NFPA 414
Standard for Aircraft Rescue and Fire Fighting Vehicles

1995 Edition

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

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Standard for

Aircraft Rescue and Fire-Fighting Vehicles

1995 Edition

This edition of NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles*, was prepared by the Technical Committee on Aircraft Rescue and Fire Fighting and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 22-25, 1995, in Denver, CO. It was issued by the Standards Council on July 21, 1995, with an effective date of August 11, 1995, and supersedes all previous editions.

This edition of NFPA 414 was approved as an American National Standard on August 11, 1995.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 414

In 1960, a tentative edition of this standard was adopted by the Association. The original document was further revised in 1962, 1963, 1964, 1965, 1967, 1968, 1969, 1970, 1975, and 1978.

In 1984, the standard was revised completely to identify three types of vehicles and to make the document easier to use. The text also was rewritten to conform with the NFPA *Manual of Style*.

The standard was revised again in 1990, and a chapter was added to provide a test method to verify the design requirements.

Notable revisions to the 1995 edition include the removal of requirements for a separate category of rapid intervention vehicle.

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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 membership may have occurred. A key to classifications is found at the back of this document.

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

Committee Scope: This Committee shall have primary responsibility for documents on aircraft rescue and fire-fighting services and equipment, for procedures for handling aircraft fire emergencies, and for specialized vehicles used to perform these functions at airports, with particular emphasis on saving lives and reducing injuries coincident with aircraft fires following impact or aircraft ground fires. This Committee also shall have responsibility for documents on aircraft fire investigation procedures as an aid to accident prevention and the saving of lives in future aircraft accidents involving fire.

Contents

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

Information on referenced publications can be found in chapter 5 and Appendix E.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard specifies the optimum design, performance, and acceptance criteria for aircraft rescue and fire-fighting vehicles intended to carry rescue and fire-fighting equipment for rescuing occupants and combating fires in aircraft on, or in the vicinity of, an airport.

1-1.2 This standard shall cover three types of vehicles as follows:

(a) Major vehicles;

(b) Rapid intervention vehicles; and

(c) Combined agent vehicles.

1-1.3 Vehicles without wheels, such as track, amphibious, or air-cushion types, are not covered by this standard.

1-1.4 The design criteria for the standard vehicles described by this document shall consider temperature extremes ranging from 32°F to 110°F (0°C to 43.3°C). For cold weather operation where temperatures periodically range from –40°F to 32°F (–40°C to 0°C) or lower, some type of winterization system shall be specified by the purchaser.

1-2 Purpose.

1-2.1 The purpose of this standard is to specify features and components that, when assembled, produce an efficient and capable fire-fighting vehicle for both on-pavement and off-pavement performance. Off-pavement capability is important to ensure timely and effective response of these vehicles to aircraft accident sites located off paved surfaces. Fire-fighting capabilities are considered to be optimum for the proper performance of these vehicles.

1-2.2 It is not the purpose of this standard to serve as a detailed purchase specification. Drafting of complete specifications for bidding purposes is the responsibility of the purchaser.

1-3 *Definitions.

AFFF. See Aqueous Film-Forming Foam Concentrate.

Aggressive Tire Tread. Tread designed to provide maximum traction for all types of surfaces. These include sand, mud, snow, ice, and hard surfaces, wet or dry.

Air-Cooled Engine. An engine in which the heat produced by the cylinder walls is absorbed directly by the atmosphere rather than by being absorbed by a liquid coolant that acts only as a vehicle for transferring the heat from the engine to a radiator.

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

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

All-Wheel Drive. A vehicle that drives on all wheels such as described in (b), (d), and (e) under the definition of Vehicle Types.

Ambient Temperature. The average temperature of the environment surrounding a vehicle.

Angle of Approach. The measure of the steepest ramp that a fully loaded vehicle can approach. It is determined by the horizontal ground line and the line tangent to the loaded radius of the front tire extended forward to that fixed point on the vehicle that forms the smallest angle.

Angle of Departure. The measure of the steepest ramp from which the fully loaded vehicle can depart. It is determined by the horizontal ground line and the line tangent to the loaded radius of the rear tire extended rearward to that fixed point on the vehicle that forms the smallest angle.

Approved.* Acceptable to the authority having jurisdiction.

Aqueous Film-Forming Foam (AFFF) Concentrate. A concentrated aqueous solution of fluorinated surfactant(s) and foam stabilizers that is capable of producing an aqueous fluorocarbon film on the surface of hydrocarbon fuels to suppress vaporization.

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

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

Axle Tread. The distance between the center of two tires or wheels on one axle. Where dual tires and wheels are used at each end of an axle, the tread is measured as the distance between centers of the pairs of tires or wheels.

Bogie. A combination of two axles used to support the end of a vehicle; therefore, in a 6×6 vehicle, there are two axles at the rear of the vehicle to support the weight on the rear. This two-axle combination is called a "rear bogie." With an 8×8 vehicle, there are two axles in the front and two axles in the rear; therefore, there is a front bogie and a rear bogie.

Center of Gravity. The point within a vehicle at which all of its weight can be considered to be concentrated. Where a vehicle is tipped to such a degree that a vertical line passing through the center of gravity falls on the ground outside the tire track, it is unstable and can turn over.

Chassis. The assembled frame, engine, drive train, and tires of a vehicle.

Component Manufacturer's Certification. A signed application approval furnished by the component manufacturer that certifies the following:

(a) The component is approved as being properly installed or applied, or both, in the vehicle for its intended use; or

(b) The component complies with the respective construction criteria required by the standard.

Cooling Preheater Device. A device for heating the engine coolant so that the engine is maintained at a constant temperature. It usually consists of a coolant jacket and an electric heating element. The engine coolant flows through the preheater jacket and is heated by the heating element, which obtains its power from an outside source, thereby maintaining the engine coolant at a constant temperature for fast starting.

Dry Nitrogen, Dry Air. Nitrogen or air that has a dew point of –60°F (–51°C) or lower.

Extendable Turret. A device, permanently mounted with a power-operated boom or booms, designed to supply a large-capacity, mobile, elevatable water stream or other fire-extinguishing agents, or both. The operator, while at the scene of the fire, has the ability to reposition the primary turret and attachments to a location that enhances the visibility of and access to hard to reach areas, thus providing the opportunity to utilize fire-fighting agents most effectively.

Fluid Coupling. A turbine-like device that transmits power solely through the action of a fluid in a closed circuit without direct mechanical connection between input and output shafts and without producing torque multiplication.

Fluoroprotein Foam Concentrate. A protein foam concentrate incorporating one or more fluorochemical surfactants to enhance its tolerance to fuel contamination.

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

Foam-Liquid Concentrate Percentage. The percentage of foam-liquid concentrate in solution with water.

Fully Loaded Vehicle. A fully loaded vehicle shall consist of the fully assembled vehicle, complete with a full compliment of crew, fuel, and fire-fighting agents. The crew allowance shall be 175 lb (79.3 kg) per seating position. Unless otherwise specified, the equipment allowance shall be 250 lb (113.3 kg) per storage compartment up to a maximum of 1000 lb (453.6 kg). Where the customer specifications require that more equipment shall be carried, the actual weight of the equipment shall be included.

In-Service Condition. A state or condition of readiness for intended duty; usually an emergency vehicle properly serviced with all equipment properly loaded and ready for immediate response.

Intended Airport Service.* All aspects of aircraft rescue and fire-fighting services as provided by this standard.

Interaxle Clearance Angle (Ramp Angle). The measure of the ability of a fully loaded vehicle to negotiate a ramp without encountering interference between the vehicle and the ramp between any two axles. It shall be determined by the horizontal ground line and whichever of the following lines forms the smaller angle:

(a) The line tangent to the loaded radius of the front tire extended rearward to that fixed point on the vehicle, ahead of a vertical line midway between the two axles, that determines the smallest angle;

(b) The line tangent to the loaded radius of the rear tire extended forward to that fixed point on the vehicle, behind a vertical line midway between the two axles, that determines the smallest angle.

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

Lightweight Construction. The use of nonferrous metals or plastics or a reduction in weight by the use of advanced engineering practices resulting in a weight saving without sacrifice of strength or efficiency.

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

May. This term is used to state a permissive use or an alternative method to a specified requirement.

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

Off-Pavement Performance. A vehicle's ability to perform or operate on other than paved surfaces. "Other than paved surfaces" includes dirt roads and trails and open cross-country of all kinds. This ability sometimes is referred to as off-road mobility or cross-country mobility. All of these terms are synonymous.

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

Overall Height, Length, and Width. The dimensions determined with the vehicle fully loaded and equipped, unless otherwise specified. These dimensions shall include all fixed protrusions that could in any way hinder the passage of the vehicle. Dimensions that include a movable protrusion shall be determined with the protrusion in its normally stored position.

Percent Grade. The ratio of the change in elevation to the horizontal distance traveled multiplied by 100. A change in elevation of 50 ft (15.2 m) over a horizontal distance of 50 ft (15.2 m) is equivalent to a grade of 100 percent.

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

Protein Foam Concentrate. A concentrate consisting primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and otherwise to ensure readiness for use under emergency conditions.

Prototype Vehicle. The first vehicle of a unique vehicle configuration built to establish its performance capability and the performance capability of all subsequent vehicles manufactured from its drawings and parts list. A given chassis, body, and fire-fighting system and fully loaded weight condition shall constitute a vehicle configuration. Product improvements and customer options shall negate previously conducted prototype tests only if they substantially affect a performance factor.

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

Reserve Capacity Rating. The number of minutes a new, fully charged battery at 80°F (26.7°C) can be discharged at 25 amperes while maintaining 1.75 volts per cell or higher.

Rubber-Gasketed Fitting. A device for providing a leakproof connection between two pieces of pipe while allowing moderate movement of one pipe relative to the other. It incorporates a rubber seal held in place by a two-piece clamp that also engages annular grooves near the end of each pipe to prevent pullout under pressure.

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

Shall. Indicates a mandatory requirement.

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

Steering Drive Ends. Steering drive ends or stub shafts are in the front wheel spindle in a driving–steering axle as used at the front of an all-wheel drive vehicle. The universal joint that allows steering while transmitting power is supported by the steering drive end at its inner end, and the outer end is connected to the wheel hub through a driving flange.

Ton. Weight equivalent to 2000 lb (906 kg).

Torque Converter. A device that is similar to a fluid coupling but that produces, by means of additional turbine blades, variable torque multiplication.

Twenty-Five (25) Percent Drainage Time. The time in minutes that it takes for 25 percent of the total liquid contained in the foam collected in a specified manner to drain. A method of measuring drainage time is provided in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment.*

Underbody Clearance Dimensions. The dimensions determined with the vehicle fully loaded and fully equipped, unless otherwise specified. These dimensions shall include all components of the vehicle, except those that are part of the axle assemblies, that could hinder the passage of the vehicle.

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

Unsprung Weight. The total weight of all vehicle components that are not supported completely by the suspension system.

Vehicle Types. Vehicle types are designed as 4 × 2, 4 × 4, 6 × 4, 6 × 6, and 8 × 8. These designations are used to indicate the number of wheels on the vehicle and the number of wheels that propel or drive the vehicle. The term "wheel" in this designation is interpreted to mean either a single tire or a set of dual tires operating as one tire. The first number is the number of wheels, the second number is the number of driving wheels, therefore:

(a) A 4 × 2 vehicle has four wheels and drives on two wheels.

(b) A 4 × 4 vehicle has four wheels and drives on all four wheels.

(c) A 6 × 4 vehicle has six wheels and drives on four wheels.

(d) A 6 × 6 vehicle has six wheels and drives on all six wheels.

(e) An 8 × 8 vehicle has eight wheels and drives on all eight wheels.

Wall-to-Wall Turning Diameter. A measurement of the space that completely contains a vehicle as it is being turned. It is, therefore, the diameter of the smallest circle that can be described by the outermost point on the vehicle as it negotiates a 360-degree turn to the right or left.

Weatherproof. Sufficiently protected to prevent the penetration of rain, snow, and wind-driven sand, dirt, or dust under all operating conditions. This term is not intended to describe items that are watertight or submersible.

Weathertight. Having sufficient compartment closure to prevent the penetration of rain, snow, and wind-driven sand, dirt, or dust under all operating conditions. This term is not intended to describe items that are watertight or submersible.

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

1-4 Requirements for All Aircraft Rescue and Fire-Fighting Vehicles — Responsibility of Contractors/Suppliers.

1-4.1* The aircraft rescue and fire-fighting vehicle manufacturer shall assume responsibility for the design, construction, and performance of all component parts of the complete vehicle, even if major portions are subcontracted, and shall certify that the completed vehicle meets the requirements of this standard.

1-4.2 The manufacturer shall supply at time of delivery at least two complete copies of the following manuals:

(a) Operator's manual;

(b) Service manual;

(c) Parts manual.

These manuals shall cover the entire vehicle and shall be in accordance with 1-4.2.1 through 1-4.2.3.2.

1-4.2.1 Operator's Manual. Operating instructions shall include all information required for operation of the vehicle, vehicle components, fire-fighting systems, and integral vehicular options. The location and function of all controls and instruments shall be covered by illustrations and descriptions.

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

(a) A complete description of the vehicle and special equipment;

(b) Preparation for use of the vehicle upon receipt;

(c) Daily maintenance and mission readiness checks to be performed by the operator;

(d) Periodic operator inspection.

1-4.2.2 Service Manual. The repair and overhaul instructions shall be factual, specific, concise, and clearly worded. The instructions shall cover such typical maintenance and repair operations as troubleshooting, adjustment procedures, minor and major repairs and overhaul, removal and replacement of units, assemblies and subassemblies, and complete instructions for disassembly and reassembly of components. The instructions also shall include data that include tolerances, specifications, and capacities. Illustrations, wiring diagrams, and exploded views shall be used to clarify text and shall appear as close to the related text as possible. Special tools needed for the repair and overhaul of the equipment shall be specified and illustrated. The service manual shall contain a suitable index.

1-4.2.3 Parts Manual. The parts list shall include illustrations and exploded views necessary for the proper identification of all parts, assemblies, and subassemblies. Assemblies or components shall be shown in illustrations and shall be identified by reference numbers that correspond to the reference numbers in the parts list. The size, thread dimensions, and special characteristics shall be given on all nonstandard nuts, bolts, washers, grease fittings, and similar items. The parts identification manual shall provide the description and quantity of each item used per vehicle. The parts identification manual shall contain a numerical index.

1-4.2.3.1 The vehicle manufacturer shall ensure the purchaser that parts critical to the mission of the vehicle are shipped within 48 hours. The original equipment manufacturers shall be disclosed to the owner if the vendor is unable to supply the necessary parts within this time frame to allow local purchase of an equivalent part.

1-4.2.3.2 A qualified and responsible representative of the contractor shall instruct personnel specified by the purchaser in the operation, care, and maintenance of the vehicle delivered. The purchasers shall specify provisions for training, including the location and duration, and shall agree on suitable training aids such as video tapes and training manuals.

1-4.3 Metal Finish.

1-4.3.1 All exposed ferrous metal surfaces that are not plated or of stainless steel or that are not otherwise treated to resist corrosion shall be cleaned thoroughly and prepared and shall be painted in the color(s) specified by the purchaser. If nonferrous body components are furnished, the purchaser shall specify which surfaces are to be painted. The paint, including the primer, shall be applied in accordance with the paint manufacturer's recommendation.

1-4.3.1.1 Paint finish shall be selected for maximum visibility and shall be resistant to damage from fire-fighting agents.

1-4.3.1.2 Dissimilar metals shall not be in contact with each other. Metal plating or metal spraying of metals of dissimilar base to provide electromotively compatible abutting surfaces shall be permitted. The use of dissimilar metals separated by suitable insulating material shall be permitted.

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

1-4.3.1.3 Materials that deteriorate when exposed to sunlight, weather, or operational conditions normally encountered during service shall not be used or shall have a means of protection against such deterioration that does not prevent compliance with performance requirements.

1-4.3.1.4 Protective coatings that chip, crack, or scale with age or extremes of climatic conditions or when exposed to heat shall not be used.

1-4.3.1.5 The use of proven, nonmetallic materials in lieu of metal shall be permitted, provided such use contributes to reduced weight, lower cost, or less maintenance and there is no degradation in performance or increase in long-term operations and maintenance costs.

1-4.4 Lettering, Numbering, and Striping.

1-4.4.1 Vehicle numbering, lettering, and minimum 8-in. (0.2-m) wide reflective striping shall be provided in accordance with ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*. Striping shall be placed horizontally on the sides of the vehicle below the body centerline. Vehicles shall display an identification number on each side and roof. Side numbers shall be a minimum of 16 in. (0.4 m) in height. Roof numbers shall be a minimum of 24 in. (0.6 m) in height and affixed with their base toward the front of the vehicle. Numbering, lettering, and striping shall be in sharp contrast to the vehicle color.

Chapter 2 Major Fire-Fighting Vehicles

2-1 General.

2-1.1 The category of major vehicles shall encompass a range of water capacity commencing at 1000 gal (3785 L) and extending to over 6000 gal (22 710 L). Because the same performance cannot be expected of all vehicles within this range, vehicles shall be classified into water capacity ranges within which a similar level of performance is practical.

2-1.2 Table 2-1.2 provides vehicles rated in gallons that shall be used to establish the class of vehicle.

2-2 Weights and Dimensions.

2-2.1 Weights.

2-2.1.1 The actual gross vehicle weight of a fully staffed, loaded, and equipped vehicle ready for service shall not exceed the manufacturer's gross vehicle weight rating.

2-2.1.2* The weight shall be distributed as equally as practical over the axles and tires of the fully loaded vehicle. The difference in weight between tires on any axle shall not exceed 5 percent of the average tire weight for that axle. The difference in weight between any two axles shall not exceed 10 percent of the weight of the heaviest axle if the heavy axle is a rear axle.

Table 2-1.2 Vehicle Water Capacities

Class	Minimum Rated Water Capacity (gal)	(L)
1	1000	3785
2	1500	5677.5
3	2500	9462.5
4	3000	11,355
5	4000	15,140
6	5000	18,925
7	6000	22,710

If the heavy axle is a front axle, the weight difference between that axle and any other axle shall not exceed 5 percent of the heavy axle weight. Under no circumstances shall the axle and tire manufacturers' ratings be exceeded.

2-2.1.3 The center of gravity of the vehicle shall be kept as low as possible under all conditions of loading. Vehicles in Classes 1, 2, 3, and 4 through 7 shall be able to stand on sideways slopes of 30 degrees, 28 degrees, 26.5 degrees, and 24 degrees (58 percent, 53 percent, 50 percent, and 45 percent, respectively).

2-2.1.4 The vehicle also shall be driven on a steering pad around a circle with a radius of 100 ft (30.5 m). The steering wheel rotation shall increase with acceleration of speed to ensure the vehicle does not exhibit oversteer characteristics. A speed in excess of 22 mph (35.4 km/h) shall be obtained with vehicles in Classes 1 and 2, and a speed in excess of 18.5 mph (29.8 km/h) shall be obtained with Classes 3 through 7 vehicles.

2-2.2 Dimensions.

2-2.2.1 The vehicle clearance shall allow mobility in soft soils and rough terrain with the vehicle tires inflated to highway inflation pressures. The minimum dimensions shall be as follows:

(a) Angle of approach — 30 degrees;

(b) Angle of departure — 30 degrees;

(c) Interaxle clearance angle — 12 degrees;

(d) Underaxle clearance — 13-in. (33.0-cm) underaxle differential housing bowl;

(e) Underbody clearance — 18 in. (45.7 cm).

2-2.2.2* The overall height, length, and width of the vehicle shall be held to a minimum consistent with the best operational performance of the vehicle and the design concepts needed to achieve this performance and to provide optimum maneuverability and facilitate movement on public highways.

2-2.2.3 The vehicle shall be constructed so that a seated driver, having an eye reference point of $31^3/_4$ in. (806.5 mm) above the seat cushion and 12 in. (30.5 cm) forward from the seat back, shall be able to see the ground 20 ft (6.1 m) ahead of the vehicle and shall have a field of vision of at least 5 degrees above the horizontal plane. The field of vision in the horizontal plane shall be at least 90 degrees on each side from the straight ahead position.

2-2.2.4 Adjustable rear view mirrors with a glass area of not less than 60 in.^{2} (387.1 cm^2) shall be provided on each side of the vehicle. Each side shall be provided with a minimum 7-in.^{2} (45.2-cm^2) wide-angle (convex) mirror.

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

2-3 Engine.

2-3.1 Performance Requirements.

2-3.1.1 The vehicle engines shall have sufficient horsepower, torque, and speed characteristics to meet and maintain all vehicular performance characteristics specified in this standard. The engine manufacturer shall certify that the installed engine is approved for this application.

2-3.1.2* The fully loaded vehicle shall be able to accelerate consistently from 0 mph to 50 mph (0 km/h to 80.5 km/h) on dry, level concrete pavement at the operational airport within the times specified in Table 2-3.1.2. The maximum speed shall not be less than 65 mph (104.6 km/h). If any vehicle accelerates from 0 mph to 50 mph (0 km/h to 80.5 km/h) in less than 20 seconds, it shall meet the tilt-table parameters of 35 degrees side slope as a minimum for all classes.

The acceleration times provided in Table 2-3.1.2 shall be achieved with the engine and transmission at their normal operating temperatures at any ambient temperature from 0°F to 110°F (–17.8°C to 43.3°C) and at elevations up to 2000 ft (609.6 m) above sea level unless a higher elevation is specified.

