conditioner should only be plugged into a receptacle protected by a ground-fault circuit-interrupter (GFCI) at the shoreline origination point.

A-9-4.6.2 The purchaser might want to consider a second "battery on" pilot light on the outside of the apparatus to warn that the batteries are on when the apparatus is parked in the fire station.

A-9-7 SAE J551, *Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHZ)*, provides test procedures and recommended levels to assist engineers in the control of broad band 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 fire ground communication equipment or other devices susceptible to magnetic radiation.

Procedures are included to measure the radiation from a single device or the entire apparatus. Compliance could be determined through actual tests on the completed apparatus or predictions based on tests previously conducted on similarly equipped apparatus. If compliance certification is required, it should be so indicated in the apparatus specifications.

A-9-8.1 The upper level optical warning devices provide warning at a distance from the apparatus and the lower level optical warning devices provide warning in close proximity to the apparatus. (*See Figure A-9-8.1.*)

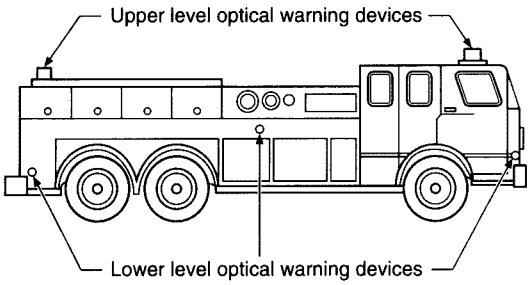


Figure A-9-8.1 Upper and lower optical warning zones.

A-9-8.6 Under typical conditions, the specified optical warning system provides effective, balanced warning. In some situations, however, the safety of the apparatus can be increased by turning off some warning devices. For example, if other vehicles must pass within close proximity to the parked apparatus, the possibility of distracting other drivers can be reduced if the headlights and lower level warning lights are turned off. When responding in snow or fog, it could be desirable to turn off forward facing strobes or oscillating lights to reduce visual disorientation of the apparatus driver.

The intent of the warning light system is to provide full coverage signals when either responding or blocking the right-of-way by the operation of a single master switch. There is no intent to prevent the use of lower levels of warning when the apparatus driver believes such reductions are appropriate, given the vehicle's mission, the weather, or other operational factors. Additional switches downstream of the master switch can be specified by the purchaser to control individual devices or groups of devices.

A-9-8.12.3 (*See Figures A-9-8.12.3(a) and A-9-8.12.3(b).*)

A-9-8.12.4 The zone totals reflect the combined performance of the individual optical warning devices oriented as intended on the apparatus when viewed along the perimeter of a circle of 100 ft (30.5 m) radius from the geometric center of the apparatus.

The zone total is the sum of the optical power of all optical sources projecting signals of permissible color into the zone as measured at 5 degree increments along the horizontal plane passing through the optical center H throughout the 90 degrees included in the zone (19 data points). The calculation of zone totals assumes that all optical sources are mounted at the geometric center of the apparatus. With the optical center of each optical source oriented as installed, the optical power contributed by every optical source at a given point is taken from the test report and added together to determine the total optical power at that point. The zone total is the sum of the optical power at the 19 measurement points in the zone. The upper and lower level optical sources are calculated independently.

The engineering basis of this section permits both the design and certification of an optical warning system by mathematical combination of the individual test reports for any number of optical warning devices of different color, flash rate, optical source, and manufacturer.

Using the test reports provided by the device manufacturer, the contribution of optical energy from each optical source is determined for every data point. The total candela-seconds/minute of optical energy is determined at each point and then the zone totals are calculated and compared to Table 9-8.12.4.

A-9-8.12.6 Optical warning systems drawing more than 45 amps might necessitate modification of the electrical system specified in Section 9-3 to supply the additional power required.

A-9-8.15 Sample Measurement Certification Procedure. In a few cases, a manufacturer might wish to type certify by actual measurement of the optical warning system on an apparatus.

Certification of the actual measurement of the performance of the optical warning system is made with each optical source either mounted on the apparatus or on a frame duplicating the mounting of the device on the apparatus. The performance of the system can be directly measured along the perimeter of a circle of 100 ft (30.5 m) radius about the geometric center of the apparatus. Each optical warning device used shall be certified by its manufacturer as conforming to all of the requirements of this standard pertaining to mechanical and environmental testing. Photometric testing of the system should be performed by qualified personnel in a laboratory for such optical measurements.

The test voltages and other details should be as called for in this standard for the photometric testing of individual optical warning devices. The elevation of the photometer, however, could be set at the elevation that maximizes the performance of the upper level devices and at a second, different elevation that maximizes the performance of the lower level devices.

With the optical center of each device oriented as installed, the sum of the actual value of the optical power contributed by every optical source is then determined at each measurement point. The zone total is the sum of the optical power at the 19 measurement points in the zone.

Measurements are made to determine all of the optical requirements of this standard including the optical power at each of the required measurement points, the zone totals at the horizontal plane passing through the optical center, and the zone totals at 5 degrees above and below the horizontal plane passing through the optical center. Any upper level warning devices mounted above the maximum height specified by the manufacture should be tested to demonstrate that at 4 ft (1.2 m) above grade and 100 ft (30.5 m) from the mounted device, the optical energy exceeds 50 percent of the minimum required at the horizontal plane passing through the optical center.

A-9-9.1 If the purchaser wishes to have the siren controls within convenient reach of persons riding in both the right

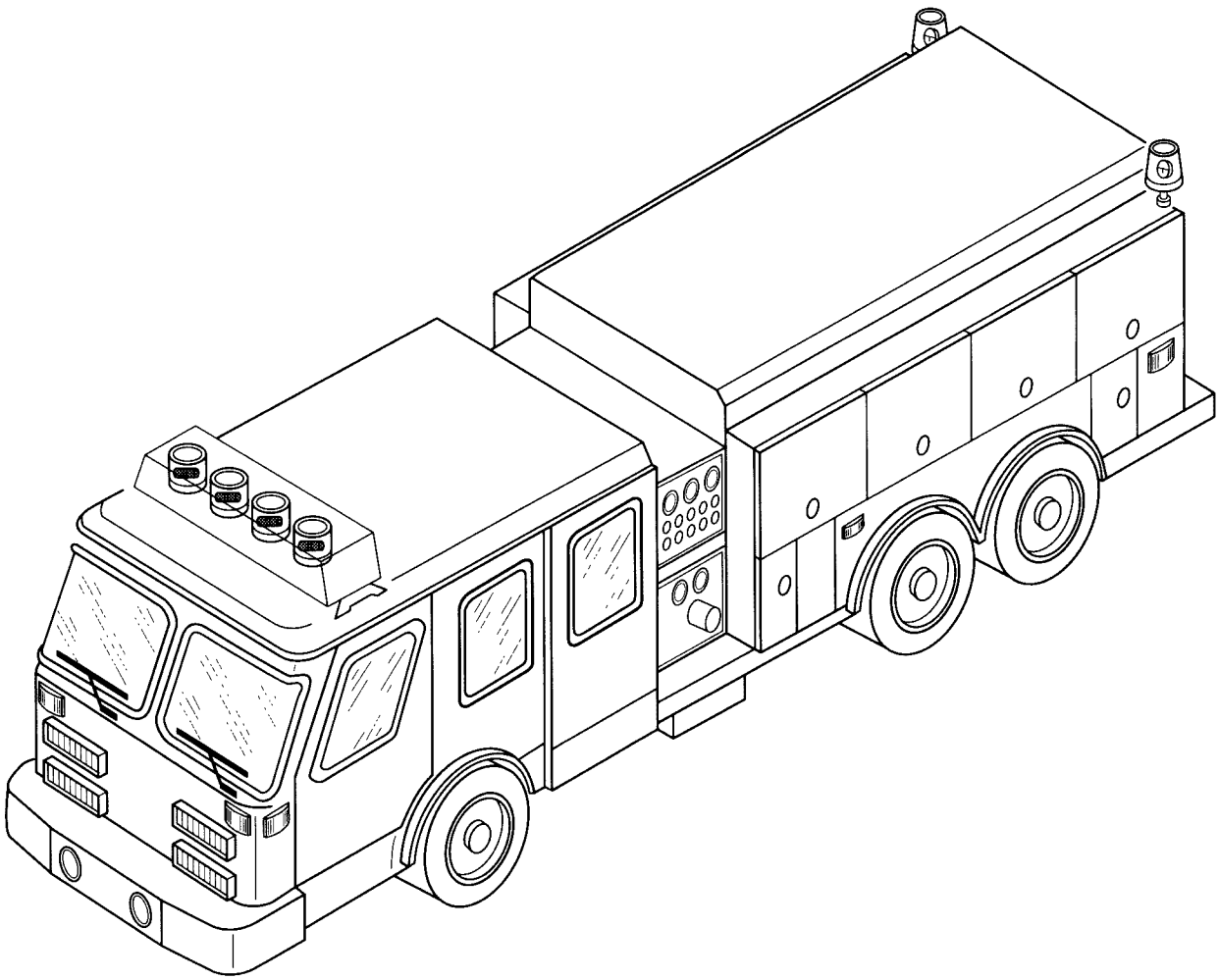


Figure A-9-8.12.3(a) Sample illustration showing the front and left sides of an apparatus using an optical warning system.

and left front seat positions, they should specify that. In some apparatus, multiple control switches might be necessary to achieve convenient reach from the two positions. If other signal devices, such as an additional siren, bell, air horn(s), or buzzer are desired, the type of device and its control location should also be specified.

A-9-14.1 The purchaser might desire to have the entire low voltage electrical system and warning device system certified by an independent testing organization.

A-10-1.1 The purchaser will need to define how many seating positions are required to carry personnel and might wish to specify the arrangement of the seating positions. Canopy cab extensions with patio door-type closures or separate telephone booth-type personnel enclosures are acceptable means to provide fully enclosed seating positions.

A-10-1.6 SCBA units and other equipment stored in the crew compartment could cause injuries to occupants of the compartment if they fly around the compartment as the result of an accident or other impact. All equipment stored within the crew compartment should be provided with brackets or compartments to minimize the chance of injury.

A-10-2 The purchaser should consider specifying remote controls on the mirrors to facilitate correct mirror adjustment. Where necessary, heated mirrors should also be considered.

A-10-2.1 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-10-2.3 The purchaser should realize that local conditions or operating procedures could cause the passenger to project into the sight pattern of the driver causing vision obstructions. Seats should be arranged so that SCBA and passengers wearing protective clothing do not cause vision obstruction. Movement of the passenger should be considered when installing radios, computers, and other equipment so forward movement or shifting is reduced to a minimum and does not block the driver's vision.

A-10-3.2 In many areas, the overall height of the vehicle must be restricted in order to clear bridges, station doors, etc. The tiller driving compartment roof is normally the highest point on the vehicle. Hence, the height of the tiller driving compartment and the inside headroom might have to be reduced to achieve the desired overall height.