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

Table 2-3.1.2 Vehicle Acceleration Requirements

Class	Minimum Water Capacity U.S. (gal)	(L)	Maximum Acceleration Time 0 mph to 50 mph (0 km/h to 80 km/h) (sec)
1	1000	4000	23
2	1500	6000	26
3	2500	9000	35
4	3000	11,000	40
5	4000	15,140	45
6	5000	18,925	50
7	6000	22,710	50

2-3.1.3 The vehicle also shall be capable of ascending, stopping, starting, and continuing ascent on a 40-percent grade on dry pavement at a speed up to at least 1 mph (1.6 km/h) with extinguishing agents being discharged from the primary turret nozzle(s).

2-3.2 Engine Cooling Systems.

2-3.2.1 Liquid-Cooled Engines. An engine coolant preheating device shall be provided as an aid to rapid starting and high initial engine performance. This device shall be fitted with a thermostat.

2-3.2.1.1 The cooling system shall be designed so that the stabilized engine coolant temperature remains within the engine manufacturer's prescribed limits under all operational conditions and at all ambient temperatures encountered at the operational airport. The cooling system shall be provided with an automatic thermostat for rapid engine warming.

2-3.2.1.2 Where specified, radiator shutters, where furnished for cold climates, shall be of the automatic type and shall be designed to open automatically upon failure.

2-3.2.2 Air-Cooled Engines. Air-cooled engines shall be designed so that the stabilized cylinder head and oil temperatures remain within the engine manufacturer's prescribed limits under all operational conditions and at all ambient temperatures encountered at the operational airport.

2-3.3 Fuel System.

2-3.3.1 A complete fuel system installed with the engine manufacturer's approval shall include a fuel pump, fuel filtration, and flexible fuel lines, where necessary, that shall be protected from damage, exhaust heat, and exposure to ground fires.

2-3.3.2 Accessible filtration shall be provided for each fuel supply line, and a drain shall be provided at the bottom of the fuel tank.

2-3.3.3 Fuel tanks shall not be installed in a manner that allows gravity feed.

2-3.3.4 The fuel tank shall have sufficient capacity to provide for a minimum of 30 mi (48.3 km) of highway travel at 55 mph (88.5 km/h) plus 2 hours of pumping at the full rated discharge. Additional fuel capacity shall be provided for a minimum of 4 hours of operation of each accessory item (such as a generator or fuel-fired heaters) that uses the common fuel tank as a source.

2-3.4 Exhaust System.

2-3.4.1 The exhaust system shall be of a size that avoids undue back pressure and shall be located and constructed in such a manner that entrance of exhaust gases into the cab is minimized under all conditions of operation. The exhaust system shall be of high-grade, rust-resistant materials. The exhaust system shall include a muffler to reduce engine noise.

2-3.4.2 The exhaust system shall be protected from damage that could result from traversing rough terrain. The tail pipe shall be designed to discharge upward or to the rear and shall not be directed toward the ground.

2-4 Vehicle Electrical System.

2-4.1 The vehicle shall be provided with one of the following electrical systems:

(a) A 12-volt electrical and starting system;

(b) A 24-volt electrical and starting system;

(c) A 12-volt electrical/24-volt starting system.

2-4.2 The electrical system shall have a negative ground including a transistorized alternator and a fully transistorized voltage regulator. The alternator shall be rated at 100 percent of the anticipated load at 50 percent of the engine-governed speed and, if belt driven, it shall be driven by dual belts.

2-4.2.1 For 12-volt electrical and starting systems and for 12-volt electrical/24-volt starting systems, the curb idle minimum charging rate of the alternator shall be 50 amperes.

2-4.2.2 For 24-volt electrical and starting systems, the curb idle minimum charging rate of the alternator shall be 30 amperes.

2-4.3 Batteries shall be mounted securely and adequately protected against physical injury and vibration, water spray, and engine and exhaust heat. Where an enclosed battery compartment is provided, it shall be ventilated adequately, and the batteries shall be readily accessible for examination, test, and maintenance.

2-4.3.1 For 12-volt starting systems, the batteries shall be connected so that their capacity meets the cold-cranking performance amperes at 0°F (–17.8°C) to comply with the engine manufacturer's recommendations. In addition to the cold-cranking performance ampere requirements, a minimum reserve capacity of 600 minutes at 80°F (26.7°C) shall be provided.

2-4.3.2 For 24-volt starting systems, the batteries shall be connected so that their capacity meets the cold-cranking performance amperes at 0°F (–17.8°C) to comply with the engine manufacturer's recommendations.

2-4.4 Battery Capacity.

2-4.4.1 Battery capacity and wiring circuits, including the starter switch and circuit and the starter to battery connections, shall meet or exceed the manufacturer's recommendations. A master power disconnect system shall isolate power from all of the electrical system except the primary power circuits to the alternator and starter. Exceptions shall apply only to systems that are required to operate when the vehicle is not attended. The control device shall be accessible from the driver's seated position.

2-4.4.2 For 12-volt electrical/24-volt starting systems, the batteries shall be connected in a series parallel through a solid-state series parallel circuit to accomplish 24-volt starting. The batteries shall be connected so that their capacity meets the cold-cranking performance amperes at 0°F (–17.8°C) to comply with the engine manufacturer's recommendations. In addition to the cold-cranking ampere requirements, a minimum reserve capacity of 600 minutes at 80°F (26.7°C) shall be provided.

2-4.5 Battery Chargers.

2-4.5.1 A built-in battery charger shall be provided on the vehicle to maintain full charge on all batteries. A grounded AC receptacle shall be provided to allow a pull-away connection from the local electric power supply to the battery charger.

2-4.5.2 Where specified, an on-board battery charger/conditioner shall be provided on the vehicle and shall have a minimum output rating of one-half percent of the cold-cranking ampere rating at 32°F (0°C) of the engine-starting battery system. The battery charger shall be supplied from an external power source of 115 volts or 220 volts AC. This battery charger/conditioner shall be the type that can be connected to the batteries at all times and yet maintain a charge to the batteries without causing any damage. The unit shall reduce its charging output level to a point where a small amount of charge is allowed to the batteries continuously or it shall shut off completely. The charger/conditioner shall have protection built into it to protect it from damage during high current demands such as those caused by starting the engine. The unit shall be provided with a grounded AC receptacle to allow a pull-away connection from the local electrical power supply to the battery charger/conditioner.

2-4.6 The electrical system and its components shall be weatherproof, insulated, and protected from chafing, damage from road debris, and exposure to ground fires. All wiring shall be coded to correspond with the wiring diagram provided with the vehicle. Circuit protection shall be provided to protect the vehicle in the event of electrical overload.

2-4.7 Radio suppression of the electrical system shall be in accordance with SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices 30-1000 MHz)*, or an equivalent radio suppression standard.

2-5 Vehicle Drive. Transmission of power from the engine to the wheels of the vehicle shall be through a torque converter and an automatic or a semiautomatic gearbox. The entire drive train shall be designed and rated by the component manufacturer as having sufficient capacity to slip the wheels of the static-loaded vehicle on a surface having a coefficient of friction of 0.8. A range of gears providing the specified top speed and a grade ability of 50 percent shall be provided with sufficient intermediate gears to achieve the specified acceleration. The transmission shall be matched to the engine properly and shall be approved for the application by the transmission manufacturer.

2-5.1 A transmission cooling system shall be provided and designed so that the stabilized transmission oil temperature remains within the transmission manufacturer's prescribed limits under all operational conditions and at all ambient temperatures encountered at the operational airport.

2-5.2 A positive drive shall be provided to each wheel by means of a fully locked driveline in order to maximize traction on low-friction surfaces. Positive drive shall be permitted to be achieved either by the use of automatic locking and torque proportioning differentials or shall be permitted to be selected manually by the seated driver by use of a single control while the vehicle is in motion.

2-5.3 All-wheel drive on these vehicles shall incorporate a drive to the front and rear axles that is engaged at all times during the intended airport service. An interaxle differential shall be installed with automatic means or driver-selected means of differential locking.

2-5.4 All traction-increasing devices shall be operated by a single control for driving simplicity.

2-5.5 Front and rear axles shall have adequate capacity to carry the maximum imposed load under all intended operating conditions. The variations in axle tread shall not exceed 20 percent of the tire sectional width at rated load.

2-6 Suspension. The suspension system shall be designed to allow the loaded vehicle to perform as follows:

(a) Travel at the specified speeds over improved surface;

(b) Travel at moderate speeds over unimproved surface;

(c) Provide diagonally opposite wheel motion 14 in. (355.6 mm) above ground obstacles without raising the remaining wheels from the ground;

(d) Prevent damage to the vehicle caused by wheel movement; and

(e) Provide a good environment for the crew when traveling over all surfaces.

2-7 Rims, Tires, and Wheels.

2-7.1 Vehicles shall be required to have off-highway mobility while meeting the specified paved surface performance.

2-7.2 Tires shall be selected to maximize the acceleration, speed, braking, and maneuvering capabilities of the vehicle on paved surfaces without sacrificing performance on all reasonable terrains found within the airport boundary.

2-7.3* The purchaser shall provide a tire description that reflects the off-road performance requirements necessitated by the soil conditions encountered at the operational airport. Soil conditions that vary from an extremely fine grain soil or clay to an extremely coarse grain soil, sand, or gravel in a dry, saturated, or frozen condition shall be considered.

To optimize floatation under soft ground conditions, tires of larger diameter or width, or both, than is needed for bearing weight only shall be specified. Similarly, the lowest tire pressure compatible with the high speed performance requirements also shall be specified.

2-7.4 Vehicle and tire manufacturers shall be consulted for the tread design most suitable for the specific soil composition at individual airports.

2-7.5 All wheels on the vehicle shall be of the single-wheel type with all rims, tires, and wheels of an identical size and the same tire tread design.

2-7.6 Rims, tires, wheels, and inflation pressures shall be approved by their respective manufacturers as having sufficient capacity to meet the specified performance and shall be certified for not less than 5 mi (8 km) of continuous operation at 65 mph (104.6 km/h) at normal operational pressure.

2-8* Towing Connections. At least two large tow eyes or tow hooks (one at the front and one at the rear), capable of towing the vehicle on level ground without damage, shall be mounted on the truck and attached directly to the frame structure or where recommended by the vehicle manufacturer.

2-9 Brakes.

2-9.1* The braking system shall feature service, emergency, and parking brake systems. Service brakes shall be of the power-actuation air, hydraulic, or air-over-hydraulic type. Expanding shoe and drum brakes or caliper disc brakes shall be furnished. A brake chamber shall be provided for each wheel and shall be mounted so that no part of the brake chamber projects below the axle bowl.

2-9.2* Service brakes shall be of the all-wheel type with split circuits so that failure of one circuit shall not cause total service brake failure.

2-9.2.1 The service brakes shall be capable of holding the fully loaded vehicle on a 50 percent grade.

2-9.2.2 For Classes 1, 2, and 3 vehicles, the service brakes shall stop the vehicle within 35 ft (10.7 m) at 20 mph (32.2 km/h), and within 131 ft (39.9 m) at 40 mph (64.4 km/h).

2-9.2.3 For Classes 4 through 7 vehicles, the service brakes shall stop the vehicle within 40 ft (12.2 m) at 20 mph (32.2 km/h) and within 160 ft (48.8 m) at 40 mph (64.4 km/h).

2-9.2.4 Stopping distances shall be accomplished on a dry, hard, approximately level roadway that is free from loose material and that has a roadway width equal to the vehicle width plus 4 ft (1.2 m) without any part of the vehicle leaving the roadway.

2-9.2.5 For each vehicle class, the service brakes shall provide one power-assisted stop while the vehicle engine is inoperative for the stopping distances specified in 2-9.2.2 through 2-9.2.4.

2-9.3 An emergency brake system shall be provided that is applied and released by the driver from the cab and is capable of modulation by means of the service brake control. When a single failure in the service brake system of a part designed to contain compressed air or brake fluid occurs, other than failure of a common valve, manifold, brake fluid housing, or brake chamber housing, the vehicle shall stop within no more than 288 ft (87.8 m) at 40 mph (64.4 km/h) without any part of the vehicle leaving a dry, hard, approximately level roadway that has a width equal to the vehicle width plus 4 ft (1.2 m).

2-9.4 The parking brake shall be capable of holding the fully loaded vehicle on a 20-percent grade without air or hydraulic assistance.

2-9.5 Brakes — Air System.

2-9.5.1 Where the vehicle is supplied with air brakes, the air compressor shall meet the following criteria:

(a) The compressor shall be engine driven;

(b) The compressor shall have sufficient capacity to increase air pressure in the supply and service reservoirs from 85 psi to 100 psi (586.1 kPa to 689.5 kPa) when the engine is operating at the vehicle manufacturer's maximum recommended revolutions per minute (rpm) in a maximum of 25 seconds;

(c) The compressor shall have the capacity for quick buildup of tank pressure from 0 psi (0 kPa) to the pressure to release spring brakes, and this buildup in pressure shall be accomplished within 15 seconds; and

(d) The compressor shall incorporate an automatic air-drying system immediately downstream from the compressor to prevent condensation buildup in all pneumatic lines.

2-9.5.2 Service reservoirs shall be provided. The calculated reservoir capacity shall include reservoirs, supply lines, and air dryer volumes. The total of the service reservoir volume shall be at least twelve times the total combined brake chamber volume at full stroke. If the reservoir volume is greater than the minimum required, a proportionately longer buildup time shall be allowed using the following formula:

$$\frac{\text{Actual reservoir capacity} \times 25}{\text{Required reservoir capacity}}$$

2-9.5.3 Reservoirs shall be equipped with drain valves and safety valves.

2-9.5.4 Provision shall be made for charging of air tanks with either a pull-away electrical connection used to power a vehicle-mounted auxiliary compressor or a pull-away air connection for charging of air tanks from an external air source.

2-9.5.5 Visual and audible low air pressure warning devices shall be provided. The low pressure warning device shall be visual and audible from the inside of the vehicle and shall be audible from the outside of the vehicle.

2-10 Steering.

2-10.1 The chassis shall be equipped with power-assisted steering with direct mechanical linkage from the steering wheel to the steered axle(s) to allow manual control in the event of power-assist failure.

2-10.2 The power steering system shall have sufficient capacity so that no more than 15 lbf (66.7 N) pull is needed on the steering wheel rim in order to turn the steering linkage from stop to stop with the fully loaded vehicle stationary on a dry, level, paved surface with the engine at idle.

2-10.3 The wall-to-wall turning diameter of the fully loaded vehicle shall be less than three times the vehicle length.

2-11 Cab.

2-11.1 The cab shall be fully enclosed (i.e., floor, roof, and four sides) and mounted on the forward part of the vehicle. Seating for the crew shall be restricted to the cab. The maximum number of crew seat positions provided in the cab shall be designated by the manufacturer and so labeled in the cab. As a minimum, two designated seat positions shall be provided, one for the driver and one for an additional crew member. Seat belts approved by the authority having jurisdiction shall be provided for each of the designated seating positions. Space shall be provided for all instrument controls and equipment specified without hindering the crew. Doors that open to as wide a position as possible shall be provided on each side of the cab with the necessary steps and handrails to allow rapid and safe entrance and exit from the cab. The cab design shall take into consideration the provision of ample space for the crew to enter and exit the cab and carry out normal operations while wearing full protective equipment.

2-11.2 The cab shall meet the visibility requirements of 2-2.2.3. Interior cab reflections from exterior and interior lighting shall be minimized. The windshield shall be shatterproof safety glass, and all other windows shall be constructed of approved safety glass. The cab shall be provided with wide gutters to prevent foam and water from dripping on the windshield and side windows. Where equipped with a roof turret having manual controls above the cab roof, the cab shall be designed with a quick-access passage to the roof turret(s).

2-11.3 The cab shall be weatherproof and shall be fully insulated thermally and acoustically with a fire-resistant material. The cab interior noise level at any seated position shall not exceed 85 dBA while traveling at 50 mph (80.5 km/h) on a level, hard surface without warning devices operating. With warning devices operating, the maximum limit shall be 90 dBA. The cab shall be permitted to be of the unitized rigid body and frame structure type, or it shall be permitted to be a separate unit flexibly mounted on the main vehicle frame. The cab shall be constructed from materials of adequate strength to ensure a high degree of safety for the crew under all operating conditions, including excess heat exposure and vehicle roll-over accidents.

2-11.4 Instruments, Warning Lights, and Controls.

2-11.4.1 The minimum number of instruments, warning lights, and controls consistent with the safe and efficient operation of the vehicle, chassis, and fire-fighting system shall be provided. All chassis instruments and warning lights shall be grouped together on a panel in front of the driver. All fire-fighting system instruments, warning lights, and controls shall

be grouped together by function to provide ready accessibility and high visibility for the driver as well as crew members.

2-11.4.2 All instruments and controls shall be illuminated, and backlighting shall be used where practical.

2-11.4.3 Groupings of both the chassis and fire-fighting system instruments, warning lights, and controls shall be easily removable as a unit or shall be on a panel hinged for back access by the use of quick-disconnect fittings for all electrical, air, and hydraulic circuits.

2-11.4.4 The following instruments or warning lights, or both, shall be provided as a minimum:

(a) Speedometer/odometer;

(b) Engine(s) tachometer;

(c) Fuel level;

(d) Air pressure;

(e) Engine(s) temperature;

(f) Engine(s) oil pressure;

(g) Voltmeter(s);

(h) Transmission(s) oil temperature;

(i) Pump(s) pressure;

(j) Water tank level;

(k) Foam tank level;

(l) Low air pressure warning;

(m) Headlight beam indicator;

(n) Engine hour meter.

2-11.4.5 The cab shall have all the necessary controls within easy reach of the driver for the full operation of the vehicle and the pumping system. The following cab controls shall be provided:

(a) Accelerator pedal;

(b) Brake pedal;

(c) Parking brake control;

(d) Steering wheel, with directional signal control and horn;

(e) Transmission range selector;

(f) Pump control or selector;

(g) Foam control;

(h) Siren switch(es);

(i) Bumper turret controls or ground sweep valve control;

(j) Where specified, undertruck valve control;

(k) Remote turret controls, where remote turret is provided;

(l) Light switches;

(m) Windshield wipers with delayed and multispeed capability and washer controls;

(n) Heater/defroster controls;

(o) Master electrical switch;

(p) Means of starting and stopping engine;

(q) Auxiliary agent pressurization control, where specified;

(r) Windshield deluge system switch, where specified.

2-11.4.6 Where specified, a windshield deluge system shall be included to cool the windshield and to provide operator visibility during fire-fighting operations. It shall be designed to flood the windshield with clear water when activated. Clear water shall be discharged under sufficient pressure and in a pattern that ensures the driver/operator's field of vision can be kept clear of foam solution where used in conjunction with the windshield wiper. The windshield wipers shall be energized automatically whenever the deluge system is operated.

2-11.5 Equipment. All interior crew and driving compartment door handles shall be designed and installed to protect against accidental or inadvertent opening.

2-11.5.1 The following equipment shall be provided in or on the cab, as applicable:

(a) Heater/defroster;

(b) Driver's suspension seat with vertical, fore, and aft adjustment, with seat belt;

Exception: The use of a nonsuspension driver's seat shall be permitted where recommended by the manufacturer.

(c) Crew seats with individual retractable seat belts;

(d) Windshield washers appropriate for removing foam;

(e) Windshield wipers appropriate for removing foam;

(f) Siren;

(g) Horn;

(h) Sun visors, interior transparent;

(i) Outside rear view mirrors, as specified in 2-2.2.4;

(j) Interior lighting;

(k) Provisions for mounting SCBA of the type specified by the purchaser at each crew seat position.

2-11.5.2 Where tools, equipment, or SCBA are carried within enclosed seating areas of fire department vehicles, such items shall be secured by either a positive mechanical means of holding the item in its stored position or in a compartment with a positive latching door. The means for holding the item in place or in the compartment shall be designed to minimize injury to persons in the enclosed area of the vehicle caused by loose equipment during travel and, in the event of an accident, a rapid deceleration or a rapid acceleration.

2-11.6 Signs that state "Occupants must be seated and wearing a seat belt when apparatus is in motion" shall be provided. Such signs shall be visible from each seated position. An accident prevention sign shall be located at the rear step area of the vehicle, if it exists. It shall warn personnel that standing on the step while the vehicle is in motion is prohibited.

2-12 Body.

2-12.1 The body shall be constructed of materials that are of the lightest weight consistent with the strength necessary for off-pavement operation over rough terrain and where exposed to excess heat. The body shall be permitted to be of the unitized-with-chassis-rigid-structure type or it shall be permitted to be flexibly mounted on the vehicle chassis. It also shall include front and rear fenders or wheel wells. Body panels shall be removable where necessary to provide access to the interior of the vehicle.

2-12.2 Access doors shall be provided for those areas of the interior of the vehicle that are inspected frequently. In particular, access doors of sufficient size and number shall be provided for access to the following:

(a) Engine;

(b) Pump;

(c) Foam proportioning system;

(d) Battery storage;

(e) Fluid reservoirs.

Other areas that need to be accessible for inspection or maintenance shall be open or shall have removable panels.

2-12.3 Suitable, lighted compartments shall be provided for convenient storage of equipment and tools to be carried on the vehicle. Compartments shall be weathertight and self-draining.

2-12.4 A working deck shall be provided and shall be reinforced adequately to allow the crew to perform its duties in the roof turret area, cab hatch area, water tank top fill area, foam-liquid top fill area, and in other areas where access to auxiliary or installed equipment is necessary.

2-12.5 Handrails or bulwarks shall be provided where necessary for the safety and convenience of the crew. Rails and stanchions shall be braced strongly and constructed of a material that is durable and resists corrosion. Handrails shall be constructed of, or covered with, a slip-resistant material.

2-12.6 Steps or ladders shall be provided for access to the top fill area. The lowermost step(s) shall be permitted to extend below the angle of approach or departure or ground clearance limits if it is designed to swing clear. All other steps shall be rigidly constructed. All steps shall have a nonskid surface. The lowermost step(s) shall be no more than 22 in. (558.8 mm) above level ground when the vehicle is fully loaded. Adequate lighting shall be provided to illuminate steps and walkways.

2-12.7 A heavy-duty front bumper shall be mounted on the vehicle and secured to the frame structure.

2-12.8 Vehicle numbering, lettering, and minimum 8-in. (20.3-cm) wide reflective striping shall be provided in accordance with ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*. Striping shall be placed on at least 60 percent of the perimeter length of each side, width, and rear. At least 40 percent of the perimeter width of the front of the vehicle shall have the reflective stripe.

Exception: A graphic design meeting the reflectivity requirements of this paragraph shall be permitted to replace all or part of the required striping, provided the design or combination thereof covers a minimum of the same perimeter length required above.

2-12.9 Attachments shall be provided for all tools, equipment, and other items that the purchaser specifies to be furnished on the vehicle. Equipment holders shall be attached firmly and designed so that equipment remains in place under all operating conditions, but the equipment shall be quickly removable for use.

2-13 Fire-Fighting Systems and Agents.

2-13.1 General.

2-13.1.1 For aircraft rescue and fire-fighting purposes, the primary and auxiliary extinguishing agents used shall be tested in accordance with NFPA 403, *Standard for Aircraft Rescue and Fire Fighting Services at Airports*.

2-13.1.2 Vehicles designed to discharge auxiliary agents shall require the use of auxiliary agents that are compatible with the primary agent.

2-13.1.3 All components of the agent systems, including such items as the tanks, piping, fill troughs, and screens, shall be made of materials resistant to corrosion by the primary agent, primary agent/water solution, water, and, where specified, the auxiliary agent.

2-14 Agent Pump(s) and Pump Drive.

2-14.1 Agent Pump(s).

2-14.1.1 The water pump(s) shall be constructed of corrosion-resistant metals and shall be of the single-stage or multiple-stage centrifugal type and shall be designed for dependable emergency service. Pumps shall be designed carefully and built in accordance with good modern practice. Pumps shall be gravity primed from the vehicle tank. The pump and piping system shall be designed to eliminate the entrapment of air.

2-14.1.2 All proportioning system components shall be made of materials resistant to corrosion by all primary agents.

2-14.1.3 Where discharging foam solution, the pumping system shall be capable of discharging at a rate equal to or exceeding the total requirements of the roof or extendable turret(s), bumper turret or ground sweep nozzles, preconnected hand line nozzles, and undertruck nozzles, where specified, discharging simultaneously at designed pressures.

2-14.2 Pump Drive.

2-14.2.1 The pump(s) drive shall allow operation of the pump(s) and simultaneous operation of the vehicle. The pump(s) shall not be affected by changes in transmission ratios or the actuation of clutches in the vehicle drive. The design of the drive system and controls shall prevent damage to the drive or shall minimize lurching of the vehicle when the vehicle drive is engaged during pumping operations. The pump(s) drive system shall be capable of absorbing the maximum torque delivered by the engine to the pump(s) and withstanding the engagement of the pump(s) at all engine and vehicle speeds and under all operating conditions. The operation of the pump(s) shall not, under any conditions, cause the engine to stall or cause more than a slight and momentary reduction in engine speed and consequent drop in pump pressure.

2-14.2.2 While pumping at rated capacity, the drive shall allow controlled vehicle operation at speeds from 1 mph to 5 mph (1.6 km/h to 8 km/h). The pump(s) drive shall have sufficient power capacity to provide the pump(s) discharge requirements of 2-14.1.3 while the vehicle is being propelled under all operating conditions where a fire-fighting capability is needed.

2-14.2.3 If an independent engine is used to drive the pump(s), it shall have the same fuel and electrical system as the chassis engine and shall be equipped with an air cleaner, a replaceable element oil filter, a full pressure lubricating system, and an overspeed governing device to prevent engine damage. The engine also shall be provided with a cooling system that meets the requirements of 2-3.2.1 or 2-3.2.2.

2-14.3 Suction Connections.

2-14.3.1 The suction system shall be designed for efficient flow at the pumping rates required by 2-14.1.3. The pump suction line(s) shall be of large diameter and of the shortest length consistent with the most suitable pump location. There shall be a drain at the lowest point with a valve for draining all of the liquid from the pumping system where desired. Suction lines and valves shall be constructed of corrosion-resistant materials.

2-14.3.2 Where two pumps are used, they shall be arranged in parallel with manifolding so that either or both can supply any discharge outlet at the required operating pressure. During single pump operation, the total capacity shall be permitted to be reduced.

2-14.4 Discharge Connections. All discharge outlets shall have National (American) Standard fire hose coupling thread. Adapter couplings, securely attached, shall be provided on each outlet if local couplings are not National (American) Standard as specified in NFPA 1963, *Standard for Fire Hose Connections*. No outlet or outlet with adapters shall add width to the vehicle.

2-14.5 Piping, Couplings, and Valves.

2-14.5.1 All piping, couplings, and valves shall be sized for necessary flow with minimum restriction and pressure loss. Material for all piping, couplings, and valves shall be selected to avoid corrosive or galvanic action.

2-14.5.2 Piping shall be mounted securely and provided with flexible couplings to minimize stress. Union or rubber-gasketed fittings shall be provided where necessary to facilitate removal of piping.

2-14.5.3 All valves shall be of the quarter-turn type and shall be selected for ease of operation and freedom from leakage.

2-14.5.4 All water system piping shall be tested on the suction side of the pump to detect possible leakage. All water and foam solution discharge piping, together with the agent pump(s), shall be tested at 50 percent above the system operating pressure.

2-14.6 Overheat Protection. A system line shall be provided from the water pump discharge and, if applicable, from the foam pump discharge to prevent overheating of the pumps while engaged and operating at zero (0) discharge. The line shall be automatic.

2-14.7 Pressure Relief Valves. A pressure relief valve shall be fitted both to protect and ensure optimum performance of the system.

2-14.8 Drains. A drainage system with collector tubing from the low points on the pump(s) and piping shall be provided. The drain shall be provided with a quarter-turn valve.

2-15 Water Tank.

2-15.1 Capacity.

2-15.1.1 A water tank shall have a usable capacity as specified in 2-1.2.

2-15.1.2 The rated capacity of the tank shall be equal to the usable capacity that can be pumped from the tank while the vehicle is parked on level ground. The tank outlets shall be arranged to allow the use of at least 75 percent of the rated capacity with the vehicle positioned as follows:

(a) On a 20-percent side slope;

(b) On a 30-percent ascending grade;

(c) On a 30-percent descending grade.

2-15.2 Construction.

2-15.2.1 The tank shall be constructed to resist all forms of deterioration that could be caused by the water and foam concentrate while affording the structural integrity necessary for off-road operation. The tank shall have longitudinal and transverse baffles. The construction and connections shall be made to prevent the possibility of galvanic corrosion of dissimilar metals.

2-15.2.2 The tank shall be equipped with easily removable manhole covers over the tank discharge. Where specified, the tank shall be designed to allow access within each baffled compartment of the tank for internal and external inspection and service. The tank shall have a drain valve(s).

2-15.2.3 Provisions shall be made for necessary overflow and venting. Venting shall be sized to allow agent discharge at the maximum design flow rate without danger of tank collapse and shall be sized to allow rapid and complete filling without exceeding the internal pressure design limit of the tank. Additionally, overflows shall be designed to prevent loss of water from the tank during normal maneuvering and to direct the discharge of overflow water directly to the ground.

2-15.2.4 The water tank shall be mounted in a manner that limits the transfer of the torsional strains from the chassis frame to the tank during off-pavement driving. The tank shall be separate and distinct from the crew compartment, engine compartment, and chassis and shall be easily removable as a unit. Water tanks used as an integral part of unitized rigid body construction shall be permitted.

2-15.2.5 The water tank shall be equipped with at least one top fill opening of not less than 8 in. (20.3 cm) internal diameter. The top fill shall be equipped with an easily removable strainer of $^1/_4$-in. (6.4-mm) mesh construction. The top fill opening shall be equipped with a cap designed to prevent spillage.

2-15.3 Tank Fill Connection(s).

2-15.3.1 A tank fill connection(s) shall be provided in a position where it can be reached easily from the ground.

2-15.3.2 All connections shall have National (American) Standard fire hose coupling threads. Securely attached adapters shall be provided on each connection if local couplings are not National (American) Standard. Connections and adapter threads shall be as specified in NFPA 1963, *Standard for Fire Hose Connections*. Connections and connections with adapters attached shall not protrude beyond the normal body metalwork of the vehicle.

2-15.3.3 The connection(s) shall be provided with strainers of $^1/_4$-in. (6.4-mm) mesh and shall have check valves or shall be constructed so that water is not lost from the tank when connection or disconnection is made.

2-15.3.4 The tank fill connection(s) shall be sized to allow filling of the water tank in 2 minutes at a pressure of 80 psi (551.6 kPa) at the tank intake connection.

2-16 Foam System.

2-16.1 Foam-Liquid Concentrate Tank(s).

2-16.1.1 The purchaser shall specify the percent concentrate foam system to be provided. The foam-liquid concentrate tank(s) shall have a working capacity sufficient for two tanks of water at the maximum tolerance specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment.*

2-16.1.2 Foam-liquid concentrate tanks shall be permitted to be of either the rigid or flexible type. Where specified, the tank(s) shall be designed for compatibility with the foam concentrate being used and shall resist all forms of deterioration that could be caused by the foam concentrate or water.

2-16.1.3 Tanks shall be designed to allow access within each baffled compartment of the tank for internal and external inspection and service. A large capacity drain connection shall be installed flush with the bottom of the sump.

2-16.1.4 The tank outlets shall be located above the bottom of the sump and shall provide continuous foam-liquid concentrate to the foam proportioning system, with that system operating as specified in 2-16.4 and with the vehicle discharging two tank loads of usable water as specified in 2-15.1.

2-16.1.5 If separate from the water tank, the foam-liquid tank shall be mounted in a manner that limits the transfer of the torsional strains from the chassis frame to the tank during off-pavement driving. The tank shall be separate and distinct from the crew compartment, engine compartment, and chassis and shall be easily removable as a unit. Foam liquid tanks used as an integral part of unitized rigid body construction shall be permitted.

A flexible tank shall be structurally supported to resist tearing. The structural support shall not be dependent on the fluid level in either the water or foam tanks.

2-16.1.6 A top fill trough shall be provided and shall be equipped with a stainless steel No. 10 mesh screen and container openers to allow emptying 5-gal (18.9-L) foam-liquid concentrate containers into the storage tank(s) at a rapid rate regardless of water tank level. The trough shall be connected to the foam-liquid storage tank(s) with a fill line designed to introduce foam-liquid concentrate near the bottom of the tank(s) to minimize foaming within the storage tank.

2-16.1.7 The tank fill connection(s) shall be provided in a position where it can be reached easily from the ground to allow the pumping of foam-liquid concentrate into the storage tank(s). The connection(s) shall be provided with strainers of $^1/_4$-in. (6.4-mm) mesh and shall have check valves or shall be constructed so that foam is not lost from the tank when connection or disconnection is made.

Where flexible tanks are used, the supply system shall be designed so that the flexible tanks are not subject to excess pressure. The supply system shall be capable of delivering foam-liquid at a rate at least equal to or greater than the maximum discharge rate of the foam system.

2-16.1.8 The tank(s) shall be vented adequately to allow rapid and complete filling without the buildup of excessive pressure and to allow emptying of the tank at the maximum design flow rate without danger of collapse. The vent outlets shall be directed to the ground to prevent spillage of foam-liquid concentrate on vehicle components.

2-16.2 Foam-Liquid Concentrate Pump.

2-16.2.1 The foam-liquid concentrate system shall be arranged so that the entire piping system, including the foam-liquid concentrate pump or pumps, can be flushed readily with clear water.

2-16.2.2 The foam-liquid concentrate pump or pumps shall be capable of delivering the necessary quantity of foam-liquid at a pressure in excess of the water pump operating pressure, regardless of the water flow rate or variations in engine speed.

2-16.3 Foam-Liquid Concentrate Piping.

2-16.3.1* The foam-liquid concentrate piping shall be of material resistant to corrosion by foam-liquid concentrates addressed in this standard. Care shall be taken that combinations of dissimilar metals that produce galvanic corrosion are not selected or that such dissimilar metals are electrically insulated. Where plastic piping is used, it shall be fabricated from unplasticized resins, unless it has been demonstrated that the stipulated plasticizer does not adversely affect the performance characteristics of the foam-liquid concentrates addressed in this standard. The plastic pipe shall be permitted to be reinforced with glass fibers.

2-16.3.2 The foam-liquid concentrate piping shall be adequately sized to allow the maximum required flow rate and shall be arranged to prevent water from entering the foam tank.

2-16.4 Foam-Liquid Proportioning Systems.

2-16.4.1 The foam concentrate proportioning system shall provide a preset or adjustable means of controlling the ratio of foam concentrate to the quantity of water in the foam solution being discharged from all orifices normally used for aircraft fire-fighting operations.

2-16.4.2 The proportioning system shall be sufficiently accurate to provide for the discharge of finished foam within the range specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment.*

2-16.5 Turret Nozzles.

2-16.5.1 Major aircraft rescue and fire-fighting vehicles shall have one or two primary turret nozzles. The primary turret nozzle(s) shall meet the requirements of 2-16.5.2 and 2-16.5.3.

2-16.5.2 The total foam solution discharge rate from the primary turret, or pair of primary turrets, shall be as specified in Table 2-16.5.2. The primary turret nozzles shall include roof turret(s), extendable turret nozzles, and bumper turrets.

For Classes 3 through 7 vehicles, the minimum combined rated turret discharge capacity shall be at least 1250 gpm (4731 lpm).

2-16.5.3 A turret(s) shall be capable of discharging foam as specified in Table 2-16.5.3 in still air in a continuously variable pattern with the turret(s) elevated to the maximum stream reach position.

Table 2-16.5.2 Turret Flow Rates

Vehicle Class	Rated Tank Capacity		Minimum Turret(s) Capacity Required		Roof Turret with Bumper Turret Flow Rates				Roof Turret without Bumper Turret	
					Roof		Bumper			
	(gal)	(L)	(gpm)	(lpm)	(gpm)	(lpm)	(gpm)	(lpm)	(gpm)	(lpm)
1	1000	3785	750	2838.8	500	1892.5	250	946.3	500	1892.5
2	1500	5677.5	750	2838.8	500	1892.5	250	946.3	750	2838.8
3	2500	9462.5	1250	4731.3	1000	3785	250	946.3	1250	4731.3
4	3000	11,355	1250	4731.3	1000	3785	250	946.3	1250	4731.3
5	4000	15,140	1250	4731.3	1000	3785	250	946.3	1250	4731.3
6	5000	18,925	1250	4731.3	1000	3785	250	946.3	1250	4731.3
7	6000	22,710	1250	4731.3	1000	3785	250	946.3	1250	4731.3

Table 2-16.5.3 Turret Requirements

Vehicle Class	Straight Stream Minimum Range Far Point		Dispersed Stream Minimum Width		Dispersed Stream Minimum Range Far Point	
	(ft	m)	(ft	m)	(ft	m)
1	160	49	35	10	60	18
2	190	58	35	10	65	20
3	230	70	35	10	70	21
4	250	76	35	10	75	23
5	250	76	35	10	75	23
6	250	76	35	10	75	23
7	250	76	35	10	75	23

2-16.5.4 Turret nozzles with liquid flow rates of 750 gpm (2839 lpm) or more shall be of the dual discharge type and arranged to allow selection of either 50 percent or 100 percent of the turret capacity. The roof turret discharge rates shall have a tolerance of +10 percent/–0 percent.

2-16.5.5 Turrets shall be permitted to be operated manually or to be power controlled. Where turret remote control is provided in the cab, operation shall be less than 30 lbf (13.6 kgf), and cab indication of turret elevation and azimuth shall be provided. Manual override of all fixed, mounted, roof turret controls shall be provided inside the cab for all power controlled turrets, and manual override operation shall be less than 30 lbf (13.6 kgf). Where turret control is at the platform, operation shall be less than 50 lbf (22.7 kgf). All power-assisted controls shall have identical operating characteristics.

2-16.5.6 Turrets shall be capable of being elevated at least 45 degrees above the horizontal and shall be depressed to discharge agent within 30 ft (9.1 m) in front of the vehicle at full output using a dispersed stream. Where a single turret is used on a vehicle, it shall be capable of being rotated not less than 105 degrees to either side, with total traverse not less than 210 degrees. Where two turrets are used on a vehicle, suitable stops shall be provided so that neither turret can interfere with the other turret.

2-16.5.7* If the primary turret is of the extendable type, it shall meet the following design and functional requirements:

(a) It shall comply with NFPA 1901, *Standard for Pumper Fire Apparatus*, Section 8-5, 8-5.2, and 8-5.3, and shall meet the requirements of 2-2.1.3 and 2-2.1.4 of this standard while in the stowed position. It shall achieve a 20-percent side slope with the extendable turret fully elevated and the nozzle rotated uphill at maximum horizontal rotation while discharging at maximum flow rate. The vehicle shall be provided with an interlock or warning system and placards in full view of the driver/operator to provide the operational limitations during all phases of operation.

Exception: Flow rates shall be in accordance with Table 2-16.5.2 for major vehicles.

(b) The extendable turret shall function without the use of outriggers or other ground contact stabilizers.

(c) The primary turret shall achieve the elevation and reach needed to service the highest tail-mounted engine for the aircraft being protected.

(d) The extendable turret shall function as a conventional roof turret in accordance with 2-16.5.2 for major vehicles.

(e) The extendable turret shall be capable of applying agent to the interior of the aircraft through cargo bay openings, passenger doorways, and emergency exits on the type of aircraft being protected while the aircraft is in either the gear up or gear down landing position.

2-16.6 Preconnected Hand Lines. Preconnected hand lines shall be those hand lines for discharging foam streams that are specified by the purchaser as intended for use as primary crash/fire/rescue attack equipment. All other hand lines that are installed on the vehicle for discharging either water or foam, or both, shall be considered as additional hand lines and not preconnected hand lines.

Each preconnected hand line compartment shall be located so that the distance between the hand line nozzle and the ground, step, or deck plate upon which the operator stands to initiate the pulling of the hand line from the reel or the top lay of the woven jacket hose is not more than 6 ft (1.8 m) above that surface.

2-16.6.1 Major aircraft rescue and fire-fighting vehicles shall have a minimum of two preconnected hand lines that meet the requirements of either 2-16.6.3 or 2-16.6.4. The two preconnected hand lines shall not be located on the same side of the vehicle.

2-16.6.2 The purchaser shall specify either two reeled hand lines as specified in 2-16.6.3 or two woven jacket hand lines as specified in 2-16.6.4 or one of each.

2-16.6.3 Reeled Hand Lines.

2-16.6.3.1 Hand lines for reels shall have a minimum internal diameter of 1 in. (25.4 mm), shall have a minimum burst pressure rating three times the nominal working pressure of the system, and shall be able to discharge the flow required in 2-16.6.3.3 without unreeling the hose.

2-16.6.3.2 At least 100 ft (30.5 m) of hose shall be provided for each reel.

2-16.6.3.3 Each hand line shall be equipped with a shutoff-type nozzle designed to discharge both foam and water at a nominal discharge rate of 60 gpm (227.1 lpm), +10 percent/–0 percent. Each nozzle shall have minimum foam discharge patterns from a dispersed stream of 15 ft (4.6 m) in width and 20 ft (6.1 m) in range to a straight foam stream with a 50-ft (15.2-m) range.

2-16.6.3.4 Each hose reel shall have capacity for at least 100 ft (30.5 m) of 1-in. (25.4-mm) hose or more if specified by the purchaser.

2-16.6.3.5 Each hose reel shall be designed and positioned to allow hose reel removal by a single person from any position in a 120-degree horizontal sector. Each hose reel shall be equipped with a friction brake to prevent the hose from unreeling when not desired. A power rewind with manual override shall be provided. The nozzle holder, friction brake, rewind controls, and manual valve control shall be accessible from the ground.

2-16.6.3.6 The discharge control to each hand line shall be adjacent to the hand line and accessible to the person using the hand line.

2-16.6.4 Woven Jacket Hand Lines.

2-16.6.4.1 Woven jacket hand lines shall have a minimum diameter of $1^1/_2$ in. (38.1 mm) and shall meet the requirements of NFPA 1961, *Standard for Fire Hose.*

2-16.6.4.2 At least 150 ft (45.7 m) of hose shall be provided for each hand line.

2-16.6.4.3 Each hand line shall be equipped with a shutoff-type nozzle designed to discharge both foam and water at a nominal discharge rate of 95 gpm (359.6 lpm), ±5 percent. Each nozzle shall have minimum foam discharge patterns from a dispersed stream of 15 ft (4.6 m) in width and 20 ft (6.1 m) in range to a straight foam stream with a 65-ft (19.8-m) range.

2-16.6.4.4 Each hand line shall be stored in a hose compartment and shall be preconnected. Each hose compartment shall have a capacity for a minimum of 150 ft (45.7 m) of $1^1/_2$-in. (38.1-mm) multiple jacket hose or more if specified by the purchaser.

2-16.6.4.5 Hose compartments shall be fabricated from noncorrosive material and shall be designed to drain effectively. The compartment shall be smooth and free from all projections that might damage the hose. No other equipment shall be mounted or located where it can obstruct the removal of the hose.