A-11-1.1 Compartmentation sized to meet the size, shape, and weight requirements of special equipment might be

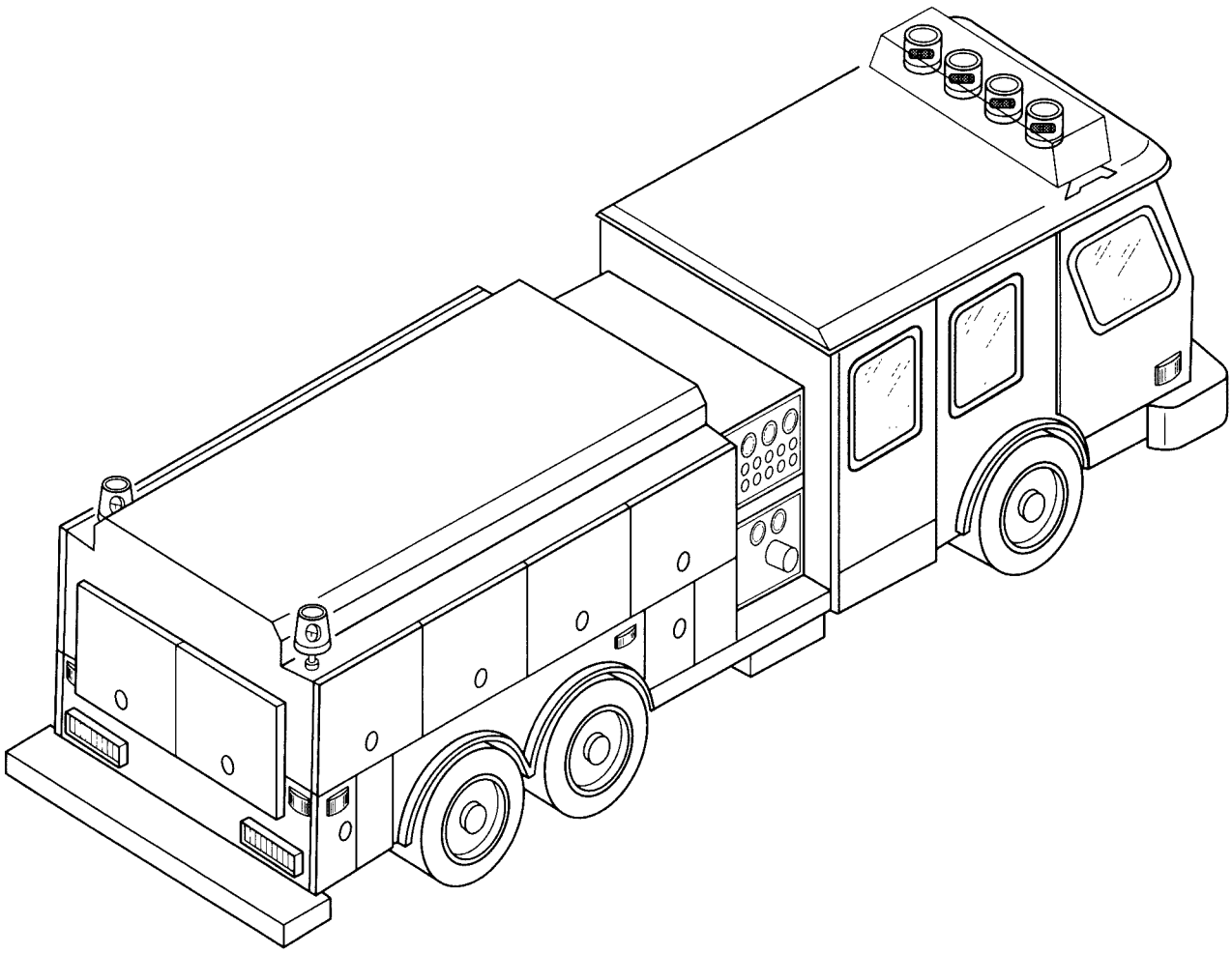


Figure A-9-8.12.3(b) Sample illustration showing the rear and right sides of an apparatus using an optical warning system.

required. 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.

A-11-2 The purchaser needs to provide the apparatus manufacturer with the details of and any special needs for communication equipment such as radio size, power consumption and location(s) for communication equipment.

A-11-3 Where equipment other than that originally mounted on the apparatus is to be carried, the user of the vehicle should ensure that the equipment is securely attached to the vehicle with appropriate holders.

A-11-5 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 hoses, straps, belts, facepiece, regulator, and other attachments. This 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 marked on the exterior.

A-11-5.5 SCBA cylinders should always be stored with valve assemblies atop the cylinder.

A-11-5.6 SCBA cylinders should be stored with valve assemblies exposed to the compartment opening or storage area to permit inspection of valves or gauges.

A-11-7.1 The intent of step size and placement requirements is to ensure that the fire fighter's foot will be supported 7 in. to 8 in. (178 mm to 203 mm) from the toe when the foot is placed on the step in the normal climbing position. The leading edge is not necessarily the side opposite the fastening location.

Ascending into and descending from certain types of driving and crew compartments is ergonomically difficult and has resulted in falls and subsequent fire fighter injuries. When designing and specifying apparatus, it is strongly suggested that chassis and apparatus manufacturers be consulted concerning available alternatives in order to make driving and crew compartment access as ergonomically convenient and as safe as possible.

A-11-8 Handrails should be mounted in a way to minimize the chances of damage or removal from brushing by objects such as trees.

A-11-9.1 Corrosion protection, commonly known as undercoating, might be desired in areas where climatic conditions or road treatment will corrode vehicle components. The material, its application method, and the areas to be protected should be carefully specified so the corrosion protection will adequately protect the vehicle's cab and body sheet metal components subject to corrosive conditions that could be encountered in the user's area.

The purchaser should give consideration to the choice of paint color(s) as it relates to the total vehicle conspicuousness.

A-11-10 Apparatus provided with booster hose and reel assemblies should have power rewind capability. However, if a manual rewind is provided, attention should be paid to the location of the hand crank. It should be placed in a location that allows the operator to rewind the hose onto the reel without having to climb onto the apparatus.

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-11-10.1 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 desirable.

A-11-11.1 If the unit is going to be moved onto and off a chassis periodically, the purchaser might wish to specify lifting eyes or forklift slots to facilitate its movement.

A-12-2.3.2 Parallel operation can be referred to as "volume," and series operation can be referred to as "pressure."

A-12-2.4.1 The values given in Table 12-2.4.1(b) 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.

A-12-2.4.2 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.

A-12-3.4 A separate pumping engine could use the vehicle chassis battery system, or it could have a separate set of dedicated batteries. Battery charging and electrical supply should be designed to meet this standard, whichever system is used.

A-12-5.1 Pumps and piping frequently required to pump salt water, water with additives, or other corrosive waters should be bronze or other corrosion-resistant materials. For occasional pumping of such water, pumps of other materials are satisfactory if properly flushed out with fresh water after such use.

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

Corrosion effects are proportional to the mass relationship of bronze to iron. It is, therefore, desirable to use like materials for the pump and piping, and where both iron and bronze are used, to keep the mass of the iron larger than that of the bronze.

A-12-6.1 Intakes can be larger than the size of the suction hose specified in Table 12-2.4.1(a). Where a larger size is desired, it should be specified by the purchaser. It might be desirable to have one or more of the intakes valved. If this is desired, the purchaser should specify which intakes are to be valved.

Intakes at the front or rear of the apparatus, or otherwise specially situated, might not allow drafting rated capacity and 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.

A-12-7.1 The flows listed for each outlet size are minimum and are for rating purposes only. If piping and valving are sufficient, much higher flows for a given outlet size might be achievable.

A-12-7.1.3 In order to provide standardization, National Hose threads are required. Adapters can then be used to adapt to locally used hose connections.

A-12-7.2 If flows greater than 200 gpm (757 L/min) through preconnected lines are desired, piping from the pump to preconnected hose lines should be larger than 2 in. (51 mm) in order to keep the friction loss to a reasonable level. If additional preconnected lines are desired, the location and hose size should be specified.

A-12-7.7 Where possible, discharge outlets should be positioned in an area away from the normal pump operator's position.

A-12-9.1 Ideally, having no intake or discharge connections at the operator's position would simplify and improve safety for the operator. If complete removal of these connections is impractical, the reduction and careful placement of these connections, with operator safety in mind, would improve the situation considerably.

A-12-9.4 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 following color coding scheme is recommended for all new apparatus labels as applicable:

Preconnect #1 or front bumper jump line	Orange (*see note*)
Preconnect #2	Red (*see note*)
Preconnect #3 or discharge #1	Yellow (*see note*)
Preconnect #4 or discharge #2	White (*see note*)
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

NOTE: Since 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 that an improvement in fire ground operations was achieved.

A-12-10 The indicator lights and interlocks specified in this section are minimum. Some manufacturers or users might choose to add additional indicator lights or interlocks.

A-12-10.2 Pumps are operated from the side, top, front, or rear of the vehicle, and the design is such that there is no power applied to the wheels while pumping. Dislocation, through vibration or accidental jarring, of any levers used to prevent power from being applied to the wheels could result in a serious accident. Therefore it is essential that any pumping system controls, which shift the vehicle out of road mode of operation to place the pumping system into operation, be equipped with a means to prevent dislocation of the control.

A-12-10.9 The purpose of a pressure control system is to control the discharge pressures to protect fire fighters who are operating hose streams as well as to protect discharge hose from damage in the event attack hose streams are shut off or other valves are closed, reducing flow rates.

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 fire ground procedures are still required.

A-12-10.9.4 Pressure control systems can be supplied in the following forms:

(a) Integral with the pump and supplied by the pump manufacturer;

(b) As an external system of components supplied by the apparatus manufacturer;

(c) As an external control system provided by a pressure control manufacturer.

The pressure control system should be certified by the appropriate manufacturer or an independent testing organization approved by the authority having jurisdiction. Due to the importance of these systems, the authority having jurisdiction might wish to have performance tests conducted on the installed system.

A-12-11.1 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-12-12.1 A pumping engine fuel level indicator or red warning light indicating when the fuel level falls below 1/4 of the tank(s') capacity should be provided on the pump operator's panel.

A-12-12.3 The rated operating pressure of large-diameter hose (LDH) is substantially less than that of standard fire hose. Therefore, an individual pressure gauge is required to allow the operator to control the discharge pressure even where a flowmeter is provided.

A-12-13.2.1.2 Where tests are performed inside a structure or elsewhere having limited air circulation, carbon monoxide monitoring equipment should be used. Such equipment should be checked and calibrated regularly and should include a suitable warning device.

A-12-13.2.3 Some test data blanks for recording the test readings and other necessary data should be provided.

Where a pump is pumping at or near full engine power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that can be touched without extreme discomfort or injury; however, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

The suction lift can be determined by either measuring the negative pressure (vacuum) in the pump intake manifold by means of a manometer (or other suitable test gauge that measures vacuum accurately) or by adding the vertical lift and the value of friction and entrance loss from Table 12-2.4.1(b). 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 might be ignored. Thus, the net pump pressure can be calculated by one of the following formulas:

(a) If intake pressure is positive, i.e., pumping from a hydrant:

$$P = D - S;$$

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

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

where:

P = net pump pressure, psi;
D = discharge pressure, psig;
S = intake pressure, psig;
H = manometer reading, in. Hg;
L = vertical lift, ft;
F = friction and entrance loss, ft of water.

A-12-13.2.3.2 The purchaser might wish to have an independent testing organization certify the test results, particularly where the pump is required to meet extended continuous duty pumping applications.

A-12-13.8 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these tests also be certified by the independent testing organization.

A-13-1 Auxiliary pumps come in a variety of different styles; gear, piston, and centrifugal designs are available. 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 fires, or other small blazes. Low capacity with high pressure through 3/4-in. (19-mm) or 1-in. (25-mm) booster hose is commonly used for these fires. Pump and roll is often required. Common capacities range up to 200 gpm (757 L/min), and pressures range up to 1000 psig (6895 kPag).

A-13-2 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-13-2.1 The volume and pressure that can be obtained safely depends 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-13-2.2 Sustained operations at either high volume, high pressure, or both high volume and high pressure could cause excessive heating of the transmission lubricant. In order 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, causing serious damage if the water is subsequently frozen.

A-13-4.1 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:

(a) External intake;
(b) Direct supply line from the water tank;
(c) Supply line from the discharge side of the fire pump.

A-13-5 The purchaser should indicate the size, number, and location of the pump discharge connections desired. The types of pump discharge connections are as follows:

(a) Discharge line(s) for nonpreconnected hose lines;
(b) Discharge line(s) to preconnected hose lines;
(c) Discharge line(s) to booster reel(s) (if provided).

A-13-5.3 In order to provide standardization, National Hose threads are required. Adapters can then be used to adapt to locally used hose connections.

A-13-8.4 A separate pumping engine could use the vehicle chassis battery system or it could have a separate set of dedicated batteries. Battery charging and electrical supply should be designed to meet this standard, whichever system is used.