2-16.6.4.6 The discharge control to each hand line shall be adjacent to the hand line and accessible to the person using the hand line.

2-16.7 Bumper Turret, Ground Sweep, and Undertruck Nozzles.

2-16.7.1 Vehicles shall have a remote-controlled bumper turret or ground sweep nozzle(s) mounted on the front of the vehicle. Controls for the bumper turret or ground sweep nozzle(s) shall be mounted inside the cab within easy reach of the driver and a crew person.

2-16.7.1.1 The bumper turret shall have a horizontal rotation of 180 degrees, +10 percent/–0 percent, and vertical travel of +45 degrees/–20 degrees. The flow rate shall be 250 gpm (946.3 lpm), +10 percent/–0 percent.

2-16.7.1.2 The ground sweep nozzle(s) shall have a total discharge rate of 100 gpm (378.5 lpm), +10 percent/–0 percent. The minimum reach requirements are as follows:

Minimum reach	30 ft (9.1 m)
Minimum pattern width	12 ft (3.7 m)

2-16.7.2 Where specified, two or more undertruck nozzles shall be mounted under the truck and controlled from the cab. A sufficient number shall be provided to protect the bottom of the vehicle and the inner sides of the wheels and tires with foam solution discharged in a spray pattern.

2-16.8 Foam Quality. Turrets, hand lines, and ground sweeps shall discharge foam having the quality specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment.*

Measurement of the expansion ratio and 25-percent drainage times shall be in accordance with the procedures outlined in NFPA 412.

2-17 Auxiliary Agent System. Where specified, the vehicle shall be equipped with an auxiliary agent system using either dry chemical (potassium bicarbonate) or Halon 1211. The minimum capacity of the auxiliary agent system shall be 450 lb (204.3 kg) of potassium bicarbonate for all classes of vehicles.

2-17.1 Dry Chemical Container. The dry chemical container shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code*, Section 8, and shall be so stamped.

2-17.1.1 All piping and fittings shall conform to the appropriate ASME code and shall be designed to withstand the working pressure of the system. The design of the piping and valving shall provide the desired flow of gas into the system and the minimum amount of restriction from the chemical container(s) to the hose connection. Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

2-17.1.2 Provisions shall be made for purging all piping and hose of dry chemical after use without discharging the dry chemical remaining in the dry chemical container(s). Provisions also shall be made for the depressurization of the dry chemical container(s) without the loss of the remainder of the dry chemical. A pressure gauge shall be provided that indicates the internal pressure of the agent storage container(s) at all times.

2-17.1.3 The system shall be designed to ensure fluidization of the dry chemical at the time of operation. Where any design includes the movement of the chemical container(s) to fluidize the contents, such design also shall include a manual operating feature.

2-17.1.4 A check valve shall be provided in the gas piping to prevent the extinguishing agent from being forced back into the propellant gas line.

2-17.1.5 A means of pressure relief conforming to appropriate ASME codes shall be provided for the dry chemical container and piping to prevent overpressurization in the event of a malfunction in the propellant gas regulator system or in the event the container is involved in a severe fire exposure.

2-17.1.6 The fill opening in the dry chemical container shall be located so that it is easily accessible for recharging and necessitates a minimum amount of time and effort to open and close. Filling shall be accomplished without the removal of any of the extinguisher piping or any major component.

2-17.1.7 A quick-acting control to be operated by the driver to pressurize the dry chemical agent system from the cab of the vehicle shall be provided, with a similar control at the hand line.

2-17.2 Propellants.

2-17.2.1 The propelling agent shall be dry nitrogen or dry air.

2-17.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. Department of Transportation (DOT) requirements or regulations. Cylinders shall bear the DOT marking.

2-17.2.3 The method of adequately pressurizing and propelling the dry chemical in the system shall provide a sufficient quantity of gas to expel the agent, as well as allowing the complete purging of all piping and hose lines after each use.

2-17.2.4 The design of the propellant source shall provide for quick and easy replacement after each use.

2-17.2.5 A pressure gauge shall be provided and shall indicate the pressure on the propellant gas source at all times.

2-17.2.6 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

2-17.3 Pressure Regulation.

2-17.3.1 Pressure regulation shall be designed to reduce the normal cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the dry chemical container(s).

2-17.3.2 All pressure regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

2-17.3.3 Pressure regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

2-17.3.4 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

2-18 Halon 1211 System.

2-18.1 Halon Container.

2-18.1.1 The storage container shall be designed for pressurization and shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code* and shall be so marked.

2-18.1.2 The material of construction shall be resistant to corrosion by the halon agent to be stored.

2-18.1.3 A readily accessible charge coupling of sufficient size to allow ease in filling shall be provided. Filling shall be accomplished without the removal of any of the extinguisher piping or any major component. A pressure gauge shall be provided that indicates the internal pressure of the agent storage containers at all times.

2-18.1.4 A means shall be provided to determine the contents of the container as a guide in recharging partial loads and to prevent overfilling of the tank.

2-18.2 Propellant Gas.

2-18.2.1 The propellant gas shall be dry nitrogen or dry compressed air and shall be provided in sufficient quantity to expel the halon agent as well as to purge all piping and hose lines after use.

2-18.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. Department of Transportation (DOT) requirements or regulations. Cylinders shall bear the DOT marking.

2-18.2.3 Pipes and valves connected to the halon container shall conform to the appropriate ASME code and shall be designed to withstand the working pressure of the system.

2-18.2.4 The design of the propellant source shall provide for quick and easy replacement after each use.

2-18.2.5 A pressure gauge shall be provided and shall indicate the pressure of the propellant gas source at all times.

2-18.2.6 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

2-18.2.7 A check valve shall be provided in the gas piping to prevent the liquid agent from being forced back into the propellant gas line.

2-18.3 Pressure Regulation.

2-18.3.1 An ASME-approved pressure relief valve of adequate capacity shall be provided on the container and shall be set to prevent pressures in excess of the maximum design working pressure.

2-18.3.2 Pressure regulation shall be designed to reduce the normal cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the halon container(s).

2-18.3.3 All pressure regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

2-18.3.4 Pressure regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

2-18.3.5 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

2-18.4 Halon Delivery Piping and Valves.

2-18.4.1 All piping, couplings, and valves shall be sized for necessary flow with minimum restriction and pressure loss. Material for all piping, couplings, and valves shall be selected to avoid corrosive and galvanic action. Piping shall be mounted securely and provided with flexible couplings to minimize stress.

2-18.4.2 All valves shall be of the quarter-turn type and shall be selected for ease of operation and freedom from leakage.

2-18.4.3 All discharge piping shall be tested at 50 percent above the system operating pressure.

2-18.4.4 Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

2-18.4.5 Provisions shall be made for purging all piping and hose of the halon after use without discharging the halon remaining in the container(s). Provisions also shall be made for venting of the halon container without loss of the remainder of the liquid agent.

2-18.4.6 A quick-acting control to be operated by the driver to pressurize the halon system from the cab of the vehicle shall be provided, with a similar control at the hand line.

2-19 Dry Chemical Turret.

2-19.1 Auxiliary Agent Discharge. Where specified, a primary turret shall have an auxiliary agent discharge mounted parallel to the primary agent discharge so that the auxiliary agent discharge is controlled the same way, and with the same travel requirements, as the primary turret.

2-19.1.1 The dry chemical minimum discharge rate from the turret shall be ≥16 lb/sec to ≤22 lb/sec (≥7.3 kg/sec to ≤10 kg/sec). The minimum far point reach for dry chemical shall be 100 ft (30.5 m), and the minimum width shall be 17 ft (5.2 m).

2-19.1.2 The dry chemical system shall be designed so that the operator can select to discharge both the primary and the auxiliary agent systems separately or simultaneously.

2-19.2 Auxiliary Agent Hand Lines.

2-19.2.1 Hand lines for auxiliary agents shall have a minimum burst pressure rating three times the nominal working pressure of the system and meet the requirements specified below. The auxiliary agent hand line shall be equipped with a nozzle that allows a fully opened to a fully closed position in a single, simple movement and shall be designed to discharge agent at a minimum rate of ≥5 lb/sec to ≤7 lb/sec (≥2.3 kg/sec to ≤3.3 kg/sec) at a minimum range of 20 ft (6.1 m). Nozzle construction shall be of nonferrous metal or stainless steel.

2-19.2.2 Twinned hand lines and nozzles shall be designed so that each agent can be discharged separately or simultaneously. The barrels shall be linked together to provide coordinated application by one operator.

2-19.2.2.1 Each reel shall have capacity for at least 100 ft (30.5 m) of 1-in. (25.4-mm) hose or more if specified by the purchaser.

2-19.2.2.2 Each reel shall be designed and positioned to allow hose line removal by a single person from any position in a 120-degree horizontal sector. Each reel shall be equipped with a friction brake to prevent the hose from unreeling when not desired. A power rewind with manual override shall be provided. The nozzle holder, friction brake, rewind controls, and manual valve control shall be accessible from the ground.

2-20 Lighting and Electrical Equipment.

2-20.1 Lighting equipment shall be installed in conformity with local road regulations, where practicable, and shall include the following:

(a) Headlights with upper and lower driving beams. A control switch that is readily accessible to the driver shall be provided for beam selection.

(b) Dual taillights and stoplights.

(c) Self-canceling turn signals, front and rear, with a steering column-mounted control and a visual and audible indicator. A four-way flasher switch shall be provided.

(d) Where specified, a minimum 6-in. (152.4-mm) spotlight on both left and right sides of the windshield, hand-adjustable type, with controls for beam adjustment inside the truck cab.

(e) Where specified, a minimum 6-in. (152.4-mm) spotlight mounted on a turret nozzle with a control switch that is readily accessible to the driver.

(f) Adequate reflectors and marker and clearance lights furnished to describe the overall length and width of the vehicle.

(g) Engine compartment lights, nonglare type, arranged to illuminate both sides of the engine, with individual switches located in the engine compartment. Service lighting shall be provided for all areas described in 2-12.2(a), (b), and (c), as well as for the engine compartment.

(h) Lighting provided for all top deck working areas.

(i) At least one back-up light and an audible alarm with a minimum of 97 dBA meeting SAE J994, *Standard on Alarm-Backup-Electric Laboratory Performance Testing*, installed in the rear of the body.

(j) A flashing red beacon or alternate red and white flashing lights mounted on the top deck and visible for 360 degrees in the horizontal plane. The mounting of the beacon also shall provide good visibility from the air. A control switch shall be provided on the instrument panel in the cab for control of the beacon.

2-20.2* A warning siren shall be provided that has a sound output of not less than 95 dBA at 100 ft (30.5 m) when measured directly ahead of the siren and not less than 90 dBA at 100 ft (30.5 m), measured at 45 degrees on either side. The siren shall be mounted to allow maximum forward sound projection but shall be protected from foam dripping from the turret or water splashed up by the tires.

2-20.3 A horn shall be provided and shall be mounted at the front part of the vehicle with the control positioned so that it is readily accessible to the driver.

2-20.4 A master switch for all emergency lights shall be provided.

2-20.5 Radios.

2-20.5.1 Provision shall be made for mounting radios. Operation of the radios shall be from the cab. Radios shall be mounted to allow quick servicing or replacement.

2-20.5.2 The purchaser shall specify all necessary radios and frequencies that are to be provided.

2-20.6 Where furnished, air horns, an electric siren(s), and an electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as practical. Audible warning equipment shall not be mounted on the roof of the apparatus.

2-20.7 The purchaser shall specify whether a manually operated or a power-assisted turret shall be provided. Where a manually operated turret is specified, controls shall be in the cab, operation force shall be less than 30 lbf (13.6 kgf), and an indication of turret elevation and azimuth shall be provided. Where a power-assisted turret is specified, controls shall be in the cab, operation forces shall be less than 30 lbf (13.6 kgf), an indication of turret elevation and azimuth shall be provided, and a manual override of all roof turret functions shall be provided in the cab. The manual override operation force shall be less than 30 lbf (13.6 kgf). Where turret control is at the platform, operation forces shall be less than 50 lbf (22.7 kgf).

2-21* Tools. Provision shall be made for mounting tools and equipment, as specified by the purchaser, on the truck. Special tools for servicing the vehicle, fire suppression system, and any of the auxiliary equipment shall be furnished as necessary by the vehicle manufacturer.

Chapter 3 Combined Agent Vehicles

3-1 General.

3-1.1 The category of combined agent vehicles shall encompass the range of water capacity commencing at 100 gal (378.5 L) and extending to 500 gal (1892.5 L). In addition to carrying foam as a primary agent, either dry chemical or Halon 1211 extinguishing agent also shall be carried as an auxiliary agent.

3-1.2 The following quantities of water and auxiliary agent shall establish the class of vehicle:

Table 3-1.2 Combined Agent Vehicle Classes

	Minimum Water Capacity		Minimum Auxiliary Agent	
Class	(gal)	(L)	(lb)	(kg)
1	100	400	450	204.3
2	200	800	450	204.3
3	300	1200	450	204.3
4	500	2000	450	204.3

3-2 Weights and Dimensions.

3-2.1 Weights.

3-2.1.1 The gross vehicle weight rating of the chassis as furnished shall equal or exceed the actual gross weight of the fully loaded and equipped vehicle.

3-2.1.2 The weight shall be distributed as equally as practical over the axles and tires of the fully loaded vehicle. The difference in weight between tires on any axle shall not exceed 5 percent of that axle weight, and the difference in weight between axles shall not exceed 15 percent of the weight of the heaviest axle. The front axle shall not be the heaviest axle. Under no circumstances shall the axle and tire manufacturers' ratings be exceeded.

3-2.1.3 The vehicle's center of gravity shall be kept as low as possible under all conditions of loading. The vehicle shall be capable of operations on a 20-percent side slope in both directions and shall be capable of ascending and descending a 50-percent grade in forward gear. Classes 1, 2, and 3 vehicles shall stand on a 30-degree side slope, and Class 4 vehicles shall stand on a 28-degree side slope. They shall be capable of ascending and descending at grades of 58 percent and 53 percent, respectively.

3-2.1.4 The vehicle also shall be driven on a steering pad around a circle with a radius of 100 ft (30.5 m). The steering wheel rotation shall increase with accelerating speed to ensure that the vehicle does not exhibit oversteer characteristics. A speed of 25 mph (40.2 km/h) shall be obtained for all classes of vehicles.

3-2.2 Dimensions.

3-2.2.1 Underchassis clearance of the vehicle shall allow mobility in soft soils and rough terrain. The minimum dimensions shall be as follows:

(a) Angle of approach — 30 degrees;

(b) Angle of departure — 30 degrees;

(c) Interaxle clearance angle — 12 degrees;

(d) Underaxle clearance — 8-in. (20.3-cm) underaxle differential housing bowl;

(e) Underbody clearance, Classes 1, 2, and 3 — 13 in. (33.0 cm);

(f) Underaxle clearance, Class 4 — $10^1/_2$ in. (26.7 cm);

(g) Underbody clearance, Class 4 — 18 in. (45.7 cm).

3-2.2.2* The overall height, length, and width of the vehicle shall be held to a minimum consistent with the best operational performance of the vehicle and the design concepts needed to achieve this performance and to provide optimum maneuverability and facilitate movement on public highways.

3-2.2.3 The vehicle shall be constructed so that a seated driver, having an eye reference point of $31^3/_4$ in. (80.7 cm) above the seat cushion and 12 in. (30.5 cm) forward from the seat back, shall be able to see the ground 20 ft (6.1 m) ahead of the vehicle and shall have a field of vision of at least 5 degrees above the horizontal plane. The field of vision in the horizontal plane shall be at least 90 degrees on each side from the straight ahead position.

3-2.2.4 Adjustable rear view mirrors with a glass area of not less than 60 in.^{2} (387 cm^2) shall be provided on each side of the vehicle. Each side shall be provided with a minimum 7-in.^{2} (45.2-cm^2) wide angle (convex) mirror.

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

3-3 Engine.

3-3.1 Performance Requirements.

3-3.1.1 The vehicle engines shall have sufficient horsepower, torque, and speed characteristics to meet and maintain all vehicular performance characteristics specified in this standard. The engine manufacturer shall certify that the installed engine is approved for this application.

3-3.1.2* The fully loaded vehicle shall be able to accelerate consistently from 0 mph to 50 mph (0 km/h to 80.5 km/h) on dry, level concrete pavement at the operational airport within the times specified in Table 3-3.1.2. The maximum speed shall not be less than 65 mph (104.6 km/h). If any vehicle accelerates from 0 mph to 50 mph (0 km/h to 80.5 km/h) in less than 20 seconds, it shall meet the tilt table parameters of 35 degrees side slope as a minimum for all classes.

The acceleration times provided in Table 3-3.1.2 shall be achieved with the engine and transmission at their normal operating temperature at any ambient temperature from 0°F to 110°F (–17.8°C to 43.3°C) and at elevations up to 2000 ft (609.6 m) above sea level unless a higher elevation is specified.

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

Table 3-3.1.2 Acceleration Times for Combined Agent Vehicles

Vehicle Class	Maximum Acceleration Time 0 mph to 50 mph (0 km/h to 80 km/h) (sec)
1	25
2	30
3	30
4	30

3-3.1.3 Where the engine is used to power both the vehicle and a fire-fighting pump, provision shall be made to ensure that the operation of the pump does not cause the following:

(a) Stalling of the engine;

(b) Pump speed in excess of that recommended.

3-3.2 Engine Cooling Systems.

3-3.2.1 Liquid-Cooled Engines. An engine coolant preheating device shall be provided as an aid to rapid starting and high initial engine performance. This device shall be fitted with a thermostat.

3-3.2.1.1 The cooling system shall be designed so that the stabilized engine coolant temperature remains within the engine manufacturer's prescribed limits under all operational conditions and at all ambient temperatures encountered at the operational airport. The cooling system shall be provided with automatic thermostat for rapid engine warming.

3-3.2.1.2 Where specified, radiator shutters, where furnished for cold climates, shall be of the automatic type and shall be designed to open automatically upon failure.

3-3.2.1.3 Air-Cooled Engines. Air-cooled engines shall be designed so that the stabilized cylinder head and oil temperatures remain within the engine manufacturer's prescribed limits under all operational conditions and at all ambient temperatures encountered at the operational airport.

3-3.3 Fuel System.

3-3.3.1 A complete fuel system installed with the engine manufacturer's approval shall include a fuel pump, fuel filtration, and flexible fuel lines, where necessary, that shall be protected from damage, exhaust heat, and exposure to ground fires. Gasoline engines shall have an electric fuel pump located near the fuel tank to prevent vapor lock.

3-3.3.2 Accessible filtration shall be provided for each fuel supply line, and a drain shall be provided at the bottom of the fuel tank.

3-3.3.3 Fuel tanks shall not be installed in a manner that allows gravity feed.

3-3.3.4 Fuel tanks shall have a minimum capacity of 18 gal (68.1 L).

3-3.4 Exhaust System.

3-3.4.1 The exhaust system shall be of a size that avoids undue back pressure and shall be located and constructed in such a manner that entrance of exhaust gases into the cab is minimized under all conditions of operation. The exhaust system shall be of high-grade, rust-resistant materials.

3-3.4.2 The tail pipe and muffler shall be protected from damage that could result from traversing rough terrain. The tail pipe shall be designed to discharge upward or to the rear and shall not be directed toward the ground.

3-4 Vehicle Electrical System.

3-4.1 The engine shall be equipped with a complete battery starting system.

3-4.2 A complete 12-volt, negative electrical system including transistorized alternator and fully transistorized voltage regulator shall be furnished. The idle minimum charging rate shall be 30 amperes. The alternator shall be driven by dual belts.

3-4.2.1 For 12-volt systems, the batteries shall be connected so that their capacity meets the cold-cranking performance amperes at 0°F (–17.8°C) to comply with the engine manufacturer's recommendations. In addition to the cold-cranking performance ampere requirements, a minimum reserve capacity of 600 minutes at 80°F (26.7°C) shall be provided.

3-4.2.2 For 24-volt systems, the batteries shall be connected so that their capacity meets the cold-cranking performance amperes at 0°F (–17.8°C) to comply with the engine manufacturer's recommendations.

3-4.3 Batteries shall be mounted securely and adequately protected against physical injury and vibration, water spray, and engine and exhaust heat. Where an enclosed battery compartment is provided, it shall be ventilated adequately, and the batteries shall be readily accessible for examination, test, and maintenance.

3-4.4 Battery Capacity.

3-4.4.1 Battery capacity shall be commensurate with the size of the engine and the anticipated electrical load. The capacity shall be not less than a rating of 120 ampere-hours at a 20-hour discharge rate (520 cold-cranking amperes) for gasoline engines and a rating of 200 ampere-hours at a 20-hour discharge rate (900 cold-cranking amperes) for diesel engines using 12-volt starting systems. One or more polarized receptacles shall be provided for charging all batteries.

3-4.4.2 Battery capacity and wiring circuits, including the starter switch and circuit and the starter to battery connections, shall meet or exceed the manufacturer's recommendations. A master power disconnect system shall isolate power from all of the electrical system except the primary power circuits to the alternator and starter. Exceptions apply only to systems that are required to operate when the vehicle is not attended. The control device shall be accessible from the driver's seated position.

3-4.4.3 Where specified, an on-board battery charger/conditioner shall be provided on the vehicle and shall have a minimum output rating of one-half percent of the cold-cranking ampere rating at 32°F (0°C) of the engine-starting battery system. The battery charger shall be supplied from an external power source of 115 volts or 220 volts AC. This battery charger/conditioner shall be the type that can be connected to the batteries at all times and yet maintain a charge to the batteries without causing any damage. The unit shall reduce its charging output level to a point where a small amount of charge is allowed to the batteries continuously or it shall shut off completely. The charger/conditioner shall have protection built into it to protect it from damage during high current demands such as those caused by starting the engine. The unit shall be provided with a grounded AC receptacle to allow a pull-away connection from the local electrical power supply to the battery charger/conditioner.

3-4.5 The electrical system and its components shall be weatherproof, insulated, and protected from chafing, damage from road debris, and exposure to ground fires. All wiring shall be coded to correspond with the wiring diagram provided with the vehicle. Circuit protection shall be provided to protect the vehicle in the event of electrical overload.

3-4.6 Radio suppression of the electrical system shall be in accordance with SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices 30-1000 MHz)*, or an equivalent radio suppression standard.

3-5 Vehicle Drive.

3-5.1 Transmission of power from the engine to the wheels of the vehicle shall be through a torque converter and an automatic or a semiautomatic gearbox. The entire drive train shall be designed and rated by the component manufacturer as having sufficient capacity to slip the wheels of the static-loaded vehicle on a surface having a coefficient of friction of 0.8. A range of gears providing the specified top speed and a grade ability of 50 percent shall be provided with sufficient intermediate gears to achieve the specified acceleration.

3-5.2 A positive drive shall be provided to each wheel by means of a fully locked driveline in order to maximize traction on low-friction surfaces. Positive drive shall be permitted to be achieved either by the use of automatic locking and torque proportioning differentials or shall be permitted to be selected manually by the seated driver by use of a single control while the vehicle is in motion.

3-5.3 All-wheel drive on these vehicles shall incorporate a drive to the front and rear axles that is engaged at all times during the intended airport service. An interaxle differential shall be installed with automatic means or driver-selected means of differential locking.

3-5.4 All traction-increasing devices shall be operated by a single control for driving simplicity.

3-5.5 Front and rear axles shall have adequate capacity to carry the maximum imposed load under all intended operating conditions. The variations in axle tread shall not exceed 20 percent of the tire sectional width at rated load.

3-6 Suspension. The suspension system shall be designed to allow the loaded vehicle to perform as follows:

(a) Travel at the specified speeds over improved surface;

(b) Travel at moderate speeds over unimproved surface;

(c) Provide diagonally opposite wheel motion 10 in. (25.4 cm) above ground obstacles without raising the remaining wheels from the ground;

(d) Prevent damage to the vehicle caused by wheel movement; and

(e) Provide a good environment for the crew when traveling over all surfaces.

3-7 Wheels, Tires, and Rims.

3-7.1 Vehicles shall be required to have off-highway mobility while meeting the specified paved surface performance.

3-7.2 Tires shall be selected to maximize the acceleration, speed, braking, and maneuvering capabilities of the vehicle on paved surfaces without sacrificing performance on all reasonable terrains found within the airport boundary.

3-7.3* The purchaser shall provide a tire description that reflects the off-road performance requirements necessitated by the soil conditions encountered at the operational airport. Soil conditions that vary from an extremely fine grain soil or clay to an extremely coarse grain soil, sand, or gravel in a dry, saturated, or frozen condition shall be considered.

To optimize flotation under soft ground conditions, tires of larger diameter or width, or both, than is needed for bearing weight only shall be specified. Similarly, the lowest tire pressure compatible with the high speed performance requirements also shall be specified.

3-7.4 Vehicle and tire manufacturers shall be consulted for the tread design most suitable for the specific soil composition at individual airports.

3-7.5 All wheels on the vehicle shall be of the single-wheel type with all rims, tires, and wheels of an identical size and the same tire tread design.

3-7.6 Rims, tires, wheels, and inflation pressures shall be approved by their respective manufacturers as having sufficient capacity to meet the specified performance and shall be certified for not less than 5 mi (8 km) of continuous operation at 65 mph (104.6 km/h) at normal operational pressure.

3-8 Towing Connections. At least two large tow eyes or tow hooks (one at the front and one at the rear), capable of towing the vehicle on level ground without damage, shall be mounted on the truck and attached directly to the frame structure or where recommended by the vehicle manufacturer.

3-9 Brakes.

3-9.1* Service brakes shall be of the all-wheel type. Service brakes shall be permitted to be of the hydraulic type with power booster or of the air-mechanical type.

3-9.2 If air-mechanical brakes are furnished, a brake chamber shall be provided for each wheel and shall be mounted so that no part of the brake chamber projects below the axle bowl.

3-9.3 Air brake systems shall include a compressor, an automatic air-drying system immediately downstream from the compressor to prevent condensation buildup in all pneumatic lines, a release valve, a brake control valve, a treadle-type actuating pedal, an air pressure gauge, enclosed-type brake adjusters, low pressure warning, and all necessary connections.

3-9.4 The compressor shall have the capacity for quick buildup of tank pressure from 0 psi (0 kPa) to the pressure to release spring brakes, and this buildup in pressure shall be accomplished within 15 seconds.

3-9.5 Compressed Air Reservoirs.

3-9.5.1 Compressed air reservoirs shall have a minimum capacity of 2000 $in.^3$ (3 277 400 cm^3) and shall be equipped with drain and safety valves.

3-9.5.2 Provision shall be made for charging of air tanks with either a pull-away electrical connection used to power a vehicle-mounted auxiliary compressor or a pull-away air connection for charging of air tanks from an external air source.

3-9.6 The service brakes shall be capable of holding the fully loaded vehicle on a 50-percent grade and shall be capable of bringing the fully loaded vehicle to five complete successive stops within 35 ft (10.7 m) at a speed of 20 mph (32.2 km/h) on dry, hard, approximately level road that is free from loose material.

3-9.7* The parking brake system shall be an entirely independent mechanical system or shall be permitted to be connected to the same brake shoes as the service brakes but through entirely separate mechanical means.

3-9.8 The parking brake shall be capable of holding the fully loaded vehicle on a 20-percent grade.

3-9.9 An emergency brake system shall be provided that is applied and released by the driver from the cab and is capable of modulation by means of the service brake control. When a single failure in the service brake system of a part designed to contain compressed air or brake fluid occurs, other than failure of a common valve, manifold, brake fluid housing, or brake chamber housing, the vehicle shall stop within no more than 288 ft (87.8 m) at 40 mph (64.4 km/h) without any part of the vehicle leaving a dry, hard, approximately level roadway that has a width equal to the vehicle width plus 4 ft (1.2 m).

3-10 Steering.

3-10.1 The chassis shall be equipped with power-assisted steering with direct mechanical linkage from the steering wheel to the steered axle(s) to allow manual control in the event of power-assist failure.

3-10.2 The power steering system shall have sufficient capacity so that no more than 15 lbf (66.7 N) pull is needed on the steering wheel rim in order to turn the steering linkage from stop to stop with the fully loaded vehicle stationary on a dry, level, paved surface with the engine at idle.

3-10.3 The wall-to-wall turning diameter of the fully loaded vehicle shall be less than three times the vehicle length.

3-11 Cab.

3-11.1 The cab shall be fully enclosed (i.e., floor, roof, and four sides) and mounted on the forward part of the vehicle. Seating for the crew shall be restricted to the cab. The maximum number of crew seat positions provided in the cab shall be designated by the manufacturer and so labeled in the cab. As a minimum, two designated seat positions shall be provided, one for the driver and one for an additional crew member. Seat belts approved by the authority having jurisdiction shall be provided for each of the designated seating positions. Space shall be provided for all instrument controls and equipment specified without hindering the crew. Doors that open to as wide a position as possible shall be provided on each side of the cab with the necessary steps and handrails to allow rapid and safe entrance and exit from the cab. The cab design shall take into consideration the provision of ample space for the crew to enter and exit the cab and carry out normal operations while wearing full protective equipment.

3-11.2 The cab shall meet the visibility requirements of 3-2.2.3. Interior cab reflections from exterior and interior lighting shall be minimized. The windshield shall be shatterproof safety glass, and all other windows shall be constructed of approved safety glass. The cab shall be provided with wide gutters to prevent foam and water from dripping on the windshield and side windows. Where equipped with a roof turret having manual controls above the cab roof, the cab shall be designed with a quick-access passage to the roof turret(s).

3-11.3 The cab shall be weatherproof and shall be fully insulated thermally and acoustically with a fire-resistant material. The cab interior noise level at any seated position shall not exceed 85 dBA while traveling at 50 mph (80.5 km/h) on a level, hard surface without warning devices operating. With warning devices operating, the maximum limit shall be 90 dBA. The cab shall be permitted to be of the unitized rigid body and frame structure type, or it shall be permitted to be a separate unit flexibly mounted on the main vehicle frame. The cab shall be constructed from materials of adequate strength to ensure a high degree of safety for the crew under all operating conditions, including excess heat exposure and vehicle roll-over accidents.

3-11.4 Instruments, Warning Lights, and Controls.

3-11.4.1 The minimum number of instruments, warning lights, and controls consistent with the safe and efficient operation of the vehicle chassis and fire-fighting system shall be provided. All chassis instruments and warning lights shall be grouped together on a panel immediately in front of the driver. All fire-fighting system instruments, warning lights, and controls shall be grouped together by function to provide ready accessibility as well as high visibility for the driver as well as crew members.

3-11.4.2 All instruments and controls shall be illuminated, and backlighting shall be used where practical.

3-11.4.3 Groupings of both the chassis and fire-fighting system instruments, warning lights, and controls shall be easily removable as a unit or shall be on a panel hinged for back access by the use of quick-disconnect fittings for all electrical, air, and hydraulic circuits.

3-11.4.4 The following instruments or warning lights, or both, shall be provided as a minimum:

(a) Speedometer/odometer;
(b) Engine tachometer(s), where specified;
(c) Fuel level;
(d) Air pressure, where specified;
(e) Engine(s) temperature;
(f) Pump pressure, where specified;
(g) Water tank level, where specified;
(h) Foam-liquid tank level, where specified;
(i) Low air pressure warning, where specified;
(j) Headlight beam indicator;
(k) Engine(s) oil pressure;
(l) Voltmeter(s);
(m) Transmission oil temperature.

3-11.4.5 The cab shall have all the necessary controls within easy reach of the driver for the full operation of the vehicle and for activating the fire-fighting system. The following cab controls shall be provided, as applicable:

(a) Accelerator pedal;
(b) Brake pedal;
(c) Parking brake control;
(d) Steering wheel, with self-canceling directional control signal and horn;
(e) Transmission range selector;
(f) Pump control or liquid agent pressurization control;
(g) Liquid agent tank valve control;
(h) Siren switch(es);
(i) Ignition switch(es);
(j) Auxiliary agent pressurization control;
(k) Remote turret, only where remote turret is furnished;
(l) Starter switch(es);
(m) Light switches;
(n) Windshield wiper and washer controls;
(o) Heater/defroster controls.

3-11.5 Equipment.

3-11.5.1 The following equipment shall be provided in or on the cab, as applicable:

(a) Heater/defroster;
(b) Driver's seat with fore and aft adjustment, with seat belt;
(c) Crew seats with individual retractable seat belts;
(d) Windshield washers appropriate for removing foam;
(e) Windshield wipers appropriate for removing foam;
(f) Siren;
(g) Horn;
(h) Sun visors;
(i) Outside rear view mirrors, as specified in 3-2.2.4;
(j) Interior lighting;
(k) Provisions for mounting SCBA of the type specified by the purchaser at each crew seat position.

3-11.5.2 The minimum number of instruments, warning lights, and controls consistent with the safe and efficient operation of the vehicle, chassis, and fire-fighting system shall be provided. All chassis instruments and warning lights shall be grouped together on a panel in front of the driver. All fire-fighting system instruments, warning lights, and controls shall be grouped together by function to provide ready accessibility and high visibility for the driver as well as crew members.

3-11.6 Signs that state "Occupants must be seated and wearing a seat belt when apparatus is in motion" shall be provided. Such signs shall be visible from each seated position. An accident prevention sign shall be located at the rear step area of the vehicle, if it exists. It shall warn personnel that standing on the step while the vehicle is in motion is prohibited.

3-12 Body.

3-12.1 The body shall be constructed of materials that are of the lightest weight consistent with the strength necessary for off-pavement operation over rough terrain and where exposed to excess heat. The body shall be permitted to be of the unitized-with-chassis-rigid-structure type or it shall be permitted to be flexibly mounted on the vehicle chassis. It also shall include front and rear fenders or wheel wells. Body panels shall be removable where necessary to provide access to the interior of the vehicle.

3-12.2 Access doors shall be provided for those areas of the interior of the vehicle that are inspected frequently. In particular, access doors of sufficient size and number shall be provided for access to the following:

(a) Engine;
(b) Pump;
(c) Battery storage;
(d) Fluid reservoirs;
(e) Foam system.

Other areas that need to be accessible for inspection or maintenance shall be open or shall have removable panels.

3-12.3 Suitable, lighted compartments shall be provided for convenient storage of equipment and tools to be carried on the vehicle. Compartment doors shall be operable for hands covered with bulky gloves. Compartments shall be weathertight and self-draining.

3-12.4 The working deck of the vehicle shall be reinforced adequately to allow the crew to perform its duties in all areas where access to auxiliary or installed equipment is necessary.

3-12.5 Handrails or bulwarks shall be provided where necessary for the safety and convenience of the crew. Rails and stanchions shall be braced strongly and constructed of a material that is durable and resists corrosion. Handrails shall be constructed of, or covered with, a slip-resistant material.

3-12.6 Steps or ladders shall be provided for access to the top fill area. The lowermost step(s) shall be permitted to extend below the angle of approach or departure or ground clearance limits if it is designed to swing clear. All other steps shall be rigidly constructed. All steps shall have a nonskid surface. The lowermost step(s) shall be no more than 22 in. (558.8 mm) above level ground when the vehicle is fully loaded. Adequate lighting shall be provided to illuminate steps and walkways.

3-12.7 A heavy-duty front bumper shall be mounted on the vehicle and secured to the frame structure.

3-12.8 Attachments shall be provided for all tools, equipment, and other items that the purchaser specifies to be furnished on the vehicle. Equipment holders shall be attached firmly and designed so that equipment remains in place under all

operating conditions, but the equipment shall be quickly removable for use.

3-13 Fire-Fighting Systems and Agents.

3-13.1 General.

3-13.1.1 For aircraft rescue and fire-fighting purposes, primary and auxiliary extinguishing agents shall be tested in accordance with NFPA 403, *Standard for Aircraft Rescue and Fire Fighting Services at Airports*.

3-13.1.2 Vehicles designed to discharge auxiliary agents shall require the use of auxiliary agents that are compatible with the primary agent.

3-13.1.3 All components of the agent systems, including such items as the tanks, piping, fill troughs, and screens, shall be made of materials resistant to corrosion by the primary agent, primary agent/water solution, water, and, where specified, the auxiliary agent.

3-13.2 Pump(s) and Pump Drive.

3-13.2.1 Water Pump(s).

3-13.2.1.1 The water pump(s) shall be constructed of corrosion-resistant metals and shall be of the single-stage or multiple-stage centrifugal type and shall be designed for dependable emergency service. It shall be designed carefully and built in accordance with good modern practice. Pumps shall be gravity primed from the vehicle tank. The pump and piping system shall be designed to eliminate the entrapment of air.

3-13.2.1.2 Where discharging foam solution, the pump shall be capable of discharging at a rate equal to or exceeding the total requirements of turrets and hand line nozzles discharging simultaneously at designed pressures.

3-13.2.2 Pump Drive.

3-13.2.2.1 The pump(s) drive shall allow operation of the pump(s) and simultaneous operation of the vehicle. The pump(s) shall not be affected by changes in transmission ratios or the actuation of clutches in the vehicle drive. The design of the drive system and controls shall prevent damage to the drive or minimize lurching of the vehicle when the vehicle drive is engaged during pumping operations. The pump(s) drive system shall be capable of absorbing the maximum torque delivered by the engine to the pump(s) and withstanding the engagement of the pump(s) at all engine speeds and under all operating conditions. The operation of the pump(s) shall not, under any conditions, cause the engine to stall or cause more than a slight and momentary reduction in engine speed and consequent drop in pump pressure.

3-13.2.2.2 While pumping at rated capacity, the drive shall allow controlled vehicle operation at speeds from 1 mph to 5 mph (1.6 km/h to 8 km/h). The pump(s) drive shall have sufficient power capacity to provide the pump discharge requirements of 3-13.2.1.2 while the vehicle is being propelled under all operating conditions where a fire-fighting capability is needed.

3-13.2.2.3 If an independent engine is used to drive the pump(s), it shall have the same fuel and electrical system as the chassis engine and shall be equipped with an air cleaner, replaceable element oil filter, a full pressure lubricating system, and an overspeed governing device to prevent engine damage. The engine also shall be provided with a cooling system that meets the requirements of 3-3.2.1 or 3-3.2.2.

3-13.2.3 Suction Connections. The suction system shall be designed for efficient flow at the pumping rates required by 3-13.2.1.2. The pump suction line(s) shall be of large diameter and of the shortest length consistent with the most suitable pump location. There shall be a drain at the lowest point with a valve for draining all of the liquid from the pumping system where desired. Suction lines and valves shall be constructed of corrosion-resistant materials.

3-13.2.4 Discharge Connections. All discharge outlets shall have National (American) Standard fire hose coupling thread. Adapter couplings, securely attached, shall be provided on each outlet if local couplings are not National (American) Standard as specified in NFPA 1963, *Standard for Fire Hose Connections*.

3-13.2.5 Piping, Couplings, and Valves.

3-13.2.5.1 All piping, couplings, and valves shall be sized for necessary flow with minimum restriction and pressure loss. Material for all piping, couplings, and valves shall be selected to avoid corrosive and galvanic action.

3-13.2.5.2 Piping shall be mounted securely and provided with flexible couplings to minimize stress. Union or rubber-gasketed fittings shall be provided where necessary to facilitate removal of piping.

3-13.2.5.3 All valves shall be of the quarter-turn type and shall be selected for ease of operation and freedom from leakage.

3-13.2.5.4 All water system piping shall be tested on the suction side of the pump to detect possible leakage. All water and foam solution discharge piping, together with the agent pump(s), shall be tested at 50 percent above the system operating pressure.

3-13.2.6 Overheat Protection. A system line shall be provided from the water pump discharge and, if applicable, from the foam pump discharge to prevent overheating of the pumps while engaged and operating at zero (0) discharge. The line shall be automatic.

3-13.2.7 Pressure Relief Valves. A pressure relief valve shall be fitted both to protect and ensure optimum performance of the system.

3-13.3 Water Tank for Nonpressurized Systems.

3-13.3.1 Capacity.

3-13.3.1.1 A water tank shall have a usable capacity as specified in 3-1.2.

3-13.3.1.2 The rated capacity of the tank shall be equal to the usable capacity that can be pumped from the tank while the vehicle is parked on level ground. The tank outlets shall be arranged to allow use of at least 85 percent of the rated capacity with the vehicle positioned as follows:

(a) On a 20-percent side slope;

(b) On a 30-percent ascending grade;

(c) On a 30-percent descending grade.

3-13.3.2 Construction.

3-13.3.2.1 The tank shall be constructed to resist all forms of deterioration that could be caused by the water and foam concentrate while affording the structural integrity necessary for off-road operation. The tank shall have longitudinal and transverse baffles. The construction and connections shall be made to prevent the possibility of galvanic corrosion of dissimilar metals.

3-13.3.2.2 The tank shall be equipped with easily removable manhole covers over the tank discharge. Where specified, the tank shall be designed to allow access within each baffled compartment of the tank for internal and external inspection and service. The tank shall have a drain valve(s).

3-13.3.2.3 Provisions shall be made for necessary overflow and venting. Venting shall be sized to allow agent discharge at the maximum design flow rate without danger of tank collapse and shall be sized to allow rapid and complete filling without exceeding the internal pressure design limit of the tank. Additionally, overflows shall be designed to prevent the loss of water from the tank during normal maneuvering and to direct the discharge of overflow water directly to the ground.

3-13.3.2.4 The water tank shall be mounted in a manner that limits the transfer of the torsional strains from the chassis frame to the tank during off-pavement driving. The tank shall be separate and distinct from the crew compartment, engine compartment, and chassis and shall be easily removable as a unit.

3-13.3.2.5 The water tank shall be equipped with at least one top fill opening of not less than 5 in. (127 mm) internal diameter. The top fill shall be equipped with an easily removable strainer of $^1/_4$-in. (6.4-mm) mesh construction. The top fill opening shall be equipped with a cap designed to prevent spillage.

3-13.3.3 Tank Fill Connection(s).

3-13.3.3.1 A tank fill connection(s) shall be provided in a position where it can be reached easily from the ground.

3-13.3.3.2 All connections shall have National (American) Standard fire hose coupling threads. Securely attached adapters shall be provided on each connection if local couplings are not National (American) Standard. Connections and adapter threads shall be as specified in NFPA 1963, *Standard for Fire Hose Connections.* Connections and connections with adapters attached shall not protrude beyond the normal body metalwork of the vehicle.

3-13.3.3.3 The connection(s) shall be provided with strainers of $^1/_4$-in. (6.4-mm) mesh and shall have check valves or shall be constructed so that water is not lost from the tank when connection or disconnection is made.

3-13.3.3.4 The tank fill connection(s) shall be sized to allow filling of the water tank in 2 minutes at a pressure of 80 psi (551.6 kPa) at the tank intake connection.

3-13.4 Foam Proportioning System.

3-13.4.1 Foam-Liquid Concentrate Tank(s).