A-14-1 This chapter does not address foam concentrate transfer pumps. Flow rates for foam concentrate transfer pumps are typically less than 250 gpm (946 L/min), and the pumps are usually positive displacement-type pumps.

A-14-2.1 It might be desirable to arrange the pump so it can be disconnected and removed from the apparatus for use in filling fire apparatus water tanks from a pond or river during an emergency incident.

A-14-2.4 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.

Where the local elevation exceeds 2000 ft (610 m) above sea level, or the purchaser desires to use the pump with suction lifts in excess of 10 ft (3 m), or through more than 20 ft (6 m) of suction hose, the conditions under which the pump is to be used should be specified so the manufacturer can design the pumping system to ensure proper performance under those conditions.

A-14-4.1 Pumps and piping frequently required to pump salt water, water with additives, or other corrosive waters should be of bronze or other corrosion-resistant materials. For occasional pumping of such water, pumps of other materials are satisfactory if properly flushed out with fresh water after such use.

The term "all bronze" indicates that the pump main casing, impellers, intake and discharge manifolds, and other principal components exposed to the water to be pumped, with the exception of the shaft, bearings, and seals, are of a high-copper alloy material.

Corrosion effects are proportional to the mass relationship of bronze to iron. It is, therefore, desirable to use like materials for the pump and piping, and where both iron and bronze are used, to keep the mass of the iron larger than that of the bronze.

A-14-5.1 Intakes can be larger than the size of the suction hose required. When a larger size is desired, it should be specified by the purchaser.

It might be desirable to have at least one valved intake. If this is desired, the purchaser should specify which intakes are to be valved.

A-14-9.2 Pumps are operated from the side, top, front, or rear of the vehicle, and the design is such that there is no power applied to the wheels while pumping. Dislocation, through vibration or accidental jarring, of any levers used to prevent power from being applied to the wheels could result in a serious accident. Therefore it is essential that any pumping system controls, which shift the vehicle out of road mode of operation to place the pumping system into operation, be equipped with a means to prevent dislocation of the control.

A-14-12.1 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these tests also be certified by the independent testing organization.

A-14-12.2.1.2 Where tests are performed inside a structure or elsewhere having limited air circulation, carbon monoxide monitoring equipment should be used. Such equipment should be checked and calibrated regularly and should include a suitable warning device.

A-14-12.2.3.1 Some test data blanks for recording the test readings and other necessary data should be provided.

Where a pump is pumping at or near full engine power while stationary, the heat generated could raise the temperature of certain chassis or pumping system components above the level that can be touched without extreme discomfort or injury; however, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, it should be considered acceptable.

The suction lift can be determined by either measuring the negative pressure (vacuum) in the pump intake manifold by means of a manometer (or other suitable test gauge that measures vacuum accurately) or by adding the vertical lift and the value of friction and entrance loss from Table 12-2.4.1(b). 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 might be ignored. Thus, the net pump pressure can be calculated by one of the following formulas:

(a) If intake pressure is positive, i.e., pumping from a hydrant:

$$P = D - S;$$

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

$$P = D + (H \times 0.5) \text{ or } P = D + 0.43 (L + F)$$

where:

P = net pump pressure, psi;
H = manometer reading, in. Hg;
D = discharge pressure, psig;
L = vertical lift, ft;
S = intake pressure, psig;
F = friction and entrance loss, ft of water.

A-15-2.1 Water tanks should have provisions that would allow for complete inside cleaning for flushing. The purchaser should indicate in the specifications if access to the interior of the tank is required.

A-15-2.2 Water tanks can appear in several different configurations (round, elliptical, rectangular, T-shaped). Handling characteristics of the apparatus can be greatly affected by its vertical and horizontal center of gravity. The purchaser should indicate the filling and dumping rates required if they exceed the requirements of this standard and any other local needs and let the apparatus manufacturer design the tank shape to best meet the axle loading and center of gravity requirements.

A-15-2.4 The design of a water tank can be a very critical factor in the handling characteristics of fire apparatus. If water is free to travel either longitudinally or laterally in a tank, as would be the case if the tank were half full, a tremendous amount of inertia can be built up that will tend to force the vehicle in the direction the water has been traveling. When the water reaches the end of the tank, this sudden application of force can throw the vehicle out of control and has been known to cause fire apparatus to turn over or skid when going around a curve or coming to a sudden stop. The only methods of preventing such an accident is to restrict or disrupt the movement of the water so that the inertia will not build up in one direction. This is done with the installation of swash partitions in a manner to either contain the water in smaller spaces within the tank (containment method) or disrupt its momentum by changing its direction of motion (dynamic method). The partitions in a containment system create compartments that are interconnected by openings between them so that air and water can flow at the specified rate when filling and emptying the tank. The partitions in a dynamic system are often staggered in an arrangement designed to change the direction of the water and turn it into a turbulent motion which absorbs much of its own energy.

A-15-3.2 For a pumper, this standard provides for a minimum flow of 500 gpm (1900 L/min) from the water tank. This is to permit the supplying of two $1\frac{1}{2}$-in. (38-mm) or $1\frac{3}{4}$-in. (44-mm) hose lines or one $2\frac{1}{2}$-in. (65-mm) hose line from the tank for an initial attack on the fire.

For an initial attack fire apparatus, this standard provides for a minimum tank to pump flow of 250 gpm (950 L/min). This permits the supplying of at least two good handlines from the tank for an initial attack on the fire.

Fire departments that desire a greater tank to pump rate of flow than these minimums should specify the greater rate of flow.

A-15-3.3 A check valve installed in the tank to pump line is the most common method used to prevent water from back flowing 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-15-4.1 An excessive flow rate when filling a tank could result in a pressure buildup in the tank that could cause permanent damage or failure.

A-15-4.2 A vent/overflow outlet is necessary so that over pressurization does not occur within the tank while filling it. However, water is likely to spill out of the vent/overflow while the vehicle is moving, (e.g., accelerating, decelerating, or cornering). The fill tower and vent/overflow outlet should be arranged so that spilling of water is minimized and is directed behind the rear tires.

A-15-4.3 It is necessary to design the tank for adequate venting and overflow for the maximum fill rate. A locking-type ball valve, globe valve, needle valve, or other type capable of regulating flows should be used. A gate valve is not recommended. 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.

Consideration should be given to providing an additional pump cooling/recirculation line that is automatic in operation, as pumps on fire apparatus are often left unattended and a line that is automatic in operation will ensure the pump does not overheat.

A-15-4.4 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 which is capable of allowing the tank to be filled at a rate of 1000 gpm (3785 L/min). Where such a fill connection is provided, it should conform to the requirements of 15-4.4.

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.

A-15-5 It is important that the purchaser evaluate how the apparatus will be used and define the location(s) and types of fittings desired on these outlets.

Where rapid dumping of the water tank to an external use is desired on other types of apparatus, the purchaser should consider an outlet directly into the tank which is capable of allowing water to be transferred from the tank at an average rate of 1000 gpm (3785 L/min).

Additional methods might be desired to improve the off-loading rate of gravity dumps. These include a jet assist or a

pneumatic pump. Control should be from the pump operator's position. Two types of jet assist can be used, one directed into the throat of the gravity dump and the other a peripheral jet system. Figure A-15-5(a) shows how the traditional jet is installed. A smooth-tipped "jet" nozzle is supplied by a pump capable of delivering at least 250 gpm (946 L/min) at 150 psig (1034 kPag). Nozzle jets range in size from ¾ in. to 1¼ in. (19 mm to 33 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 proven 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 (7570 L/min) have been obtained using a 300-gpm (1136-L/min) pump to supply two ¾-in. (19-mm) nozzles in a 6-in. (152-mm) dump valve configuration. Figure A-15-5(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.

On other apparatus where rapid filling from an external water source is desired, the purchaser should consider an outlet directly into the tank to allow the tank to be filled at an average rate of 1000 gpm (3785 L/min).

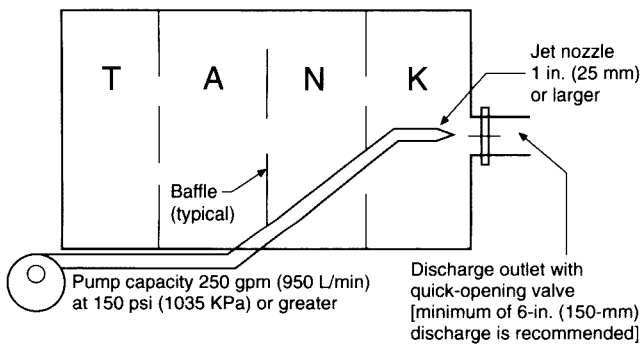
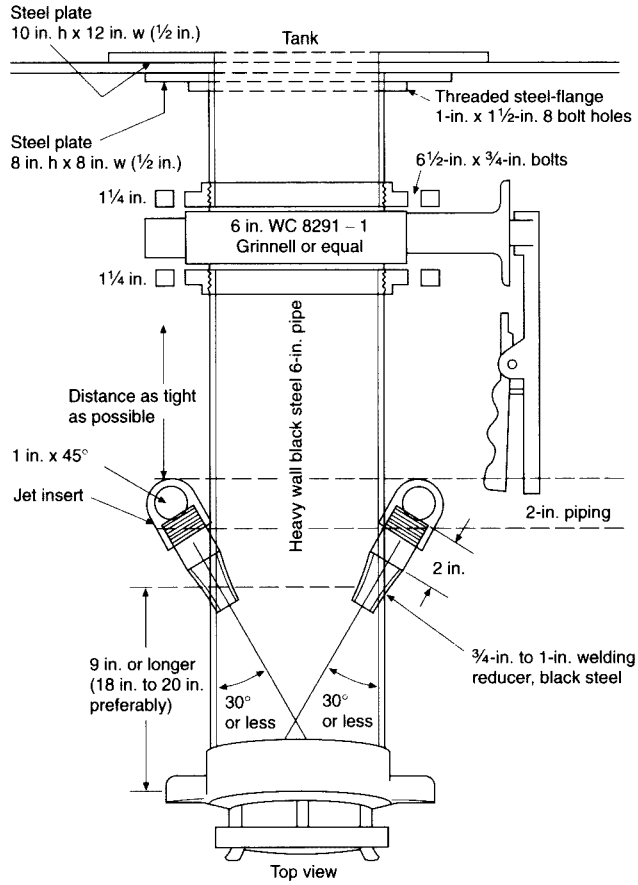


Figure A-15-5(a) Traditional internal jet dump.

A-15-6 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that the water tank capacity also be certified by the independent testing organization.

A-16-1 If the purchaser intends to suspend personnel or equipment from the aerial device using ropers, cables, or chains, the purchaser should inform the manufacturer of the intended use in order to determine proper mounting devices and locations as well as associated capacities. Equipment users have the potential to overload the aerial device components if improper methods are used.



Note: 6 in. NST., 6 in. Storz, or 6-in. bell cap with quick lock lugs or other quick connect coupling recommended.

Figure A-15-5(b) Peripheral jet assist arrangement.

A-16-3.4 Ladder capacity ratings are established in many different operating positions other than full extension and zero degrees elevation. Ladders are often rated at higher tip capacities as elevation angles increase or when the ladder is not fully extended. Most manufacturers provide distributed load capacities (several persons) dependent on the ladder'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.

A-16-4.1 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. The operator's space on the turntable should be at least 5 ft^2 (0.46 m^2) 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-16-4.3 A two-way communication system at two positions on the apparatus is considered a minimum. Depending on the configuration of the apparatus, communication systems at additional positions, such as at a pump panel or at the monitor operating position on the ladder, might be desirable.

A-16-5.2.1 Turntable bearing bolts are required to be checked and retorqued at regular intervals. The apparatus body should be constructed to make this task relatively simple by unbolting access panels, ladder slides, and other obstructions. Sufficient space should be provided for checking and torquing the bearing bolts above and below the turntable using the appropriate tools.