3-13.4.1.1 The purchaser shall specify the percent concentrate foam system to be provided. The foam-liquid concentrate tank(s) shall have a working capacity sufficient for two tanks of water at the maximum tolerance specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment.*

3-13.4.1.2 Foam-liquid concentrate tanks shall be permitted to be of either the rigid or flexible type. The tank(s) shall be designed for compatibility with the foam concentrate being used and shall resist all forms of deterioration that could be caused by the foam concentrate or water.

3-13.4.1.3 Tanks shall be designed to provide ready access for internal and external inspection and service. A large capacity drain connection shall be installed flush with the bottom of the sump.

3-13.4.1.4 The tank outlets shall be located above the bottom of the sump and shall provide continuous foam-liquid concentrate to the foam proportioning system, with that system operating as specified in 3-13.4.3 and with the vehicle discharging two tank loads of usable water as specified in 3-13.3.1.

3-13.4.1.5 If separate from the water tank, the foam-liquid tank shall be mounted in a manner that limits the transfer of the torsional strains from the chassis frame to the tank during off-pavement driving. The tank shall be separate and distinct from the crew compartment, engine compartment, and chassis and shall be easily removable as a unit.

A flexible tank shall be structurally supported to resist tearing. The structural support shall not be dependent on the fluid level in either the water or foam tanks.

3-13.4.1.6 A top fill trough shall be provided and shall be equipped with a stainless steel No. 10 mesh screen and container openers to allow emptying 5-gal (18.9-L) foam-liquid concentrate containers into the storage tank(s) at a rapid rate regardless of water tank level. The trough shall be connected to the foam-liquid storage tank(s) with a fill line designed to introduce foam-liquid concentrate near the bottom of the tank(s) to minimize foaming within the storage tank.

3-13.4.1.7 The tank fill connection(s) shall be provided in a position where it can be reached easily from the ground to allow the pumping of foam-liquid concentrate into the storage tank(s). The connection(s) shall be provided with strainers of $^1/_4$-in. (6.4-mm) mesh and shall have check valves or be constructed so that foam is not lost from the tank when connection or disconnection is made.

Where flexible tanks are used, the supply system shall be designed so that the flexible tanks are not subject to excess pressure. The supply system shall be capable of delivering foam-liquid at a rate at least equal to or greater than the maximum discharge rate of the foam system.

3-13.4.1.8 The tank(s) shall be vented adequately to allow rapid and complete filling without the buildup of excessive pressure and to allow emptying the tank at the maximum design flow rate without danger of collapse. The vent outlets shall be directed to the ground to prevent spillage of foam-liquid concentrate on vehicle components.

3-13.4.2 Foam-Liquid Concentrate Piping.

3-13.4.2.1* The foam-liquid concentrate piping shall be of material resistant to corrosion by foam-liquid concentrate. Care shall be taken that combinations of dissimilar metals that produce galvanic corrosion are not selected or that such dissimilar metals are electrically insulated. Where plastic piping is used, it shall be fabricated from unplasticized resins, unless it has been demonstrated that the stipulated plasticizer does not adversely affect the performance characteristics of the

foam-liquid concentrate. The plastic pipe shall be permitted to be reinforced with glass fibers.

3-13.4.2.2 The foam-liquid concentrate piping shall be adequately sized to allow the maximum required flow rate and shall be arranged to prevent water from entering the foam tank.

3-13.4.3 Foam-Liquid Proportioning System.

3-13.4.3.1 The foam concentrate proportioning system shall provide a means of controlling the ratio of foam concentrate to the quantity of water in the foam solution being discharged from all orifices normally used for aircraft fire-fighting operations.

3-13.4.3.2 The proportioning system shall be sufficiently accurate to provide for the discharge of finished foam within the range specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam.*

3-13.5 Premixed — Pump System. Where premix solution in the main water tank is selected as the means of proportioning foam to water, the foam solution used shall be AFFF only. Care shall be exercised that the premixed solution is mixed to exact proportions. Where premix solution is used, operation of the vehicle fire-fighting system shall conform to the requirements of 3-13.2 and 3-13.3.

3-13.6 Premixed — Pressurized System.

3-13.6.1 Liquid Agent Container(s).

3-13.6.1.1 The storage container(s) and liquid agent(s) shall be designed for pressurization and shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code* and shall be so marked.

3-13.6.1.2 The material of construction shall be resistant to corrosion by the AFFF agent to be stored, or a suitable lining material shall be provided.

3-13.6.1.3 An ASME-approved pressure relief valve of adequate capacity shall be provided on the container and set to prevent pressures in excess of the maximum design working pressure. A pressure gauge shall be provided that indicates the internal pressure of the agent storage container at all times.

3-13.6.1.4 A readily accessible fill opening of sufficient size to allow ease in filling, and stirring if necessary, shall be provided. It shall be in compliance with ASME or local codes and in no case shall be less than 3 in. (76.2 mm) in diameter. Filling shall be accomplished without the removal of any of the extinguisher piping or any major component.

3-13.6.1.5 A means shall be provided to determine the contents of the container as a guide in recharging partial loads.

3-13.6.2 Propellant Gas.

3-13.6.2.1 The propellant gas shall be dry nitrogen or dry compressed air and provided in sufficient quantity to expel the fire-fighting agent as well as to purge all piping and hose lines after use.

3-13.6.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. Department of Transportation (DOT) requirements or regulations. Cylinders shall bear the DOT marking.

3-13.6.2.3 The design of the propellant source shall provide for quick and easy replacement after each use.

3-13.6.2.4 A pressure gauge shall be provided and shall indicate the pressure of the propellant gas source at all times.

3-13.6.2.5 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

3-13.6.2.6 The cylinder valve shall be capable of being opened by quick-acting control and also shall be suitable for remote operation.

3-13.6.3 Pressure Regulation.

3-13.6.3.1 Pressure regulation shall be designed to reduce the normal cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the liquid agent container(s).

3-13.6.3.2 All pressure regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

3-13.6.3.3 Pressure regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

3-13.6.3.4 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

3-13.6.4 Piping and Valves.

3-13.6.4.1 All propellant piping and fittings shall conform to the appropriate ASME code and shall be designed to withstand the working pressure of the system. The design of the piping and valving shall provide the desired flow of gas into the system and the minimum amount of restriction from the liquid agent container(s) to the hose connection. Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

3-13.6.4.2 Provisions shall be made for purging all piping and hose of the liquid after use without discharging the liquid agent remaining in the container(s). Provisions also shall be made for the depressurization of the liquid agent container(s) without the loss of the remainder of the liquid agent.

3-13.6.4.3 Drains shall be provided to allow complete draining of the system.

3-13.6.4.4 All valves shall be of the quarter-turn, quick-opening, ball type. A maximum of two operations, exclusive of the nozzle, shall be provided to charge the system. Controls shall be arranged for simultaneous charging of the liquid agent and dry chemical systems.

Exception: Valves on the gas cylinder specified in 3-13.6.2.2 shall not be required to be of the quarter-turn, quick-opening ball type.

3-13.6.4.5 A quick-acting control to be operated by the driver to pressurize the liquid agent system from the cab of the vehicle shall be provided, with a similar control at the unit.

3-13.6.4.6 All valves and piping shall be resistant to corrosion by the foam-liquid concentrate.

3-13.6.4.7 A check valve shall be provided in the gas piping to prevent the liquid agent from being forced back into the propellant gas line.

3-13.7 Dry Chemical System.

3-13.7.1 General.

3-13.7.1.1 The dry chemical container(s) shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code*, Section 8, and shall be so stamped.

3-13.7.1.2 All piping and fittings shall conform to the appropriate ASME code and shall be designed to withstand the working pressure of the system. The design of the piping and valving shall provide the desired flow of gas into the system and the minimum amount of restriction from the chemical container(s) to the hose connection. Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

3-13.7.1.3 Provisions shall be made for purging all piping and hose of dry chemical after use without discharging the dry chemical remaining in the dry chemical container(s). Provisions also shall be made for the depressurization of the dry chemical container(s) without the loss of the remainder of the dry chemical. A pressure gauge shall be provided that indicates the internal pressure of the agent storage container(s) at all times.

3-13.7.1.4 The system shall be designed to ensure fluidization of the dry chemical at the time of operation. Where any design includes the movement of the chemical container(s) to fluidize the contents, such design also shall include a manual operating feature.

3-13.7.1.5 A check valve shall be provided in the gas piping to prevent the extinguishing agent from being forced back into the propellant gas line.

3-13.7.1.6 A means of pressure relief conforming to appropriate ASME codes shall be provided for the dry chemical container(s) and piping to prevent overpressurization in the event of a malfunction in the propellant gas regulator system or in the event the container is involved in a severe fire exposure.

3-13.7.1.7 The fill opening in the dry chemical container shall be located so that it is easily accessible for recharging and necessitates a minimum amount of time and effort to open and close. Filling shall be accomplished without the removal of any of the extinguisher piping or any major component.

3-13.7.1.8 A quick-acting control to be operated by the driver to pressurize the dry chemical agent system from the cab of the vehicle shall be provided, with a similar control at the hand line.

3-13.7.2 Propellants.

3-13.7.2.1 The propelling agent shall be dry nitrogen or dry air.

3-13.7.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. Department of Transportation (DOT) requirements or regulations. Cylinders shall bear the DOT marking.

3-13.7.2.3 The method of adequately pressurizing and propelling the dry chemical in the system shall provide a sufficient quantity of gas to expel the agent, as well as allowing the complete purging of all piping and hose lines after each use.

3-13.7.2.4 The design of the propellant source shall provide for quick and easy replacement after each use.

3-13.7.2.5 A pressure gauge shall be provided and shall indicate the pressure on the propellant gas source at all times.

3-13.7.2.6 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

3-13.7.3 Pressure Regulation.

3-13.7.3.1 Pressure regulation shall be designed to reduce the normal cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the dry chemical container(s).

3-13.7.3.2 All pressure regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

3-13.7.3.3 Pressure regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

3-13.7.3.4 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

3-13.8 Halon 1211 System.

3-13.8.1 Halon Container.

3-13.8.1.1 The storage container shall be designed for pressurization and shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code* and shall be so marked.

3-13.8.1.2 The material of construction shall be resistant to corrosion by the halon agent to be stored.

3-13.8.1.3 A readily accessible charge coupling of sufficient size to allow ease in filling shall be provided. Filling shall be accomplished without the removal of any of the extinguisher piping or any major component. A pressure gauge shall be provided that indicates the internal pressure of the agent storage container at all times.

3-13.8.1.4 A means shall be provided to determine the contents of the container as a guide in recharging partial loads and to prevent overfilling of the tank.

3-13.8.2 Propellant Gas.

3-13.8.2.1 The propellant gas shall be dry nitrogen or dry compressed air and provided in sufficient quantity to expel the halon agent as well as purge all piping and hose lines after use.

3-13.8.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. Department of Transportation (DOT) requirements or regulations. Cylinders shall bear the DOT marking.

3-13.8.2.3 Pipes and valves connected to the halon container shall conform to the appropriate ASME code and shall be designed to withstand the working pressure of the system.

3-13.8.2.4 The design of the propellant source shall provide for quick and easy replacement after each use.

3-13.8.2.5 A pressure gauge shall be provided and shall indicate the pressure of the propellant gas source at all times.

3-13.8.2.6 Cylinder valves, gauges, and piping shall be arranged to preclude accidental mechanical damage.

3-13.8.2.7 A check valve shall be provided in the gas piping to prevent the liquid agent from being forced back into the propellant gas line.

3-13.8.3 Pressure Regulation.

3-13.8.3.1 An ASME-approved pressure relief valve of adequate capacity shall be provided on the container and shall be set to prevent pressures in excess of the maximum design working pressure.

3-13.8.3.2 Pressure regulation shall be designed to reduce the normal cylinder pressure automatically and to hold the propellant gas pressure at the designed operating pressure of the halon container.

3-13.8.3.3 All pressure regulating devices shall be sealed or pinned at the designed operating pressures after final adjustment by the system manufacturer.

3-13.8.3.4 Pressure regulating devices shall be equipped with a spring-loaded relief valve that relieves any excess pressure that develops in the regulator.

3-13.8.3.5 The pressure regulator shall be permitted to be of a type without pressure indicating gauges.

3-13.8.4 Halon Delivery Piping and Valves.

3-13.8.4.1 All piping, couplings, and valves shall be sized for necessary flow with minimum restriction and pressure loss. Material for all piping, couplings, and valves shall be selected to avoid corrosive and galvanic action. Piping shall be mounted securely and provided with flexible couplings to minimize stress.

3-13.8.4.2 All valves shall be of the quarter-turn type and shall be selected for ease of operation and freedom from leakage.

3-13.8.4.3 All discharge piping shall be tested at 50 percent above the system operating pressure.

3-13.8.4.4 Where more than one hose line is provided, piping and fittings shall be sized and designed so that there is equal flow to each line, regardless of the number of lines placed in operation.

3-13.8.4.5 Provisions shall be made for purging all piping and hose of the halon after use without discharging the halon remaining in the container(s). Provisions also shall be made for venting of the halon container without loss of the remainder of the liquid agent.

3-13.8.4.6 A quick-acting control to be operated by the driver to pressurize the halon system from the cab of the vehicle shall be provided, with a similar control at the hand line.

3-13.9 Primary Turret Nozzles.

3-13.9.1 Classes 2, 3, and 4 vehicles shall have a foam turret or a twin (dry chemical and foam) turret. Where Halon 1211 is utilized, a twin turret shall not be required.

3-13.9.2 The nominal foam solution discharge rate from the foam turret shall be 150 gpm (567.8 lpm) for Class 2 vehicles, 200 gpm (757 lpm) for Class 3 vehicles, and 250 gpm (946.3 lpm) for Class 4 vehicles. The roof turret discharge rate shall have a tolerance of +10 percent/–0 percent.

3-13.9.3 Both single foam turrets and the foam barrel of a twin turret for simultaneous agent discharge shall be capable of discharging foam, as specified in Table 3-13.9.3, in still air in a variable pattern with the turret elevated to the maximum stream reach position.

Table 3-13.9.3 Foam Turret Barrel Pattern

Vehicle Class	Straight Stream		Dispersed Stream			
	Far Point		Full Width		Full Width Far point	
	(ft)	(m)	(ft)	(m)	(ft)	(m)
2	125	38	20	6	25	7.6
3	125	38	25	7.6	25	7.6
4	125	38	25	7.6	25	7.6

3-13.9.4 The dry chemical barrel of a twin turret for simultaneous agent discharge shall be designed to dispense the dry chemical agent at a minimum discharge rate of ≥16 lb/sec to ≤ 22 lb/sec (≥7.3 kg/sec to ≤10.0 kg/sec) and with a minimum far point range of not less than 100 ft (30.5 m), with a pattern width not less than 17 ft (5.2 m) with the turret stationary.

3-13.9.5 The foam barrel of a twin turret for simultaneous agent discharge shall be positioned so that the foam stream pattern falls to the ground 10 ft (3 m) behind the dry chemical stream pattern.

3-13.9.6 Turret controls for both foam and dry chemical turrets shall be accessible both to the driver and the crew member.

3-13.9.7 Both single and twin turrets shall be capable of being elevated at least 45 degrees above the horizontal and depressed to discharge agent within 20 ft (6.1 m) in front of the vehicle at full output using a dispersed stream. The turret shall be capable of being rotated not less than 90 degrees to either side, with total traverse not less than 180 degrees. Where two turrets are used on a vehicle, suitable stops shall be provided so that neither turret can interfere with the other turret.

3-13.9.8 The dry chemical agent system shall be designed so that the operator can discharge both the primary and the auxiliary agent system separately or simultaneously.

3-13.10 Preconnected Hand Lines, Reels, and Nozzles.

3-13.10.1 Combined agent vehicles shall have at least one preconnected hand line and nozzle for each agent. Hand lines and nozzles shall be permitted to be separate or twinned together for simultaneous agent discharge. Hand lines shall be permitted to be reeled hand lines as specified in 3-13.10.2 or woven jacket hand lines as specified in 3-13.10.3.

3-13.10.2 Preconnected Hand Lines.

3-13.10.2.1 Preconnected hand lines for reels shall have a minimum internal diameter of 1 in. (25.4 mm), shall have a minimum burst pressure rating three times the nominal working pressure of the system, and shall discharge the gpm (lpm) required in 3-13.10.2.3 without unreeling the hose.

3-13.10.2.2 At least 100 ft (30.5 m) of hose shall be provided for each reel.

3-13.10.2.3 Each hand line shall be equipped with a shutoff-type nozzle designed to discharge both foam and water at a nominal discharge rate of 60 gpm (227.1 lpm), +10 percent/–0 percent. Each nozzle shall have minimum foam discharge patterns from a dispersed stream of 15 ft (4.6 m) in width and 20 ft (6.1 m) in range to a straight foam stream with a 50-ft (15.2-m) range.

3-13.10.2.4 Each reel shall have capacity for at least 100 ft (30.5 m) of 1-in. (25.4-mm) hose or more if specified by the purchaser.

3-13.10.2.5 Each reel shall be designed and positioned to allow hose line removal by a single person from any position in a 120-degree horizontal sector. Each reel shall be equipped with a friction brake to prevent the hose from unreeling when not desired. A power rewind with manual override shall be provided. The nozzle holder, friction brake, rewind controls, and manual valve control shall be accessible from the ground.

3-13.10.2.6 The discharge control to each hand line shall be adjacent to the hand line and accessible to the person using the hand line.

3-13.10.3 Woven Jacket Hand Lines.

3-13.10.3.1 Woven jacket hand lines shall have a minimum diameter of $1^1/_2$ in. (38.1 mm) and shall meet the requirements of NFPA 1961, *Standard for Fire Hose*.

3-13.10.3.2 At least 150 ft (45.7 m) of hose shall be provided for each hand line.

3-13.10.3.3 Each hand line shall be equipped with a shutoff-type nozzle designed to discharge both foam and water at a nominal discharge rate of 95 gpm (359.6 lpm), +10 percent/–0 percent. Each nozzle shall have minimum foam discharge patterns from a dispersed stream of 15 ft (4.6 m) in width and 20 ft (6.1 m) in range to a straight foam stream with a 65-ft (19.8-m) range.

3-13.10.3.4 Each hand line shall be stored, flat loaded, in a hose compartment and shall be preconnected. Each hose compartment shall have a capacity for a minimum of 150 ft (45.7 m) of $1^1/_2$-in. (38.1-mm) multiple jacket hose or more if specified by the purchaser.

3-13.10.3.5 Hose compartments shall be fabricated from noncorrosive material and shall be designed to drain effectively. The compartment shall be smooth and free from all projections that might damage the hose. No other equipment shall be mounted or located where it can obstruct the removal of the hose. Each preconnected hand line compartment shall be located so that the distance between the hand line nozzle and the ground, step, or deck plate upon which the operator stands to initiate the pulling of the hand line from the reel or the top lay of the woven jacket hose is not more than 6 ft (1.8 m) above that surface.

3-13.10.3.6 The discharge control to each hand line shall be adjacent to the hand line and accessible to the person using the hand line.

3-13.10.4 Auxiliary Agent Hand Lines.

3-13.10.4.1 Hand lines for auxiliary agents shall have a minimum burst pressure rating three times the nominal working pressure of the system and meet the requirements specified below. The auxiliary agent hand line shall be equipped with a nozzle that allows a fully opened to a fully closed position in a single, simple movement and shall be designed to discharge agent at a minimum rate of ≥5 lb/sec to ≤7 lb/sec (≥2.3 kg/sec to ≤3.3 kg/sec) at a minimum range of 20 ft (6.1 m). Nozzle construction shall be of nonferrous metal or stainless steel.

3-13.10.4.2 Twinned hand lines and nozzles shall be designed so that each agent can be discharged separately or simultaneously. The barrels shall be linked together to provide coordinated application by one operator.

3-13.10.4.2.1 Each reel shall have capacity for at least 100 ft (30.5 m) of 1-in. (25.4-mm) hose or more if specified by the purchaser.

3-13.10.4.2.2 Each reel shall be designed and positioned to allow hose line removal by a single person from any position in a 120-degree horizontal sector. Each reel shall be equipped with a friction brake to prevent the hose from unreeling when not desired. A power rewind with manual override shall be provided. The nozzle holder, friction brake, rewind controls, and manual valve control shall be accessible from the ground.

3-13.10.4.2.3 The discharge control to each hand line shall be adjacent to the hand line and accessible to the person using the hand line.

3-13.11 Foam Quality. Turrets and hand lines shall discharge foam having the quality specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*.

Measurement of the expansion ratio and 25-percent drainage times shall be in accordance with the procedures outlined in NFPA 412.

3-14 Lighting and Electrical Equipment.

3-14.1 Lighting equipment shall be installed in conformity with local road regulations, where practicable, and shall include the following:

(a) Headlights with upper and lower driving beams. A control switch that is readily accessible to the driver shall be provided for beam selection.

(b) Dual taillights and stoplights.

(c) Self-canceling turn signals, front and rear, with a steering column-mounted control and a visual and audible indicator. A four-way flasher switch shall be provided.

(d) Where specified, a minimum 6-in. (152.4-mm) spotlight on both left and right sides of the windshield, hand-adjustable type, with controls for beam adjustments inside the truck cab.

(e) Adequate reflectors, and marker and clearance light, shall be furnished to describe the overall length and width of the vehicle.

(f) Engine compartment lights, nonglare type, arranged to illuminate both sides of the engine, with individual switches located in the engine compartment. Service lighting shall be provided for all areas described in 2-12.2(a), (b), and (c), as well as for the engine compartment.

(g) Two swivel-mounted lights, 6 in. (152.4 mm) minimum, with clear lens and individual switches, mounted on the top deck for equipment lighting.

(h) Lighting provided for all top deck working areas.

(i) At least one back-up light and an audible alarm with a minimum of 97 dBA meeting SAE J994, *Standard on Alarm-Backup-Electric Laboratory Performance Testing*, installed in the rear of the body.

(j) A flashing red beacon or alternate red and white flashing lights mounted on the top deck and visible for 360 degrees in the horizontal plane. The mounting of the beacon also shall provide good visibility from the air. A control switch shall be provided on the instrument panel in the cab for control of the beacon.

3-14.2* A warning system shall be provided that has a sound output of not less than 95 dBA at 100 ft (30.5 m), when measured directly ahead of the siren and not less than 90 dBA at 100 ft (30.5 m), measured at 45 degrees on either side. The siren shall be mounted to allow maximum forward sound projection but shall be protected from foam dripping from the turret or water splashed up by the tires.

3-14.3 A master switch for all emergency lights shall be provided.

3-14.4 An electric or air horn shall be provided and shall be mounted at the front part of the vehicle with the control positioned so that it is readily accessible to the driver.

3-14.5 Where furnished, air horns, an electric siren(s), and an electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as practical. Audible warning equipment shall not be mounted on the roof of the apparatus.

3-14.6 Radios.

3-14.6.1 Provision shall be made for mounting radios. Operation of the radios shall be from the cab. Radios shall be mounted to allow quick servicing or replacement.

3-14.6.2 The purchaser shall specify all necessary radios and frequencies that are to be provided.

3-15* Tools. Provision shall be made for mounting tools and equipment, as specified by the purchaser, on the truck. Special tools for servicing the vehicle, fire suppression system, and any of the auxiliary equipment shall be furnished as necessary by the vehicle manufacturer.

Chapter 4 Acceptance Criteria

4-1 General.

4-1.1 Compliance with the requirements of this standard shall be verified by one of the following methods:

(a) The component manufacturer's certification;

(b) Prototype vehicle tests;

(c) Operational tests.

4-1.2 The component manufacturer's certification shall be provided where specified in Section 4-2. The manufacturer shall certify that the component is approved for use in the RFF application.

4-1.3 Prototype vehicle tests shall be conducted by the manufacturer in accordance with the standardized procedures found in Section 4-3 to ensure that the performance requirements have been achieved with the design. Calculated performance capability shall not be substituted for an actual prototype test.

4-1.4 Operational tests shall be performed either at the airport or the manufacturer's facility as specified in Section 4-4. The test shall be conducted by the manufacturer on every vehicle built.

4-1.5 The manufacturer of the vehicle shall demonstrate to the purchasing authority or its designee the care and maintenance and operational capability of the vehicle.

4-2 Component Manufacturer's Certification.

4-2.1 A copy of the manufacturer's signed application for approval shall be provided with the vehicle documents for the following components:

(a) Engine;

(b) Transmission;

(c) Axles;

(d) Transfer case;

(e) Wheels;

(f) Tires;

(g) Hand line hose with couplings attached;

(h) Premixed storage container;

(i) Premixed system pressure relief valve;

(j) Propellant gas cylinder;

(k) Propellant gas cylinder regulating device;

(l) Complementary agent storage container;

(m) Complementary agent pressure relief device.

4-2.2 The cooling system shall be certified by the vehicle manufacturer to satisfy all operational conditions at all ambient temperatures encountered at the operational airport for both the engine and the transmission.

4-2.3 The brake system shall be certified by the vehicle manufacturer to satisfy the service brake, emergency brake, and grade-holding performance requirements for the corresponding class of vehicle.

4-2.4 Where the vehicle is equipped with an air brake system, the vehicle manufacturer shall provide itemized, certified data relative to the air system as follows:

(a) Total reservoir capacity;

(b) Total required volume (twelve times the total combined brake chamber volume at full stoke);

(c) Quick buildup system capacity;

(d) Quick buildup system pressure needed to release the spring brakes.

4-3 Prototype Vehicle Tests. Where the vehicle is fitted with an extendable turret (*see definition in Section 1-3*), the test shall be conducted with the extendable turret in the stowed position.

4-3.1 Rated Water/Foam Tank Capacity Test.

4-3.1.1 Test facilities shall consist of an open site suitable for discharging agent that includes both level ground and measured grades of at least 20 percent and 30 percent. Access to a refill water supply shall be required.

4-3.1.2 Test equipment shall consist of the following:

(a) A calibrated sight gauge;

(b) A liquid volume measuring device accurate to within ±1.0 percent;

(c) *Alternative:* A stopwatch and a scale capable of measuring the total vehicle weight accurate to within ±1.0 percent.

4-3.1.3 The vehicle shall have had its primary turret(s) discharge rate verified prior to beginning this test to ensure that the turret(s) discharges at or above the minimum rate specified, and the accuracy of the foam metering system shall have been verified.

4-3.1.4 The rated water and foam tank capacity shall be determined as follows:

(a) Park the vehicle on level ground.

(b) If necessary, attach a calibrated site gauge to both the water tank and the foam tank.

(c) Fill the water piping up to a level even with the bottom of the tank. Do not record the water quantity used.

(d) *Alternative:* After completion of 4-3.1.4(c), record the weight of the vehicle. Fill the water tank and foam tank and record the weight of the vehicle.

(e) While filling both tanks with a liquid volume measuring device, correlate and record the amount of water added to each tank with the site gauge calibrations. When the tanks are filled to the top, record the total liquid capacity for each tank.

(f) Add dye to the foam tank.

(g) Set the agent system to discharge at the specified foam solution rate, and adjust the system discharge pressure to the recommended pressure.

(h) Starting with tanks that are completely full, discharge at maximum rate through the primary turret(s) until the agent pump(s) shows a drop in discharge pressure, and then stop immediately. Verify that dye is apparent in the discharge stream throughout the test. Record the discharge time if using the weight measurement method.

(i) *Alternative:* Record the weight of the vehicle after discharging. Calculate the pump-out capacity of the water tank using the weight of the water plus the foam discharged, the foam proportioning rate as verified in 4-3.1.3, and the discharge time.

(j) Measure the amount of liquid remaining in both tanks and convert to gallons using the conversion established in 4-3.1.4(e). Subtract the amount remaining from the total capacity to determine the amount pumped out. Record the total amount of liquid pumped out of the tanks.

(k) Refill the water tank only (not the foam tank). Discharge the water tank as in 4-3.1.4(h). Verify that dye is apparent throughout the test. Measure and record the additional amount of liquid discharged from the foam tank. Fill the water tank and discharge as many times as necessary to eliminate all usable liquid from the foam tank.

(l) Total and record the amount of liquid discharged from the foam tank from the time of initial fill.

(m) Refill both tanks and repeat 4-3.1.4(f) through with the vehicle parked in the following attitudes:

After pumping on a slope, with the vehicle in the following slope conditions, return the vehicle to level ground to measure the water volume discharged:

1. A 20-percent side slope, left side up;
2. A 20-percent side slope, right side up;
3. A 30-percent slope, ascending;
4. A 30-percent slope, descending;

(n) Divide the volume of liquid discharged from each tank on the four slope conditions by 0.75 and record.

4-3.1.5 The rated or usable water tank capacity shall be the lesser of the volumes calculated in 4-3.1.4(j) or 4-3.1.4(n). The rated or usable foam tank capacity shall be the lesser of the volumes calculated in 4-3.1.4(l) or 4-3.1.4(n).

4-3.2 Side Slope.

4-3.2.1 Test facilities shall consist of either a measured fixed grade equal to or in excess of the slope requirement for the class of vehicle being tested or a surface on which the tires of the vehicle can be placed that is capable of being tilted. Means to restrain the vehicle at the balance point shall be required.

4-3.2.2 Test equipment shall consist of a suitable inclinometer capable of measuring the slope of the support surface with an accuracy of ±1 degree.

4-3.2.3 Vehicle Testing.

4-3.2.3.1 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended operating pressure. A suitable ballast shall be used in place of the crew for safety.

4-3.2.3.2 Where the vehicle is fitted with an extendable turret, an additional test shall be performed as follows:

Tilt the vehicle on a table, or position the vehicle on a 20-percent grade. Elevate the extendable turret to the highest elevation. Position the turret nozzle uphill at maximum horizontal rotation, and discharge the agent at maximum flow rate for the class of vehicle being tested.

4-3.2.4 The side slope capability of the vehicle shall be determined as follows:

(a) Tilt the vehicle on a table, or position the vehicle on a grade having an angle above the horizon at least equal to the side slope angle specified for the vehicle being tested.

(b) Once the vehicle is positioned at the required angle, check the vehicle restraints to ensure that no tension is applied.

4-3.2.5 The vehicle shall be considered to meet its side slope requirement if the vehicle can stand by itself on the grade without the use of the safety restraints.

4-3.3 Cornering Stability.

4-3.3.1 Test facilities shall consist of a level site having a dry, paved surface at least 250 ft (76.2 m) in diameter that is free from loose material upon which a circle with a radius of 100 ft (30.5 m) shall be marked in a manner that can be followed easily by a driver.

4-3.3.2 A calibrated speedometer and a means of indicating steering wheel angle shall be required.

4-3.3.3 The vehicle shall be tested in its fully loaded condition. (*See definition of Fully Loaded Vehicle in Section 1-3.*)

4-3.3.4 The vehicle shall be tested as follows:

(a) Slowly drive the vehicle around the 100-ft (30.5-m) radius circle while keeping the centerline of the front of the vehicle directly over the marked line.

(b) Establish a reference position on the steering wheel position indicator at a slow speed.

(c) Gradually increase the speed until the maximum safe speed, as judged by the driver, is reached.

(d) Record the maximum speed and the corresponding position of the steering wheel.

(e) Repeat 4-3.3.4(a) through (d) while driving the vehicle in the opposite direction.

4-3.3.5 The speed achieved shall equal or exceed the requirement for the corresponding class of vehicle, and the steering angle shall not decrease with increasing speed.

4-3.4 Vehicle Dimensions.

4-3.4.1 Test facilities shall consist of a flat measurement pad that is large enough to accommodate the entire vehicle.

4-3.4.2 Test equipment shall consist of a tape measure and a protractor.

4-3.4.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended operating pressure.

4-3.4.4 The following vehicle dimensions shall be measured in accordance with their definitions with the vehicle positioned on the flat pad:

(a) Angle of approach;

(b) Angle of departure;

(c) Interaxle clearance angle;

(d) Underbody clearance;

(e) Underaxle clearance.

4-3.4.5 Linear dimensions shall be rounded down to the nearest $^1/_2$ in. (1.3 cm), and angular dimensions shall be rounded down to the nearest $^1/_2$ degree and compared against the vehicle specifications.

4-3.5 Driver Vision Measurement.

4-3.5.1 Test facilities shall consist of a level site at least 20 ft (6.1 m) longer than the vehicle.

4-3.5.2 Test equipment shall consist of a plumb bob, tape measure, and a protractor or an inclinometer.

4-3.5.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended operating pressure.

4-3.5.4 The driver's vision shall be determined as follows:

(a) Adjust the driver's seat to its mid position with respect to height, weight, and fore and aft adjustments.

(b) Place a suitable structure on the seat cushion for locating an eye height of $31^3/_4$ in. (806.5 mm) and a position 12 in. (30.5 cm) forward from the seat back. Place the seat back in a vertical position.

(c) Establish the features that limit the upward and downward line of vision that are located directly in front of the driver's seat.

(d) Measure and record the angle above the horizon at which upward vision is obstructed from the eye height point established in 4-3.5.4(b).

(e) Establish the lowest possible line of vision below the horizon directly in front of the eye height point and project this line forward of the cab until it intersects with the ground. Project this line of vision by using a light beam, or, if the windshield is removed, use a string line. Measure and record the distance from this intersection with the ground and the front face of the bumper at the front of the truck.

(f) Stretch a line from the eye height point laterally across the cab in order to establish and record the 90-degree line of vision to the left and right of the straight ahead position. Note obstructions within these angles.

4-3.5.5 The recorded values for the distance at which the line of vision meets the ground in front of the truck and the angle of vision above the horizon shall equal or exceed the vehicle's specification. Obstacles within the 90-degree horizontal line of vision to the right or left shall not create an obstruction of more than 5 degrees per obstruction.

4-3.6 Pump and Roll on a 40-Percent Grade.

4-3.6.1 Test facilities shall consist of a site suitable for discharging agent that includes a measured grade of 40 percent that is at least twice the vehicle's length or a level, paved test pad adequate for an extended draw bar pull.

4-3.6.2 Test equipment shall consist of the following:

(a) A calibrated speedometer;

(b) A vehicle equipped pump pressure gauge;

(c) A load cell accurate to within ±500 lb (± 227 kg) (applicable only to the alternate draw bar method);

(d) A variable load dynamometer sled (applicable only to the alternate draw bar method).

4-3.6.3 The vehicle shall have had its primary turret(s) discharge rate and pressure verified prior to beginning this test to ensure that the turret(s) discharges at or above the minimum rate specified. The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended operating pressure.

4-3.6.4 The capability of the vehicle to ascend, stop, start, and continue ascent on a 40-percent grade without interruption in the discharge rate shall be demonstrated either on an actual grade or by means of an equivalent draw bar test as follows:

(a) Fill both the water and foam tanks with water, and add dye to the foam tank.

(b) Set the agent system to discharge in the foam mode, and set the system discharge pressure for optimum performance.

(c) Position the vehicle at the bottom of a 40-percent grade and initiate discharge at full output through the primary turret nozzles. Verify that dye is apparent in the discharge stream throughout the test.

(d) Initiate the vehicle's ascent of the grade and achieve a speed of at least 1 mph (1.6 km/h). During the ascent, bring the vehicle to a stop and resume the ascent at a speed of at least 1 mph (1.6 km/h) without interruption in the discharge stream. Record the vehicle speed and any variation in discharge pressure.

(e) If an actual 40-percent grade is not available, repeat 4-3.6.4(a) through (d) with the vehicle coupled to a 40-percent grade equivalent draw bar load determined as follows:

1. A 40-percent grade — 21.8-degree angle.

2. The loaded vehicle weight × sin 21.8 degrees (0.371) equals the necessary draw bar pull to simulate ascending a 40-percent grade.

3. The area of the load cell shall be determined at the time of the test.

4. The load cell reading, in psi (kPa), that simulates a 40-percent grade shall be calculated by the following:

$$\frac{\text{sin 21.8 degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

4-3.6.5 The vehicle shall negotiate the grade or draw bar pull smoothly while maintaining an operating pressure of at least 50 percent of the specified design pressure for the primary turret(s) at speeds of at least 1 mph (1.6 km/h).

4-3.7 Electrical Charging System.

4-3.7.1 Test facilities shall consist of an area suitable for running the engine while the electric loads and charging rates are being measured.

4-3.7.2 Test instrumentation shall consist of the following:

(a) A laboratory quality voltmeter with a scale range compatible with the design voltage of the vehicle's electrical system. The scale on the voltmeter shall be graduated to allow reading voltages with a ±0.1-volt accuracy.

(b) A laboratory quality ammeter with a scale range compatible with the anticipated electrical load present on the vehicle. The ammeter shall be graduated to allow reading current flow within a ±3-percent accuracy.

(c) The tachometer installed in the vehicle.

4-3.7.3 The test vehicle shall have a fully charged set of batteries, and the vehicle's electric and charging systems shall be fully operational. The test shall be conducted in ambient conditions of 50°F to 90°F (10°C to 32.2°C).

4-3.7.4 The test shall be conducted as follows:

(a) Check each battery cell to verify that voltage and specific gravity are at the battery manufacturer's specifications.

(b) Install a voltmeter to monitor the battery charge continuously during the test.

(c) Install an ammeter/shunt system at the battery to measure the full current demand of the electrical system. Install another ammeter/shunt system at the alternator to measure the total current output of the alternator.

(d) Record voltage and ampere readings under the following conditions:

1. Battery (engine off, no load).

2. Engine at idle and all electrical devices shut off. The engine shall be allowed to run long enough after starting to recharge the batteries prior to making these measurements.

3. Engine at idle and all electrical loads that normally run simultaneously turned on.

4. Engine at 50 percent of governed speed with all electrical loads that normally run simultaneously turned on.

5. Engine at governed speed with all electrical loads that normally run simultaneously turned on.

4-3.7.5 The electrical system performance shall be compared against the specification at engine idle and at 50 percent of engine rpm. The measured voltage of the batteries shall remain above 13 volts (for a 12-volt system) and 26 volts (for a 24-volt system) at all times while the alternator is running.

4-3.8 Radio Suppression.

4-3.8.1 Test facilities shall be in accordance with SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz)*, or the equivalent standard being used.

4-3.8.2 Test equipment shall be in accordance with SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz)*, or the equivalent standard being used.

4-3.8.3 The vehicle shall be configured with all standard electrical features mounted and operational. During the tests, all vehicle engines shall be operated at idle, and all vehicle-mounted electrical devices normally functioning at the crash site shall be turned on with the following stipulations:

(a) All vehicle lighting shall be on.

(b) All heating, defrosting, and air conditioning systems shall be on with their respective fans adjusted to the maximum speed setting.

(c) Auxiliary power generating devices (where applicable) shall be running.

(d) Intermittent warning devices, such as hazard flashers, warning buzzers, and horns, shall be turned off.

4-3.8.4 The vehicle shall be tested in accordance with SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz),* or the equivalent standard being used.

4-3.8.5 The results of the test shall be evaluated in accordance with SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz)*, or the equivalent standard being used.

4-3.9 Gradability Test.

4-3.9.1 Test facilities shall consist of a site that includes a measured grade of 50 percent at least equal to the vehicle in length or a level, paved test pad adequate for an extended draw bar pull.

4-3.9.2 Test equipment shall consist of the following:

(a) A load cell accurate to within ± 500 lb (± 227 kg) (applicable only to the alternate draw bar method).

(b) A variable load dynamometer sled (applicable only to the alternate draw bar method).

4-3.9.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended operating pressure.

4-3.9.4 The capability of the fully loaded vehicle (*see definition of Fully Loaded Vehicle in Section 1-3*) to ascend a 50-percent grade shall be demonstrated either on an actual grade or by means of an equivalent draw bar pull test. If an actual 50-percent grade is not available, then the vehicle shall be coupled to a 50-percent equivalent draw bar load determined as follows:

(a) A 50-percent grade — 26.57-degree angle.

(b) The loaded vehicle weight×sin 26.57 degrees (0.447) equals the necessary draw bar pull to simulate ascending a 50-percent grade.

(c) The area of the load cell shall be determined at the time of the test.

(d) The load cell reading, in psi (kPa), that simulates a 50-percent grade shall be calculated by the following:

$$\frac{\text{sin } 26.57 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

4-3.9.5 The vehicle shall negotiate the grade or draw pull smoothly and safely.

4-3.10 Body and Chassis Flexibility Test.

4-3.10.1 Test facilities shall consist of a flat test pad suitable for discharging agent and securing portable ramps under the vehicle.

4-3.10.2 Test equipment shall consist of two to four 14-in. (35.6-cm) ramps with flat tops large enough for the tire footprint and graduated on both sides to allow the vehicle to ascend and descend safely.

4-3.10.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended operating pressure.

4-3.10.4 The vehicle shall be tested as follows:

(a) For a 4 × 4, drive the fully loaded vehicle onto 14-in. (35.6-cm) blocks positioned under the diagonally opposite front and rear wheels. For a 6 × 6, these correspond to axle 1 and axle 3. For an 8 × 8, these correspond to axle 1 and axle 4.

(b) With the vehicle in this position:

1. Inspect the vehicle thoroughly to ensure that there are no sheet metal interferences and that all moving parts are free to function.

2. Demonstrate all systems to ensure that they function normally, including discharge from all orifices.

(c) For a 6 × 6 and an 8 × 8, add a block under the second wheel of the bogie axle(s) so that both wheels on one side of the tandem axle are elevated simultaneously and diagonally opposite front and rear, and then repeat 4-3.10.4(b)1.

(d) Switch the blocks to the opposite sides of the truck and repeat 4-3.10.4(a) through (c).

4-3.10.5 No moving part shall interfere with another. If component contact should occur, it shall in no way damage the component or detract from the vehicle's ability to carry out its mission. No clearance shall be permitted between any tire and its supporting surface.

4-3.11 Service/Emergency Brake Test.

4-3.11.1 Test facilities shall consist of any dry, smooth, level, paved surface adequate in length to reach the respective test speeds and stop safely. The test area shall be marked so that a lane equivalent in width to that of the vehicle plus 4 ft (1.2 m) is established.

4-3.11.2 Instrumentation shall consist of the following:

(a) A calibrated fifth-wheel-type speed measuring device that is accurate to within ±0.5 mph (± 0.8 km/h) or ± 0.5 percent of the actual vehicle speed;

(b) A ground speed readout device controlled by the fifth wheel;

(c) A trigger device that detects brake pedal movement;

(d) A strip chart recorder suitable for recording distance traveled, vehicle speed, and the point at which actuation of the brake system occurs.

4-3.11.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with the brakes adjusted and the tires inflated to the vehicle manufacturer's recommended specifications. The brakes shall have been adequately burnished to ensure repeatable results.

4-3.11.4 The service and emergency brake stopping distances shall be determined in the following manner:

(a) While traveling down the center of the lane established by the width of the vehicle plus 4 ft (1.2 m), attain a speed slightly above the desired test speed and release the throttle.

(b) With the strip chart recorder running, at the instant that the vehicle reaches the desired test speed, actuate the brake pedal as if in a panic stop and continue applying the brakes until the vehicle comes to a complete stop. While stopped, modulate the brake pedal, as necessary, to maintain vehicle control. Record the distance traveled from the time that the brake pedal is applied to the time that the vehicle comes to rest.