A-16-5.4 The controls located at the tip of an aerial ladder are primarily intended to perform the final positioning of the aerial ladder in rescue or other fire-fighting 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) must use caution due to the following potential problems:

(a) Tip control operators must be aware of personnel who are on the ladder sections behind them.

(b) Lower control operators must remain in position and deactivate the tip controls when anyone is moving on the ladder.

(c) Tip control operators must take care to place their feet on the steps at the tip to avoid injury to their feet from the moving ladder sections below.

(d) Tip control operators must be securely belted in position to protect against abrupt or unexpected ladder movements.

A-16-6.1 Where freezing conditions are expected, an automatic drain valve should be specified in order to drain the waterway when water is not flowing.

A-16-6.1.3 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 apparatus has a pump and normal operations are to supply the waterway through the pump, a suitable cap might be sufficient on the external inlet.

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 76-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 desires to use the auxiliary inlet as a discharge, a slow-acting valve must be installed in the riser to the swivel.

A-16-6.1.4 The tip of an aerial ladder should be capable of being positioned up to a window or other location to allow fire fighters and civilians to climb onto the aerial ladder easily. It might be desirable to keep the monitor behind the last rung of the fly section to protect it in the road position.

A-16-6.2 If the purchaser desires 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 (1900-L/min) minimum fog nozzle.

The size of hose used to supply the ladder pipe has 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 without consulting the aerial ladder manufacturer first.

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.

A-16-6.2.2 Where pulleys and cables for vertical control of the stream from the turntable are desired, the purchaser should specify these.

A-16-9.2 Position lights might be desirable on the outer corners of the platform to provide increased visibility of the platform's location from the ground operator's position.

A-16-9.4 A two-way communication system at two positions on the apparatus is considered a minimum. Depending on the configuration of the apparatus, communication systems at additional positions such as the pump panel might be desirable.

A-16-12.2.1 Because the water system can be closed at both the top and bottom of the waterway, the purchaser might want to require a vacuum relief valve.

A-16-12.3 See A-16-6.1.3.

A-16-12.6 Where freezing conditions are expected, an automatic drain valve should be specified in order to drain the waterway when water is not flowing.

A-16-16.3 The arrangement of the auxiliary inlet should be specified by the purchaser based on local operations in supplying water to the waterway. If normal operations are to supply the waterway with large-diameter hose, a valve should be provided. A valved three- or four-inlet siamese should be provided when 2½-in. or 3-in. (65-mm or 76-mm) supply lines are used.

Attention should be given to the inlet arrangement to limit friction loss. Also, if the purchaser desires to use the auxiliary inlet as a discharge, a slow acting valve must be installed in the riser to the swivel.

A-16-16.5 Where freezing conditions are expected, an automatic drain valve should be specified in order to drain the waterway when water is not flowing.

A-16-17.4 It might be desirable to provide an override system to deactivate the interlocks when it is necessary to operate the device with reduced payload or reach. Where an override system is specified, it should require the action of a person in addition to the operator to deactivate the interlock system. Where an override system is provided, it is also advisable to provide an indicator at all aerial device operating positions to warn the operator that the override controls have been activated.

A-16-18.1 If the operator's position is located on the turntable, the operator should have at least 5 ft^2 (0.46 m^2) of standing and work 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-16-20.1 Structural safety factors are widely recognized terms in 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 follows:

DL = Dead Load Stress. 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 must be subtracted from the rated capacity.

RL = Rated Capacity Stress. 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].

WL = Water Reaction Stress. Stress produced by nozzle reaction force and the weight of the water in the water delivery system.

FY = Material Yield Strength. The stress at which a material exhibits a specified permanent distortion or set.

(a) With no water in the system, the aerial device positioned at full extension, zero-degree elevation and loaded at the rated capacity, the criteria 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) (*see formula that follows*). This is a 2 to 1 safety factor.

$$2 \times DL + 2 \times RL \leq FY$$

(b) With water flowing in the system and the aerial device in the position that creates the highest stress, the criteria 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). (*See formula that follows.*)

$$2 \times DL + 2 \times RL + WL \leq FY$$

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-16-21.1 Water, hose, ground ladders, and equipment on the apparatus all provide stability when they are in place. However, at a fire, this equipment and water is often removed. Therefore, stability needs to be measured under worst conditions, which is with the equipment removed.

A-16-21.1.3 The lifting of a tire or stabilizer on the opposite side of the vehicle from the load does not necessarily indicate a condition of instability.

A-16-25 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these tests also be certified by the independent testing organization.

A-17-1 It is important for the purchaser to understand the types and properties of mechanical foam and its application to specify a foam proportioning system properly. Specific information regarding foam concentrates and their application is available in NFPA 11, *Standard for Low-Expansion Foam*, and NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*. Information on foam concentrates for Class A fires is available in NFPA 298, *Standard on Fire Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas*.

The following terms are not used in this document but are associated with foam systems and are included here to aid understanding.

Aerated Foam. The end product of a discharge of foam solution and air.

Aspirate. To draw in air; nozzle aspirating systems draw air into the nozzle to mix with the agent solution.

Aspirated Foam. The end product of a mechanically induced air stream that is drawn into the foam solution at atmospheric pressure to create foam. The aeration is generated by the energy of the foam solution stream.

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

Batch Mix. The manual addition of foam concentrate to a water storage container or tank to make foam solution.

Foam Blanket. A body of foam used for fuel protection that forms an insulating and reflective layer from heat.

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-17-2 Foam proportioning systems can be designed with the following features:

(a) The ability to proportion different types of foam concentrate including Class A and Class B foam concentrates;

(b) The ability to proportion foam concentrate at fixed or variable proportioning ratios;

(c) The ability to proportion foam concentrate into single or multiple discharge outlets;

(d) The ability to proportion foam solution and water simultaneously from a multiple discharge outlet foam proportioning system;

(e) Manual or automatic foam proportioning system operation.

A-17-2.1 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 drawn into the eductor (into the water stream) at the design rate of the device [*see Figure A-17-2.1(a)*]. By design, a nonrecoverable pressure drop of 30 percent or greater is required for eductor operation. The maximum recovered pressure, including friction loss and static head pressure, is nominally 65 percent of the inlet pressure to the eductor. The in-line eductor is a manually regulated proportioning system.

(a) A variable flow by-pass eductor system is a modification of the in-line eductor foam proportioning system. An eductor is placed in a by-pass line around the mainline water flow control valve so that when the valve is adjusted to produce water flow through the by-pass eductor, foam concentrate is drawn into the eductor (into the water stream) [*see Figure A-17-2.1(b)*]. The foam solution in the by-pass line is then joined with the mainline water flow downstream of the water flow control valve. The variable flow by-pass eductor is a manually regulated proportioning system.

(b) Variable pressure eductors are a modification of the in-line eductor foam proportioning system. This type of eductor is designed to automatically adjust the area of the eductor venturi to compensate for changes in water pressure at the inlet of the device. The variable pressure eductor is a manually regulated proportioning system.

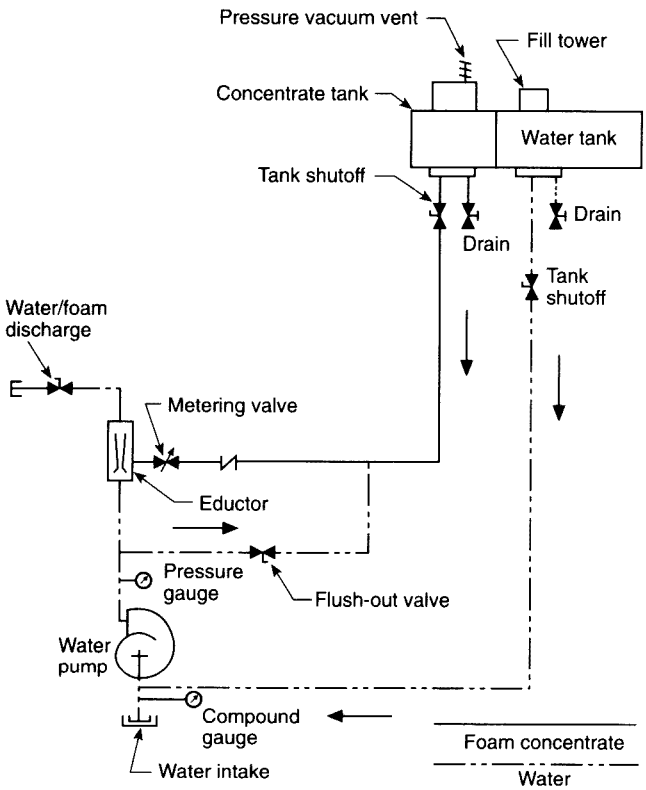


Figure A-17-2.1(a) In-line eductor foam proportioning system.

A-17-2.2 Self-educting master stream nozzles are mounted on the discharge side of the pump. These devices comprise a complete foam proportioning system, consisting of a foam proportioner and application device (nozzle). Self-educting master stream nozzles have the following operating characteristics:

(a) Operator-adjustable foam solution rates of 3 percent or 6 percent;

(b) Minimal pressure drop, approximately 1 percent to 2½ percent of inlet pressure.

A-17-2.3 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 draws foam concentrate directly into the pump intake. Hydrant or relay operation is not possible with this type of foam proportioning system.

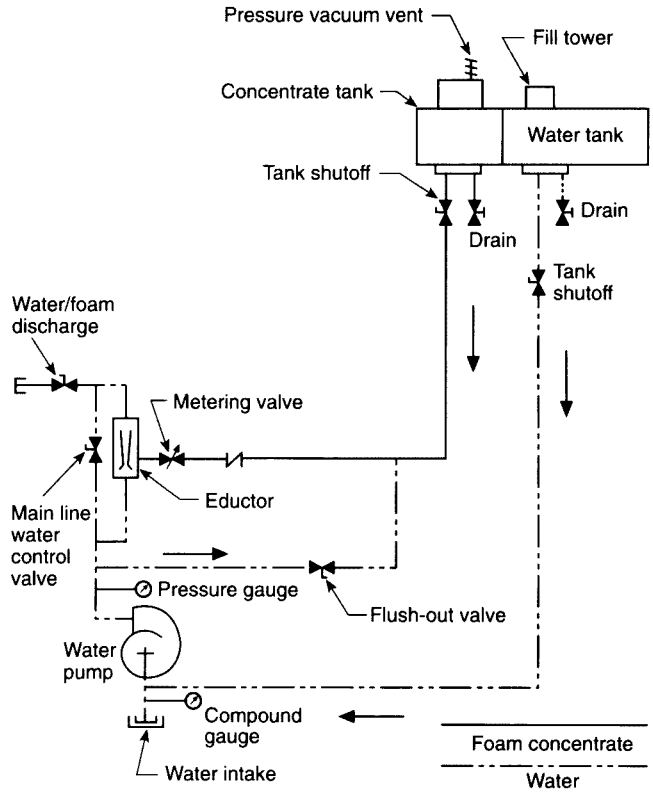


Figure A-17-2.1(b) Variable flow by-pass eductor system.

A-17-2.4 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 drawn 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) A manual around-the-pump proportioning system utilizes a manually adjustable foam concentrate metering valve to control the proportioning ratio. [*See Figure A-17-2.4(a).*]

(b) A flow meter sensing around-the-pump proportioning system utilizes a flow meter sensing system to monitor total solution flow and foam concentrate flow. The flow data is transmitted to an electronic control that controls the proportioning ratio through a foam concentrate metering valve. [*See Figure A-17-2.4(b).*]

(c) A conductivity sensing automatic variable metering around-the-pump proportioning system utilizes electrical conductivity meters to sense the foam solution percentage and provide feedback from the control sample module. Data from the electrical conductivity meters is transmitted to an electronic control that controls the proportioning ratio through a foam concentrate metering valve. [*See Figure A-17-2.4(c).*]

A-17-2.5 Balanced pressure foam proportioning systems are installed on the discharge side of the water pump. Two

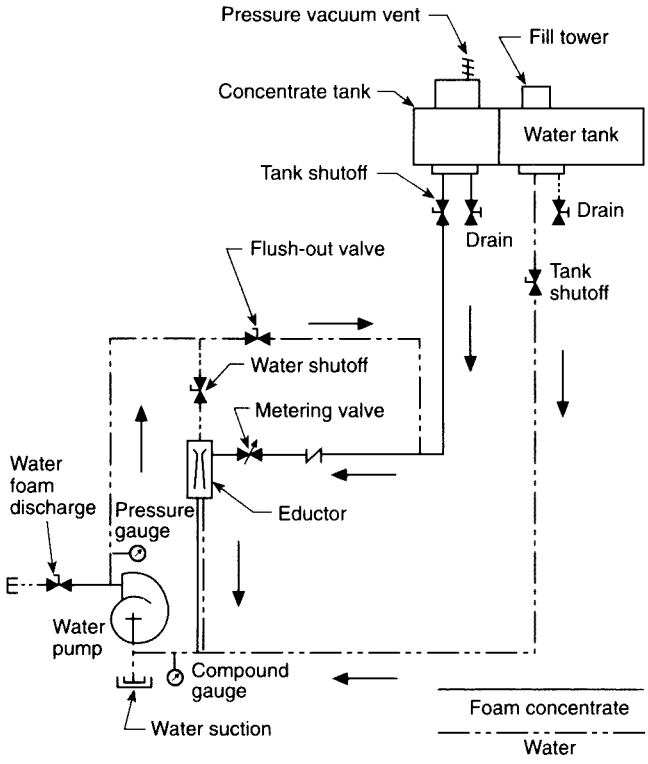


Figure A-17-2.4(a) Manual around-the-pump proportioning system.

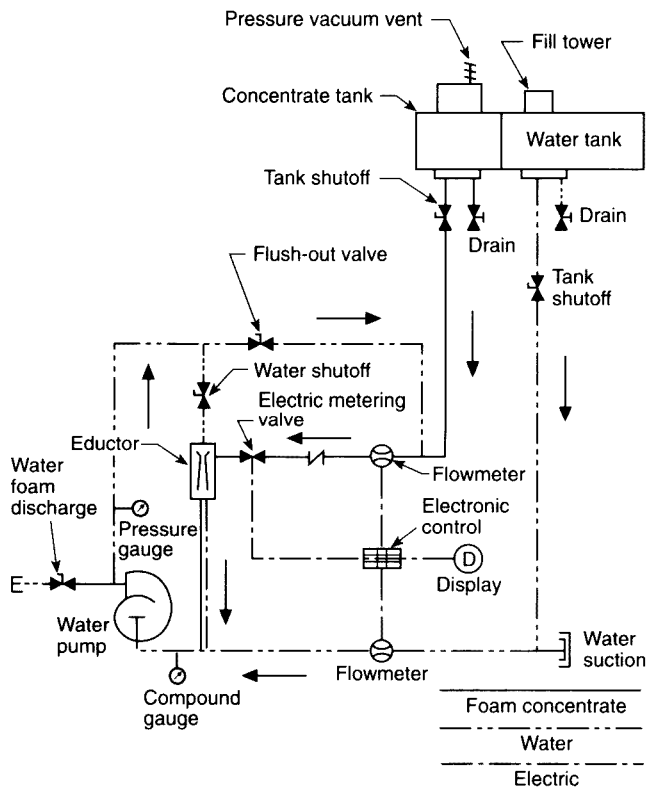


Figure A-17-2.4(b) Flow meter sensing around-the-pump proportioning system.

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

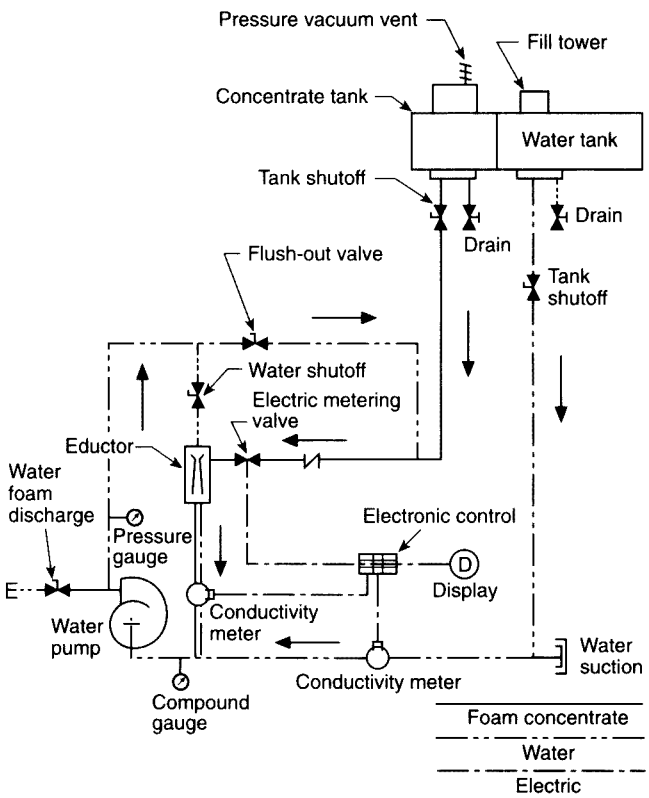


Figure A-17-2.4(c) Conductivity sensing automatic variable metering around-the-pump proportioning system.

particular ratio, the percent of injection can be controlled if the intake pressures are equal. The method of controlling or balancing the foam concentrate pressure with the water pressure varies with different balanced pressure system designs. The two basic types of balanced pressure systems are systems without a foam concentrate pump and systems with a concentrate pump. Balanced pressure foam proportioning systems are generally automatic regulating proportioning systems.

Balanced pressure systems without a foam concentrate pump are referred to as "pressure proportioning systems" [*see Figure A-17-2.5(a)*]. These systems utilize a pressure vessel with an internal bladder to contain the foam concentrate. When in operation, water pump pressure is allowed to enter the pressure vessel between the shell and the internal bladder to exert pressure on the internal bladder. The foam concentrate is forced out of the bladder to the foam proportioner at a pressure equal to the water pump pressure.

There are two basic types of balanced pressure foam proportioning systems that utilize a foam concentrate pump. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank in these types of foam proportioning systems.

(a) A by-pass system utilizes a valve in the foam concentrate pump recirculating line that balances the foam concentrate and water pressure by by-passing excess foam concentrate. [*See Figure A-17-2.5(b).*]

(b) A 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-17-2.5(c).*]

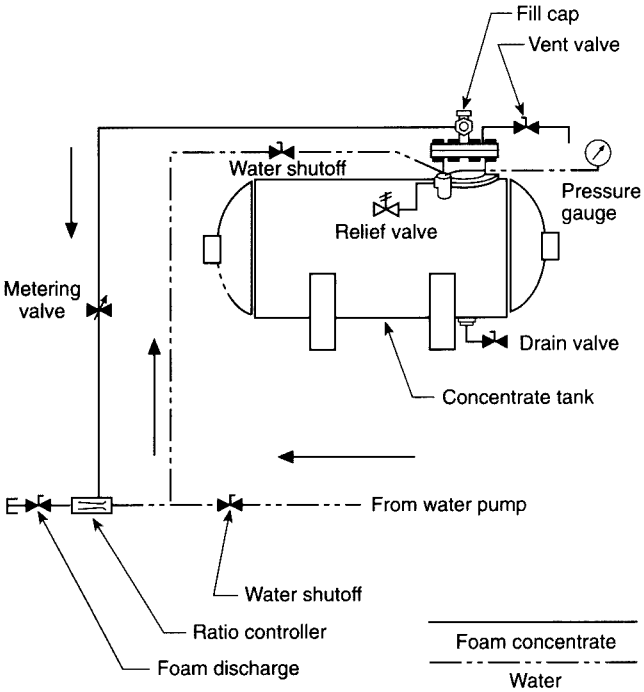


Figure A-17-2.5(a) Pressure proportioning balanced pressure proportioning system.

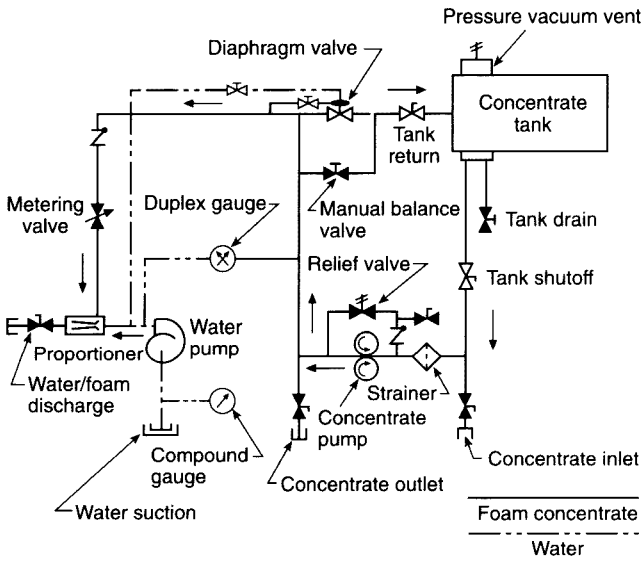


Figure A-17-2.5(b) By-pass balanced pressure proportioning system.

A-17-2.6 Direct injection foam proportioning systems utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. Foam proportioning system operation is not affected by water pump intake pressure or interrupted while refilling the foam concentrate tank. Direct injection foam proportioning systems are generally automatic regulating proportioning systems.

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

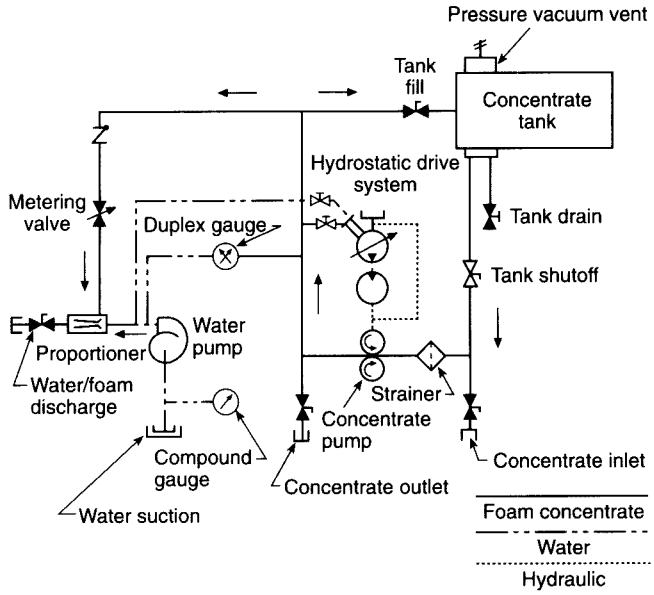


Figure A-17-2.5(c) Demand balanced pressure proportioning system.

(a) An electronic control receives electronic signals corresponding to the proportioning ratio from the control panel and water flow data from the flow meter. The electronic control then commands the foam concentrate pump module to deliver foam concentrate at the proportional rate. [*See Figure A-17-2.6(a).*]

(b) An electronic control receives electronic signals corresponding to the foam concentrate flow from a foam concentrate flow meter, the proportioning ratio from the control panel, and water flow data from the water flow meter. The electronic control controls the proportioning ratio through a foam concentrate metering valve. [*See Figure A-17-2.6(b).*]

A conductivity sensing direct injection foam proportioning system utilizes an electrical conductivity meter(s) to sense the proportioning ratio at the water pump discharge(s) and transmits this information to an electronic control that controls the proportioning ratio through a metering valve. A second electrical conductivity meter provides feedback from

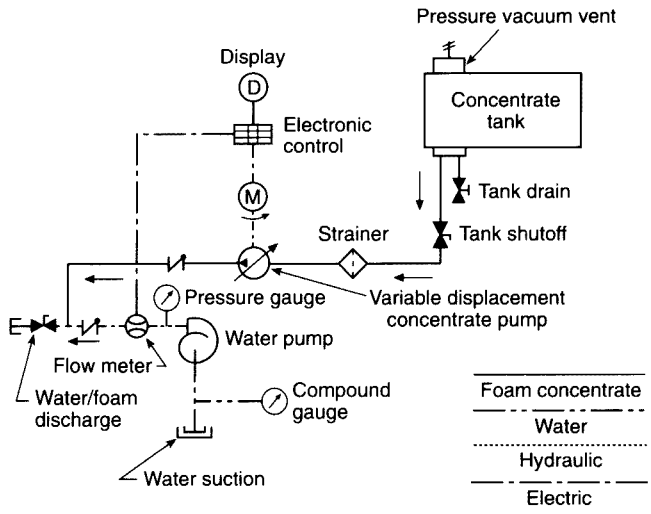


Figure A-17-2.6(a) Single meter flow sensing direct injection foam proportioning system.

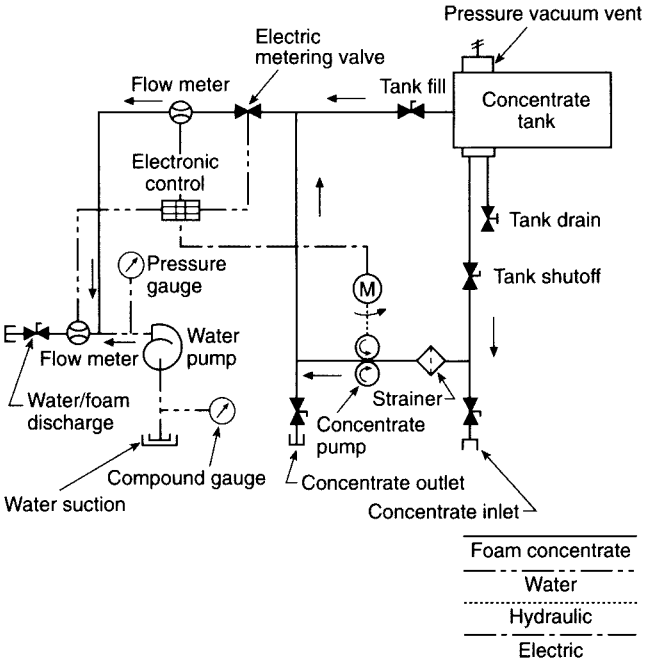


Figure A-17-2.6(b) Dual meter flow sensing direct injection foam proportioning system.

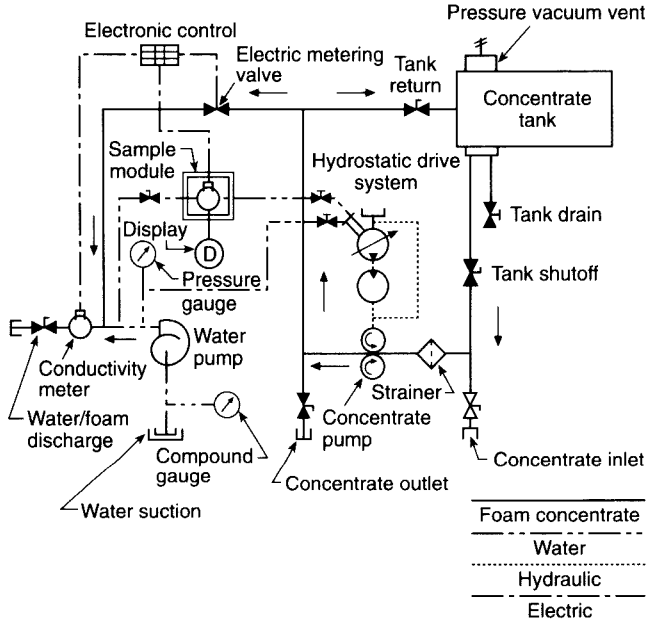


Figure A-17-2.6(c) Conductivity sensing direct injection foam proportioning system.

the control sample module to the electronic control. Foam pump pressure is maintained at a pressure higher than water pump pressure to ensure injection of the concentrate. [*See Figure A-17-2.6(c).*]

A-17-2.7 In a water motor-type foam proportioning system, a water motor drives a positive displacement foam concentrate pump. The water motor can be of either a positive displacement type or a turbine type. Water motor foam proportioning system are automatic regulating proportioning systems.

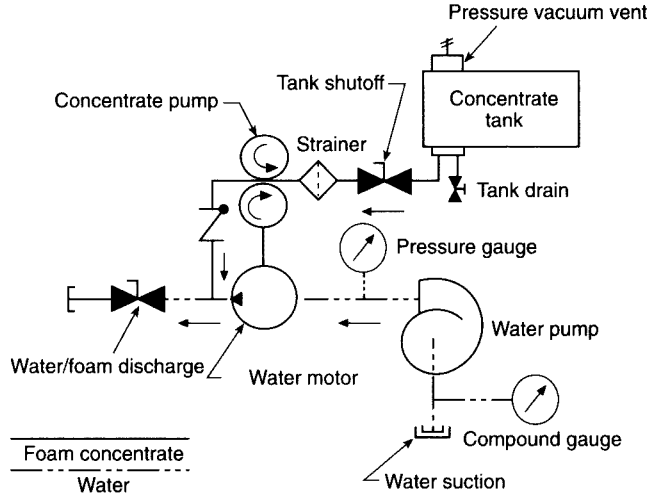


Figure A-17-2.7(a) Water motor foam proportioning system.

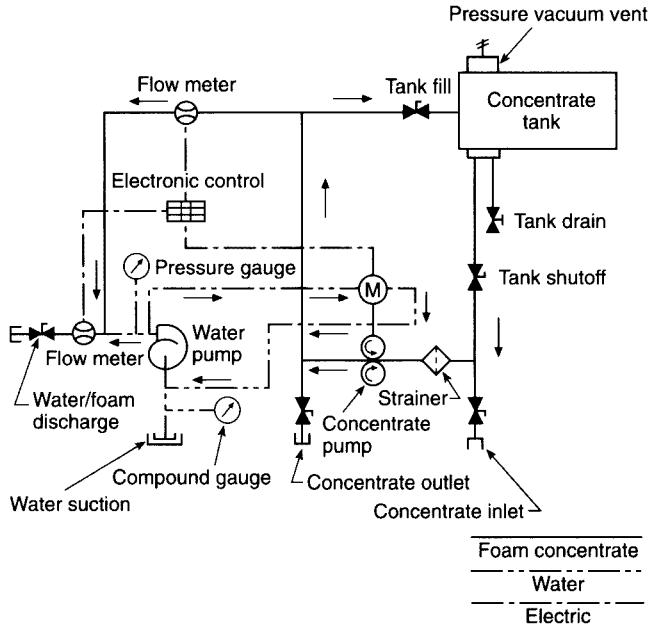


Figure A-17-2.7(b) Water turbine driven flow sensing direct injection foam proportioning system.

Where a positive displacement type water motor drives the foam concentrate pump, the ratio of the water motor displacement to the displacement of the foam concentrate pump is the ratio of the desired foam solution. A positive displacement water motor proportioning system requires no external power. [*See Figure A-17-2.7(a).*]

A water turbine powered type of foam proportioning system uses a water turbine to power a positive displacement foam concentrate pump. Flow meters sense the foam concentrate pump output and the water flow, sending signals to an electronic control which controls the proportioning ratio by adjusting the water turbine speed. [*See Figure A-17-2.7(b).*]

A-17-3.3 Most foam concentrate manufacturers differentiate in the materials they recommend between those foam-proportioning system components that are designed to be

flushed with water after operation and those components that are intended to be continuously wetted with foam concentrate.

A-17-4.1 It is desirable to have a visual indicator at the operator's position that shows that the foam proportioning system is in the "operating" or the "off" position. A visual means of indicating positive foam concentrate flow at the operator's position is also desirable.

A-17-6.3 Suitable means to attach the cover to the fill tower could include use of a threaded cap or a hinged cover with a mechanical latching device.

A-17-6.6 On vehicles where a single foam storage tank is used, provisions should be made to flush the tank and all foam concentrate plumbing to avoid contamination of dissimilar foam concentrates when switching types or brands.

A-17-6.8 The foam concentrate tank(s) can be an integral part of the water tank.

A-17-6.10 Different types and brands of concentrates can be incompatible with each other and should not be mixed in storage. Concentrate viscosity varies with different types of products and temperatures.

A-17-7 The foam concentrate pump is a very critical component of both balanced pressure and direct injection foam proportioning systems. Positive displacement pumps are recommended for several reasons. Positive displacement pumps are relatively slow speed when compared to centrifugal pumps, which is desirable 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-17-7.5 A suitable suction device is required to operate from an external source such as 5-gal (19-L) pails, 55-gal (208-L) drums, and portable tanks or containers.

A-17-9.3 It is desirable for in-line eductor systems to have a label that indicates the system flow rate, the maximum usable hose length, the hose size required, the nozzle type, and allowable elevation changes.

A-17-10 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these tests also be certified by the independent testing organization.

There are four methods for testing a foam proportioning system for calibration accuracy:

Test Method 1. Water is substituted for foam concentrate.

Test Method 2. Foam percent is determined by use of a refractometer.

Test Method 3. Foam concentrate pump output is measured directly.

Test Method 4. Foam percent is determined by use of a conductivity meter.

Test Method 1. Water Is Substituted for Foam Concentrate. The foam system is operated at the water flow rates at which the system is to be tested. Water is used as a substitute for foam concentrate. The substitute water for foam concentrate is drawn from a calibrated tank instead of foam concentrate from the foam concentrate tank. The volume of water drawn from the calibrated tank divided by the volume of water pumped over the same time period times 100 represents the percentage of foam the foam proportioner is producing.

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

To use a refractometer to determine percent of foam solution, a base calibration curve must be prepared using the following equipment:

Equipment Required:

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

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

(a) The nominal intended percentage;
(b) The nominal intended percentage plus 1 percent; and
(c) The nominal intended percentage minus 1 percent.

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

(a) The nominal intended percentage;
(b) The nominal intended percentage plus 0.3 percent; and,
(c) The nominal intended percentage minus 0.3 percent.

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

An alternate method of making up three foam solution samples is to use a very accurate scale. When a very accurate scale is used, only small amounts of water and foam concentrate are required. To use the scale method, the density of the foam concentrate must be known. Look at the data sheet

or the MSDS for the foam product density. For example, to make 100 ml of a 3 percent foam solution using a foam concentrate with a density of 1.04, measure 97 g of water into a beaker and add 3.12 g of foam concentrate to the beaker (1.04 × 3 g = 3.12 g).

After the foam solution samples are thoroughly mixed, a refractive index reading is taken of each percentage foam solution sample. This is done by placing a few drops of the solution on the refractometer prism, closing the cover plate, and observing the scale reading at the dark field intersection. Since the refractometer is temperature compensated, it could take 10 seconds to 20 seconds for the sample to be read properly. It is important to take all refractometer readings at ambient temperatures of 50°F (10°C) or above.

Using standard graph paper, the refractive index readings are plotted on one axis and the percent of concentration on the other. This plotted curve serves as the known baseline for the test series. The solution samples should be set aside in the event the measurements need to be checked.

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

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

Test Method 4. Foam Percent Is Determined by Use of a Conductivity Meter. The conductivity test method is based on changes in electrical conductivity as foam concentrate is added to water. Conductivity is a very accurate method provided there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages. Since salt or brackish water is very conductive, this method might not be suitable due to small conductivity changes as foam concentrate is added to salt or brackish water. It is necessary to make foam and water solutions in advance to determine if adequate changes in conductivity can be detected if the water source is salty or brackish. This method cannot be used when the water base has more total solids than the foam concentrate. Three methods can be used to determine the foam percentage by the conductivity method.

1. *Direct Reading Conductivity Test Method*

Equipment Required:

(a) Two 100-ml or larger containers;

(b) One direct reading foam solution conductivity meter.

Procedure. A sample of the water to be used in the test is obtained using one of the 100-ml or larger containers. The conductivity meter head is immersed in the water sample and the meter display 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 must be developed. The calibration curve might show that the direct meter readings are correct for the foam concentrate being used or it might indicate that the calibration curve must be used when that foam concentrate is used.

The foam proportioning system is operated and a sample of the foam solution produced by the system is collected using the other 100-ml or larger container. The conductivity meter head is immersed in the foam solution sample and the percentage of the foam solution is read on the meter display. If the conductivity meter is mounted in a discharge line, the percentage of the foam solution is read on the meter display while foam solution is being discharged.

2. *Conductivity Comparison Method*

Equipment Required:

(a) Two 100-ml or larger containers;

(b) Conductivity meter reading in ms/cm (microsiemens per centimeter).

Procedure. A sample of the water to be used in the test is obtained using one of the 100-ml or larger containers. Using the conductivity meter, the conductivity valve of the water sample is determined.

The foam proportioning system is operated and a sample of the foam solution produced by the system is obtained using the other 100-ml or larger container. Using the conductivity meter, the conductivity value of the foam solution sample is measured.

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

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

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

3. *Conductivity Calibration Curve Method*

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

Equipment Required:

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

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

(c) One 100-ml or larger graduated cylinder;

(d) Three plastic-coated magnetic stirring bars;

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

(f) Standard graph paper;

(g) A ruler or other straight edge.

Procedure. A base calibration curve is prepared using the water and foam concentrate from the system to be tested. Three standard solutions are made using the 100-ml or larger graduate. These known foam solution samples should include:

(a) The nominal intended percentage;

(b) The nominal intended percentage plus 1 percent; and

(c) The nominal intended percentage minus 1 percent.

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

(a) The nominal intended percentage;

(b) The nominal intended percentage plus 0.3 percent; and

(c) The nominal intended percentage minus 0.3 percent.

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

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

After the foam solution samples are thoroughly mixed, the conductivity of each solution is measured. The instructions that come with the conductivity meter should be consulted to determine proper procedures for taking readings. It is necessary to switch the meter to the correct conductivity range setting in order to obtain a proper reading. Most synthetic-based foams used with fresh water result in foam solution conductivity readings of less than 2000 ms/cm. Protein-based foams generally produce conductivity readings in excess of 2000 ms/cm when fresh water is used to make the foam solution. Due to the temperature-compensation feature of the conductivity meter it could take a short time to obtain a consistent reading.

Once the solution samples have been measured and recorded, the bottles should be set aside for control samples reference. The conductivity readings then should be plotted on the graph paper. It is most convenient to place the foam solution percentage on the horizontal axis and the conductivity readings on the vertical axis.

A ruler or straight edge can be used to draw a line that approximates connecting all three points. While it might not be possible to connect all three points with a straight line, they should be very close. If not, the conductivity measurements should be repeated and, if necessary, new control sample solutions should be made until all three points plot in a nearly straight line. This plot serves as the known base (calibration) curve to be used for the test series.

Sampling and Analysis. Foam solution samples are collected from the proportioning system using care to be sure the sample is taken at an adequate distance downstream from the foam proportioner being tested. Using foam solution samples that have been allowed to drain from expanded foam can produce misleading conductivity readings; therefore this type of sample should not be used to determine percent of foam solution.

When test samples have been collected, their conductivity is measured and the percent of foam solution is determined from the base curve prepared from the control sample foam solutions.

A-18-1 The following terms are not used in this document but are associated with compressed air foam systems and are included here to aid in understanding.

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

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

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

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

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

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

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

A-18-2.1 It is desirable that the concentrate proportioning system be automatic, inject into the discharge side of the pump, and proportion at a minimum water flow of 2 gpm (8 L/min).

A-18-2.5 It is recommended that compressed air not be injected into the water/foam discharge piping until the flow of water/foam solution has been established in the discharge piping. The nozzle reaction at the end of a hose can be quite high if just air or air and water with no foam solution is flowing in the discharge line. The nozzle reaction could be a safety issue with an operator that is not expecting or not properly braced to withstand this reaction force. The reaction force is substantially reduced when a foam solution is flowing in the discharge hose.

A-18-4 If it is desired to test the expansion ratio, the following test is recommended.

Equipment Required:

(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).

The empty container is placed on the scale and the scale is set to zero. Using the container, a full sample of foam is collected and the foam is struck at the 1000-ml level. The container is placed on the scale and the mass is read in grams.

$$\text{Expansion ratio} = \frac{100}{\text{Foam mass in grams}^{1}}$$

A-18-5 Any components of the piping system exposed to pressurized air from the CAFS should be designed for at least 500 psig (344 kPag) burst pressure.

[1]This assumes that 1 g of foam solution occupies 1 ml of volume.

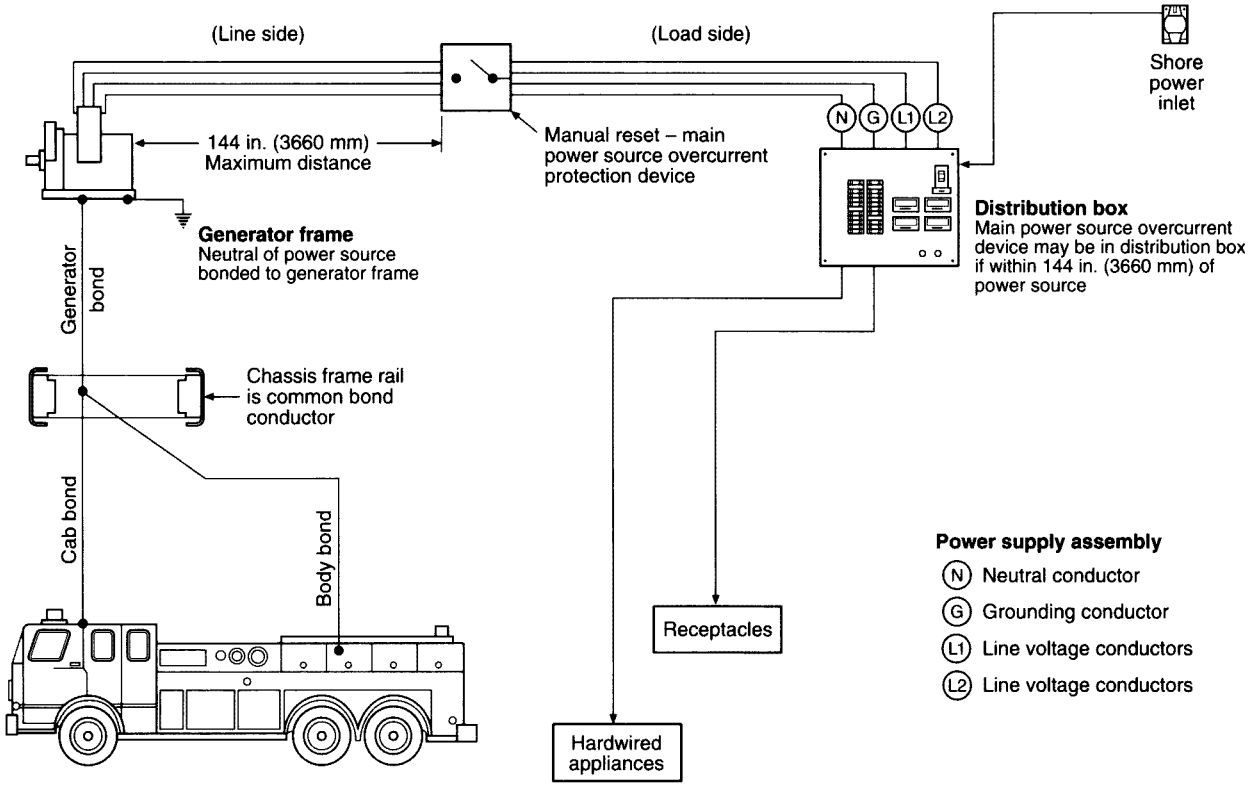


Figure A-19-1 Typical line voltage electrical system.

A-18-7.6 Some systems provide automatic regulation of the water flow, however, instrumentation is still useful to the operator. Even automatic systems have adjustments and performance limits which warrant instrumentation. Where the system design does not allow for such automatic regulation, or where the operator has the ability to control water flow or airflow, air and water flow meters are necessary for the operator to monitor the operational performance of the CAFS where the nozzle person cannot be seen. Where pumping long hose lays or pumping to great heights, the operator must know what is flowing in order to be certain the proper product is being delivered.

A-18-9 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these tests also be certified by the independent testing organization.

A-18-9.1.3 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 hearing, eye, and dust protection during the airflow test.

A-18-9.2 The person conducting the test should check with the manufacturer of the hose being used to ensure the hose has been approved for use with CAFS.

A-19-1 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 power supply assembly also includes a manually resetable, main power source overcurrent protective device.

The neutral conductor of the power supply assembly is grounded to the generator frame. This is the only location that the neutral is grounded in the entire system. The power supply assembly terminates at the panelboard for distribution to the rest of the system. Figure A-19-1 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:

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

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

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

(d) 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.

(e) If an earth grounded system is required, the details of grounding rods, plates, clamps, or other means to establish bonding of the vehicle and the power source to the earth.

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 line voltage equipment use is extensive, a separately driven generator is 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 cycles is normally required. However, because of the substantial reduction of size and cost that results from three-phase operation, ac motors larger than 5 horsepower 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.

If premises wiring or other fixed wiring systems are to be powered by the generator, the installation should be preplanned and in accordance with NFPA 70, *National Electrical Code*, for that intended purpose. Grounding of the system should comply with Section 250-5 (*Alternating-Current Circuits and Systems to Be Grounded*) and other applicable sections of the *NEC*.

A-19-2.1 On certain unregulated-voltage generators, (other than engine speed regulation) the voltage range might exceed 250 volts until saturation is reached or sufficient load is applied.

A-19-2.4 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-19-3.1 Because of the non-earth grounded nature of apparatus mounted line voltage equipment and the wet environment in which it operates, great care should be taken in the use and maintenance of such line voltage circuits and equipment. Ground fault protection for personnel should be furnished through an assured equipment grounding conductor program in accordance with Section 305-6(b) (*Assured Equipment Grounding Conductor Program*) of the *NEC*. All cord sets, receptacles, and electrical equipment should be maintained in accordance with NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.

This protection can be supplemented by the use of ground-fault circuit-interrupters. These GFCIs should be attached to the end of distribution cords and located close enough to the equipment being operated that the GFCI can be conveniently reset in the event it trips. Locating GFCI devices as close as possible to the end of a cord will reduce tripping caused by stray capacitance and leakage associated with long cord lengths and multiple connections.

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

A-19-4.7.2 The purchaser should consider the following additional remote instruments where a prime mover, other than the propulsion engine, is used to drive a generator.

(a) Prime mover tachometer;

(b) Oil pressure gauge and low pressure indicator light and audible alarm;

(c) Engine temperature gauge and high temperature indicator light and audible alarm.

The instrumentation should be protected from vibration that can lead to false readings. Particular attention should be paid to reed type cycle indicators. Digital electronic instrumentation should be selected that incorporates sample times and intervals that accurately report system performance under varying conditions.

A-19-5.1 A PTO generator system typically consists of a propulsion engine, a controller to regulate the propulsion engine's speed, an appropriate PTO arrangement, drive train components, a generator, and other miscellaneous parts.

A-19-5.1.1 Where possible, the generator PTO system should be prevented from engaging if engine speed is above idle.

PTO gear ratios and engine governor components should be selected and matched to provide an engine speed high enough to maintain adequate performance of the alternator and air conditioning system (if provided). Engine speed should be high enough to maintain adequate performance of the low voltage electrical system. Continuous excessive engine speed will result in premature generator drive train component failure and unnecessary fuel consumption.

The purchaser should consider the specification of a means to automatically disconnect the generator or reduce engine speed to idle in the event of engine overspeed.

A-19-5.1.2 Operations in conjunction with a fire pump, aerial device, or other component driven off the vehicle's engine could require special or alternate interlock systems.

A-19-5.2 A hydraulic generator system generally consists of a variable displacement hydraulic pump deriving its power from the propulsion engine, a controller to regulate the hydraulic fluid flow rate, a hydraulic motor driving the generator, hydraulic fluid cooler, reservoir, and other miscellaneous parts.

All hydraulic generator systems have a window of operation (speed range). When selecting the power output of the hydraulic generator system, its speed range should be compared to the operating window of the vehicle's engine and the PTO ratios available. By selecting the hydraulic generator system and PTO ratio to match the application, electrical power can be provided over a wide operating range.

The selected PTO should have a gear ratio that will allow the widest possible range of engine speeds without over speeding the hydraulic pump.

Where possible, engagement of the generator PTO system should be prevented if engine speed is above idle.

A-19-5.2.1 This means may be either a mechanical or hydraulic device.

A-19-5.2.4.3 The use of 90-degree fittings should be avoided.

A-19-5.2.4.4 Hose runs should not include "S" turns that would allow air to be trapped.

A-19-5.3 Engine-driven generator systems use an internal combustion engine close coupled to a generator. Some

installations are capable of producing power while the vehicle is in motion. Generators used in these applications should be specifically designed for mobile applications. Remote generator controls should be considered and specified if desired.

A-19-5.3.3.1 Emissions from exhaust discharge pipes should be directed away from any fire-fighting tools since such emissions contain an oily substance that could make the tools difficult to handle and possibly dangerous to use.

A-19-5.4 Belt-driven generator systems use a voltage regulator and a generator driven off the propulsion engine. The complexity of modern engine drive belt configurations limit power output to about 6000 watts. This system will generally maintain acceptable voltage, but the frequency will vary with engine speed. Motor loads should not be powered by this type of power supply.

An alternative system uses a separately driven alternator to supply electrical energy to an invertor which in turn produces line voltage electrical power. These systems are separate from, and do not effect, the performance of the low voltage electrical system. These systems are voltage regulated and provide ample power for scene lighting. Due to belt-driven configuration, the system is still subject to low voltage at idle conditions which could damage motors.

A-19-5.5.1 A brief description of several different types of systems follows. All of these systems can overload the low voltage electrical system and cause the load management system to terminate the generation of line voltage. As a result, the amount of line voltage power that can be supplied, at any given time, is totally dependent on the other, higher priority demands placed on the low voltage system.

Dynamic Power Inverter. A dynamic power invertor converts alternator output power to 120 volts ac (or 120/240 volts ac). Power is electronically inverted to ac. Usually the largest system of this type is 7500 watts. Voltage and frequency control are typically very good.

Static Power Inverter. A static power invertor converts 12-volt to 14-volt dc power to 120-volt ac (or 120/240 volts ac) power. Power is electronically inverted to ac. Usually the largest system of this type is 2000 watts. Voltage and frequency control are typically very good.

Motor-Driven Generators. A motor-driven generator system converts 12-volt dc power to 120-volt ac (or 120/240 volts ac) power. The 12-volt dc motor drives an ac generator. Typical power ratings are less than 1600 watts. Voltage and frequency control are less precise than some of the other systems available. These types of systems are suited to providing electric power while the apparatus is in motion.

Transformers. Transformer systems convert energy from the alternator that is then rectified to 120-volt dc power. Typical installations provide 1000 watts. Output voltage is directly dependent upon input voltage. Input voltage is dependent on engine and alternator speed.

A-19-6 Portable generator systems are generally 8 kW or less and designed with an integral fuel tank and controls in one modular package. This allows the system to be picked up and transported to a remote location from the vehicle. Generators designed for portable use should be easily accessible for removal. These generators are generally not suited for "enclosed" compartment operation.

The generator performance specifications should be evaluated carefully to ensure the required level of performance can be met. Article 445 (*Generators*) of the *NEC* requires that overcurrent protection be provided on portable generators.

A-19-7.1 The purchaser should specify the location on the apparatus for the power inlet. Consideration should be given to placement of the power inlet so that it disconnects if the vehicle is moved forward.

A-19-7.2.2 This paragraph differs from the requirements in the *NEC* in that this standard does not permit two sources to be simultaneously connected together.

A-19-10.3 Common connectors and terminations that comply with these requirements include the following:

(a) Welded or brazed connectors;

(b) Crimped connectors;

(c) Soldered connections that are mechanically secured before soldering;

(d) Screw-type positive pressure connectors;

(e) Ring terminals;

(f) Hooks;

(g) Upturned spade;

(h) Crimped-on pins;

(i) Other methods providing a positive mechanical and electrical connection that are acceptable to the authority having jurisdiction.

A-19-10.4 The following switch terminology can be helpful in understanding the different types of switches.

One Pole (1P) or Single Pole (SP). A switch device that opens, closes, or changes connections in a single conductor of an electrical circuit.

Two Pole (2P) or Double Pole (DP). A switch device that opens, closes, or changes connections in both conductors of the same circuit.

Two Circuit (2 CIR). A switch device that opens, closes, or changes connections in a single conductor of two independent circuits.

Single Throw (ST). A switch that opens, closes, or completes a circuit at only one of the extreme positions of its actuator.

Double Throw (DT). A switch that opens, closes, or completes a circuit at both extreme positions of its actuator.

Normally Open (NO). A switch in which one or more circuits are open when the switch actuator is at its normal or rest position.

Normally Closed (NC). A switch in which one or more circuits are closed when the switch actuator is at its normal or rest position.

Switch Ratings — Types of Loads

(a) Resistive;

(b) Inductive;

(c) Horsepower (i.e., motor loads);

(d) Tungsten (i.e., incandescent lamp loads);

(e) Alternating current;

(f) Direct current.

The ampere rating of a given switch is dependent on the type of load. In particular, switches used to control dc circuits should have the appropriate dc rating.

A-19-10.4.2 In lieu of a "switch-rated" circuit breaker, a standard circuit breaker could be used with a separate switching device.

A-19-10.5.1.1 The purchaser should specify the number and location of receptacles that are needed to operate the devices to be powered by the system. The purchaser should specify the NEMA number (if applicable), manufacturer, and style of the receptacles desired. For other than NEMA type receptacles, the purchaser should additionally specify the wiring configuration.

A 19-10.5.1.2 If the "off-road" vehicle is to ford water, the receptacle distance should be increased above 30 in. (762 mm). The purchaser should review the proposed height for any receptacles on the apparatus and specify a higher mounting height if desired.

A-19-10.5.5 While NEMA configurations as defined in NEMA WD-6, *Wiring Devices — Dimensional Requirements*, are recommended to promote compatibility of equipment during mutual aid operations, other configurations are in use and have been adopted by various fire departments.

Acceptable NEMA-type plug and receptacle configurations for various ac voltage and current ratings are shown in Figure A-19-10.5.5.

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

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

A-19-11.4 A suggested minimum capacity of a reel is at least 100 ft (30.5 m) of cable rated to carry 20 amperes at 120 volts ac. When sizing the reel, extra capacity should be provided when multiple receptacles are attached to the cable stored on the reel.

A-19-11.5 The cable on the reel should be provided with a disconnect means within 18 in. (457 mm) from the reel for cable removal if the cable is 8 AWG or smaller.

A-19-11.6 The purchaser might want to color code the cable or cable reel to identify the voltage.

A-19-11.7.2 It might be desirable to specify a remote power distribution box that has a provision for hanging the unit from a door or ladder.

A-19-11.7.3 Consideration should be given to the use of GFCI devices mounted in the remote power distribution box to provide additional protection to personnel using equipment powered through the box.

A-19-11.7.5 The lamps used in this application should be "rough service" type. Scene lighting around the remote power distribution box can be provided with an integral, mechanically protected light fixture.

For increased visibility, reflective tape can be applied to the distribution box.

A-19-13.1 The purchaser should specify the type of rotation, telescopic, pan and tilt operations, and other features that are required.

A-19-13.2.3 To reduce the electrocution hazard associated with the operation of masts above the apparatus, the purchaser should consider specifying one or more of the following:

(a) A slide-out operator's platform;
(b) A raised remote platform on the vehicle;
(c) A wireless remote control;
(d) Appropriate warning labels.

A-19-13.2.8 The lighting assembly should be supported when it is in a "transport mode" to prevent damage to lighting assembly from vibration.

A-19-14.1 If the tests of some components of the apparatus are being certified by an independent testing organization, the purchaser might wish to specify that these tests also be certified by the independent testing organization.

A-19-14.3 The fire department should check the polarity of the wiring in a building prior to interconnecting the vehicle mounted electrical system to the electrical system in a building.

A-19-14.4.1 The purchaser should consider the range of temperatures in which the power source is to be operated. If extreme conditions are anticipated, the purchaser should specify any specific test conditions that are desired.

A-19-14.4.2 Category certified line voltage electrical systems have already been tested and proven their capability to perform as designed. The shorter test is intended to verify that the system is correctly wired and that the individual components are operating correctly.

A-20-2 The command center could be an area of the crew compartment, the apparatus body, or a portion of either of these areas. The environment for the area is subject to wide variations in size, noise levels, facilities, and appointments. Command areas in enclosed body areas could be designed to accommodate several personnel. Normally it is common to separate the crew or equipment areas from command areas. A separate entry and enclosed area might be required by the purchaser.

A-20-2.1 If a separately enclosed area is desired, the purchaser should specify the arrangements desired and whether a locking door is necessary.

A-20-2.2 The exact layout, design, and usage of the command area should be determined by each purchaser for each vehicle.

A-20-3 If such equipment is to be thermostatically controlled automatically, the purchaser should so state. Powered or nonpowered ventilation equipment should be provided as required by the purchaser.

A-20-4 Supplemental floor, wall, and ceiling acoustical material should be added where required to reduce noise levels below 80 dba.

A-20-5.2 The cab or crew cab command areas should be provided with 120-volt lighting systems to reduce 12-volt loads.

A-20-6.1 Removable Plexiglas® or wired safety glass-type surfaces can be added to the top of work surfaces.

Nonlocking plugs and receptacles

		15 Ampere		20 Ampere		30 Ampere		50 Ampere		60 Ampere	
		Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug
2-pole 3-wire grounding	5 125 V	 5-15R	 5-15P	 5-20R	 5-20P	 5-30R	 5-30P	 5-50R	 5-50P		
	6 250 V	 6-15R	 6-15P	 6-20R	 6-20P	 6-30R	 6-30P	 6-50R	 6-50P		
3-pole 4-wire grounding	14 125/ 250 V	 14-15R	 14-15P	 14-20R	 14-20P	 14-30R	 14-30P	 14-50R	 14-50P	 14-60P	 14-60P
	15 3 ø 250 V	 15-15R	 15-15P	 15-20R	 15-20P	 15-30R	 15-30P	 15-50R	 15-50P	 15-60P	 15-60P

Locking plugs and receptacles

		15 Ampere		20 Ampere		30 Ampere		50 Ampere		60 Ampere	
		Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug
2-pole 3-wire grounding	5 125 V	 L5-15R	 L5-15P	 L5-20R	 L5-20P	L5-30R	L5-30P	L5-50R	L5-50P	L5-60R	L5-60P
	6 250 V	L6-15R	L6-15P	L6-20R	L6-20P	L6-30R	L6-30P	L6-50R	L6-50P	L6-60R	L6-60P
3-pole 4-wire grounding	14 125/ 250 V	L14-20R	L14-20P	L14-30R	L14-30P	L14-50R	L14-50P	L14-60R	L14-60P
	15 3 ø 250 V	L15-20R	L15-20P	L15-30R	L15-30P	L15-50R	L15-50P	L15-60R	L15-60P
4-pole 5-wire grounding	21 3 ø 208 Y 120 V	L21-20R	L21-20P	L21-30R	L21-30P	L21-50R	L21-50P	L21-60R	L21-60P

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Figure A-19-10.5.5 Common NEMA plug configurations.