(c) Observe whether or not the vehicle leaves the established lane during the brake stop.

(d) Repeat 4-3.11.4(a) through (c) for a total of five stops from each test speed.

(e) Repeat 4-3.11.4(a) through (d) to obtain results at speeds of 20 mph (32.2 km/h) and 40 mph (64.4 km/h).

(f) Disable the front service brakes and repeat 4-3.11.4(a) through (d) at a test speed of 40 mph (64.4 km/h).

(g) Reconnect the front service brakes and disable the rear service brakes and repeat 4-3.11.4(a) through (d) at a test speed of 40 mph (64.4 km/h).

4-3.11.5 Each of the recorded stops shall be within the specified distance without any part of the vehicle leaving the established test lane.

4-3.12 Service/Parking Brake Grade Holding Test.

4-3.12.1 Test facilities shall consist of dry, smooth, measured grades of 20 percent and 50 percent that are at least equal to the vehicle in length.

4-3.12.2 No instrumentation shall be required.

4-3.12.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with the brakes adjusted and the tires inflated to the vehicle manufacturer's recommended specifications. The brakes shall have been adequately burnished to ensure repeatable results.

4-3.12.4 The tests shall be conducted in the following manner:

(a) Drive the vehicle in a forward direction onto the 20-percent grade, stop, and set the parking brake.

(b) Shift the transmission to neutral and release the service brakes and verify that there is no wheel rotation.

(c) Repeat 4-3.12.4(a) and (b) with the vehicle facing the opposite direction.

(d) Drive the vehicle in a forward direction onto the 50-percent grade, apply the service brakes, and shift the transmission to neutral.

(e) Verify that there is no wheel rotation.

(f) Repeat 4-3.12.4(d) and (e) with the vehicle facing the opposite direction.

4-3.12.5 The brakes shall lock the wheels and hold the vehicle stationary on both the 20-percent and 50-percent grades with the vehicle pointed either uphill or downhill.

4-3.13 Steering Control Test.

4-3.13.1 Test facilities shall consist of any dry, level, paved surface that is free from loose material.

4-3.13.2 Test equipment shall consist of a steering wheel and a torque meter or a spring scale.

4-3.13.3 The vehicle shall be tested in a fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their normal operating pressure.

4-3.13.4 The vehicle shall be tested as follows:

(a) Set the road wheels in the straight ahead position, engage neutral, and release the brakes, ensuring that there is no vehicle movement.

(b) With the engine at idle speed, measure and record the force applied to the steering rim that is necessary to turn the steering linkage from stop to stop.

4-3.13.5 The measured force shall not exceed the design specifications.

4-3.14 Vehicle Clearance Circle Test.

4-3.14.1 Test facilities shall consist of a level site having a dry, paved surface greater than three times the vehicle's length in diameter and shall be free from loose material.

4-3.14.2 A tape measure, markers or a marking device, and a calculator shall be required.

4-3.14.3 The vehicle's steering system shall be fully operational, and the steering linkage stops shall be adjusted within the manufacturer's specified production tolerance limits.

4-3.14.4 The vehicle shall be tested as follows:

(a) Drive the vehicle in a full cramp, making a left or right turn as necessary, in at least one complete circle to fully "settle" the wheels into their steady-state condition.

(b) Slowly drive the vehicle in the full cramp turn.

(c) Stop the vehicle in three locations around the turning circle, applying the brake smoothly and gradually.

(d) At each stop, mark the outermost projected point of the vehicle on the ground.

(e) Measure and record the straight line distances between the marks for each of the stop locations (length 1, length 2, and length 3).

(f) Calculate the vehicle clearance circle radius (R) as follows:

$$S = \text{length 1} + \text{length 2} + \text{length 3}$$

$$R = \frac{(\text{length 1})(\text{length 2})(\text{length 3})}{4[S(S - \text{length 1})(S - \text{length 2})(S - \text{length 3})]^{1/2}}$$

(g) Repeat 4-3.14.4(a) through (f) while turning the vehicle in the opposite direction.

4-3.14.5 The vehicle's clearance circle diameter (2R) shall be less than three times the maximum overall length of the vehicle.

4-3.15 Agent Pump(s)/Tank Vent Discharge Test.

4-3.15.1 Test facilities shall consist of a level, open site suitable for discharging agent. Access to a refill water supply shall be required.

4-3.15.2 Test equipment shall consist of a liquid level measuring device accurate to with ± 1.0 percent.

4-3.15.3 Each discharge nozzle on the vehicle shall have been individually verified as discharging at a flow rate at or above the minimum rate specified when the agent system is operated at the recommended pressure.

4-3.15.4 The test shall be conducted as follows:

(a) Fill the water and the foam tank to the top.

(b) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.

(c) Set the agent system pressure relief to the recommended pressure.

(d) Engage the agent pumps and operate them at maximum pumping speed with all discharge outlets closed.

(e) Simultaneously initiate discharge of the primary roof turret(s), primary hand lines, ground sweeps/bumper turret, and undertruck nozzles. After approximately 75 percent of the contents from the water tank has been discharged, simultaneously stop discharge through all nozzle outlets. Record the time of discharge.

(f) Measure and then add together the total amount of liquid discharged from the water tank and the foam tank. Calculate the average discharge rate using the discharge time from 4-3.15.4(e).

(g) Calculate the quantity of liquid used from the foam tank as a percentage of the total liquid discharged.

4-3.15.5 The measured total discharge rate shall be equal to at least the sum of the minimum specified discharge rates of the nozzles used during the test. A calculated average foam concentration within the tolerance permitted for the respective foam type confirms the adequacy of the foam-liquid concentrate piping to supply foam at a rate compatible with the maximum discharge requirements of the vehicle.

4-3.16 Water Tank Fill and Overflow Test.

4-3.16.1 Test facilities shall consist of a level site with pumping or hydrant capacity, or both, sufficient to provide the water delivery rate needed to fill the water tank in 2 minutes at an inlet pressure of 80 psi (551.6 kPa).

4-3.16.2 Instrumentation shall consist of calibrated mechanical or electronic pressure measuring devices with an accuracy of ±3 percent and a stopwatch.

4-3.16.3 The water tank shall be empty, and the water tank fill and vent system shall be fully operational for this test.

4-3.16.4 The water tank fill and vent system shall be tested as follows to verify that the tank can be filled in 2 minutes or less:

(a) Park the vehicle on level ground.

(b) Attach one pressure measuring device at the inlet to the tank fill piping, and attach the other pressure measuring device to the tank body or an extension of the tank body.

(c) Simultaneously initiate flow to the tank and start the stopwatch. The water supply pressure shall be maintained at 80 psi (551.6 kPa) throughout the test.

(d) At the moment water begins to flow from the overflow piping, stop the watch and record the elapsed time.

(e) While maintaining an 80 psi (551.6 kPa) supply pressure and an overflow condition, record the internal tank pressure. After recording this pressure, shut off the water supply.

4-3.16.5 The results of this test shall be evaluated as follows:

(a) The time to fill the tank to the overflow condition shall be 2 minutes or less.

(b) The internal tank pressure shall not exceed the tank design pressure.

4-3.17 Flushing System Test.

4-3.17.1 Test facilities shall consist of an open site suitable for discharging agent and draining the vehicle. Access to a refill water supply shall be required.

4-3.17.2 No special instrumentation shall be required for this test.

4-3.17.3 The vehicle's agent system and flushing system shall be fully operational for this test.

4-3.17.4 The vehicle's flushing system shall be tested as follows:

(a) Fill the water tank and foam tank with clean water and add dye to the foam tank.

(b) Discharge agent through each discharge orifice on the vehicle while operating in the foam mode until dye is present in the discharge stream.

(c) Mark the liquid level in the foam tank.

(d) Set the agent system in the flush mode and discharge through each discharge orifice until clear water is present in the discharge stream.

(e) Shut the agent system down and drain the piping.

(f) Recheck the foam tank level.

4-3.17.5 Failure to develop a clear water stream through each nozzle shall be considered evidence that the flushing system is inadequate. There shall be no evidence of feedback of clear water into the foam tank.

4-3.18 Roof Turret Flow Rate Test.

4-3.18.1 Test facilities shall consist of a level, open site suitable for discharging agent. Access to a refill water supply shall be required.

4-3.18.2 Test equipment shall consist of the following:

(a) A calibrated sight gauge;

(b) A liquid volume measuring device accurate to within ±1.0 percent;

(c) A calibrated pressure gauge, if not already provided on the truck;

(d) *Alternative:* A stopwatch and a scale capable of measuring total vehicle weight accurate to within ±1.0 percent.

4-3.18.3 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

4-3.18.4 The roof turret discharge rate shall be determined as follows:

(a) Set the roof turret pattern for straight stream operation.

(b) Fill the water tank completely.

(c) Engage the pump and operate it at design speed.

(d) Open the turret flow control valve.

(e) The following procedures also shall be performed, as necessary:

1. If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.

2. If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. Read and record the tank volume in gallons when the watch is stopped after allowing flow for at least 1 minute. Determine the flow rate in gpm by dividing the difference in gallons by the time of discharge.

3. If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge and calculate the flow rate.

(f) Reset the roof turret pattern to the dispersed setting and repeat 4-3.18.4(b) through (e).

(g) Reset the roof turret to the half flow rate setting (if applicable) and repeat 4-3.18.4(a) through (f).

4-3.18.5 The measured turret flow rates shall equal the specified flow rate within a tolerance of +10 percent/–0 percent.

4-3.19 Roof Turret Pattern Test. The roof turret pattern test shall be conducted in accordance with the requirements of NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, and the results shall be evaluated in accordance with the vehicle specifications.

4-3.20 Roof Turret Control Force Measurement.

4-3.20.1 Test facilities shall consist of a level, open site suitable for discharging agent. Access to a refill water supply shall be required.

4-3.20.2 Test equipment shall consist of a spring scale that can be attached to the end of the turret control handle or a torque measuring device that can be attached to the rotational axis of the turret.

4-3.20.3 The water tank shall be filled prior to starting the test, and it shall have been verified that the vehicle pump system is capable of operating at design flow and pressure. The test shall be conducted with the roof turret at the full flow rate setting. The turret power-assist system, if applicable, shall be fully operational.

4-3.20.4 The test shall be conducted as follows:

(a) Set the turret pattern control for straight stream and, where applicable, engage the power assist.

(b) Engage the pump and operate it at design speed.

(c) Open the turret flow control valve.

(d) Using a spring scale attached to the end of the turret aiming handle, rotate the turret to the right and to the left, recording the needed force for each direction. Again, using the spring scale attached to the end of the turret aiming han-

dle, elevate and depress the turret and record the force needed to elevate and depress.

(e) Repeat 4-3.20.4(b) through (d) with the pattern control set at the maximum dispersed position after refilling the water tank as necessary.

4-3.20.5 The forces recorded shall not exceed the forces specified.

4-3.21 Roof Turret Articulation Test.

4-3.21.1 Test facilities shall consist of a level, open site suitable for discharging agent. Access to a refill water supply shall be required.

4-3.21.2 The test equipment shall consist of a tape measure, a level, and a protractor.

4-3.21.3 The water tank shall be filled prior to the test, and the turret power-assist system, if applicable, shall be fully operational.

4-3.21.4 The test shall be conducted as follows:

(a) With the turret pointed ahead, raise the turret barrel to the maximum elevated position. With a level held horizontal at the vertical rotation axis, measure the angle between the level and the turret barrel with the protractor and record.

(b) Rotate the roof turret barrel to the right and left to the angle needed.

(c) Place a marker 30 ft (9.1 m) in front of the vehicle. Aim the turret straight ahead with the rate control at full flow, with the pattern control in the maximum dispersed position, and with the turret in the maximum depressed position. When water discharges, observe whether water strikes the marker or strikes closer to the vehicle.

4-3.21.5 Turret articulation shall be considered acceptable if the measurements meet or exceed the specifications.

4-3.22 Hand Line Nozzle Flow Rate Test.

4-3.22.1 Test facilities shall consist of a level, open site suitable for discharging agent. Access to a refill water supply shall be required.

4-3.22.2 Test equipment shall consist of the following:

(a) A calibrated sight gauge;

(b) A liquid volume measuring device accurate to within ±1.0 percent;

(c) A calibrated pressure gauge, if not already provided on the truck;

(d) *Alternative:* A stopwatch and a scale capable of measuring total vehicle weight accurate to within ±1.0 percent.

4-3.22.3 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

4-3.22.4 The hand line nozzle flow rate shall be determined as follows:

(a) Set the hand line nozzle pattern for straight stream operation.

(b) Fill the water tank completely.

(c) Engage the pump and operate it at design speed.

(d) Open the hand line nozzle flow control valve.

(e) The following procedures also shall be performed, as necessary:

1. If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.

2. If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. Read and record the tank volume in gallons when the watch is stopped after allowing flow for at least 5 minutes. Determine the flow rate in gpm by dividing the difference in gallons by the time of discharge.

3. If an open top calibrated tank is used, discharge through the nozzle until the pressure stabilizes, and then simultaneously direct the stream into the tank while starting the stopwatch. Stop the stopwatch when the tank is full and remove or shut off the nozzle. Determine the flow rate by dividing the tank volume in gallons by the fill time in minutes.

4. If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge and calculate flow rate.

(f) If the nozzle is the nonair-aspirated type, repeat 4-3.22.4(b) through (e) with the nozzle pattern setting in the fully dispersed position.

4-3.22.5 The measured hand line nozzle flow rates shall equal the specified flow rate within a tolerance of +10 percent/–0 percent.

4-3.23 Hand Line Nozzle Pattern Test. The hand line nozzle pattern test shall be conducted in accordance with the requirements of NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, and the results shall be evaluated in accordance with the vehicle specifications.

4-3.24 Ground Sweep/Bumper Turret Flow Rate Test.

4-3.24.1 Test facilities shall consist of an open site suitable for discharging agent. Access to a refill water supply shall be required.

4-3.24.2 Test equipment shall consist of the following:

(a) A calibrated sight gauge;

(b) A liquid volume measuring device accurate to within ±1.0 percent;

(c) A calibrated pressure gauge, if not already provided on the truck;

(d) *Alternative:* A stopwatch and a scale capable of measuring total vehicle weight accurate to within ±1.0 percent.

4-3.24.3 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

4-3.24.4 The ground sweep/bumper turret discharge rate shall be determined as follows:

(a) Set the ground sweep/bumper turret pattern for straight stream operation.

(b) Fill the water tank completely.

(c) Engage the pump and operate it at design speed.

(d) Open the ground sweep/bumper turret flow control valve.

(e) The following procedures also shall be performed, as necessary:

1. If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.

2. If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. Read and record the tank volume in gallons when the watch is stopped after allowing flow for at least 1 minute. Determine the flow rate in gpm by dividing the difference in gallons by the time of discharge.

3. If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge and calculate the flow rate.

(f) If the ground sweep/bumper turret is the nonair-aspirated type, repeat 4-3.24.4(b) through (e) with the nozzle pattern setting in the fully dispersed position.

4-3.24.5 The measured flow rates shall equal the specified flow rate within a tolerance of +10 percent/–0 percent.

4-3.25 Ground Sweep/Bumper Turret Pattern Test. The ground sweep/bumper turret pattern test shall be conducted in accordance with the requirements of NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, and the results shall be evaluated in accordance with the vehicle specifications.

4-3.26 Undertruck Nozzle Test.

4-3.26.1 Test facilities shall consist of an open site suitable for discharging agent.

4-3.26.2 Markers shall be available for use in defining the pattern boundaries.

4-3.26.3 It shall have been verified that the vehicle's pump system is capable of operating at full rate, and the agent tanks shall be filled with water and foam, respectively.

4-3.26.4 The test shall be conducted as follows:

(a) Set the agent system to operate in the foam mode.

(b) Engage the agent pump and operate it at design speed.

(c) Open the undertruck nozzles to discharge simultaneously, and continue to discharge until a definite pattern outline is apparent.

(d) Close the discharge and mark and record the boundaries of the pattern.

4-3.26.5 The pattern shall be considered acceptable if the foam spray covers the outline created by the vehicle on the ground and wets the inside of all tires.

4-3.27 Foam Concentration/Foam Quality Test.

4-3.27.1 Test facilities shall consist of an open site suitable for discharging agent. Access to a refill water supply and a foam concentrate supply shall be required.

4-3.27.2 The test equipment described in NFPA 412, *Standard for Aircraft Rescue and Fire Fighting Foam Equipment*, shall be used for this test.

4-3.27.3 Each discharge nozzle on the vehicle shall have been individually verified as discharging at a flow rate within the tolerance specified. The agent system shall have been verified as capable of operating at full rate.

4-3.27.4 The test shall be conducted as follows:

(a) Fill the water tank and the foam tank to the top and refill as necessary throughout the test.

(b) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.

(c) Set the agent system pressure relief to the recommended pressure.

(d) Engage the agent pumps and operate them at maximum pumping speed with all discharge outlets closed.

(e) Each foam delivery system shall be tested first for the individual nozzle/flow rate specified in the following list and then for a total combined simultaneous discharge in accordance with NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*:

1. Roof turret(s) full rate;
2. Roof turret(s) half rate;
3. Ground sweep/bumper turret;
4. Hand line nozzles;
5. Undertruck nozzles.

4-3.27.5 The foam concentrations measured shall fall within the permitted tolerances specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, for each nozzle and for the combined simultaneous discharge. The foam expansion and drainage time measurements shall equal or exceed those specified in NFPA 412 for each nozzle.

4-3.28 Warning Siren Test.

4-3.28.1 Test facilities shall consist of a flat, open area that is free from any large reflecting surfaces (such as other vehicles, signboards, or hills) within a 200-ft (61-m) radius of the vehicle.

4-3.28.2 Test equipment shall consist of the following:

(a) A sound level meter that meets the requirements of ANSI S1.4, *Specification for Sound Level Meters*, for Type 1 or S1A meters. The sound level meter shall have been calibrated by a certified testing laboratory within the previous 12 months.

(b) A tape measure.

4-3.28.3 The vehicle's siren speaker shall be mounted in its proper location and shall be in working order.

4-3.28.4 The capability of the warning siren on the vehicle to project sound forward and to the sides shall be determined as follows:

(a) Set the sound level meter to the A-weighing network, "fast" meter response, and position the meter directly ahead of the vehicle at a distance of 100 ft (30.5 m) from the front bumper. The microphone shall be at ear level.

(b) Energize the siren and record the meter reading.

(c) Repeat 4-3.28.4(a) and (b) with the sound level meter 100 ft (30.5 m) from the vehicle, first at a position 45 degrees to the right and then at 45 degrees to the left of the longitudinal centerline of the vehicle.

4-3.28.5 The recorded noise level shall equal or exceed the specifications.

4-3.29 Propellant Gas.

4-3.29.1 Test facilities shall consist of an open site suitable for discharging AFFF, dry chemical, or halon agent.

4-3.29.2 Test equipment shall consist of a calibrated scale or load cell with an accuracy of ± 1.0 percent.

4-3.29.3 The vehicle extinguishing agent piping system shall be operational, and the agent tank(s) shall be empty. The propellant gas tank(s) shall be fully charged and within proper pressure. A means of lifting the agent tanks for weighing without loss of agent shall be provided. Alternatively, the extinguishing agent tank(s) shall be permitted to be tested outside of the vehicle. Where this alternative is used, the test shall be conducted with the agent tank(s) and related piping, fittings, valves, hose, and nozzle(s) in the same configurations in which they are installed on the vehicle.

4-3.29.4 The test for each of the extinguishing agents shall be conducted in the following manner:

(a) Weigh the empty tank(s) and record as tare weight.

(b) Using the manufacturer's recommended filling procedure, charge the tank(s) with the manufacturer's recommended extinguishing agent to the upper fill weight/volume tolerance. Reweigh and record this as gross filled weight.

(c) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.

(d) Pressurize the agent tank(s) using the manufacturer's recommended procedure.

(e) Simultaneously, fully open all discharge nozzles and keep open until only the pressurizing gas is expelled.

(f) Shut down the propellant gas supply.

(g) Reweigh the agent tank(s) and record this as post-discharge weight.

(h) Calculate and record the total agent discharged as follows:

Gross filled weight – post-discharge weight = total agent discharge.

4-3.29.5 There shall be a sufficient supply of propellant gas to purge all discharge lines as evidenced by the emission from each nozzle of gas only. The total agent discharged shall equal or exceed the design capacity.

4-3.30 Pressure Regulation.

4-3.30.1 Test facilities shall consist of an open site suitable for discharging the AFFF, dry chemical, or halon agent.

4-3.30.2 Test equipment shall consist of a calibrated pressure gauge or transducer capable of reading the recommended tank top discharge pressure and possessing an accuracy of ±5.0 psi (±34.5 kPa).

4-3.30.3 The vehicle extinguishing agent system shall be piped to all discharge outlets with the tank(s) empty. The propellant gas tank(s) shall be fully charged and at proper pressure. A means for mounting a pressure gauge or transducer somewhere between the downstream (low pressure) side of the regulator and the agent tank top shall be provided. Alternatively, the extinguishing agent tank(s) shall be permitted to be tested outside of the vehicle. Where this alternative is used, the test shall be conducted with the agent tank(s) and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

4-3.30.4 The test for each of the extinguishing agents shall be conducted in the following manner:

(a) Using the manufacturer's recommended filling procedure, charge the tank(s) with the manufacturer's recommended extinguishing agent to the upper fill weight/volume tolerance.

(b) Install a pressure gauge or transducer between the downstream (low pressure) side of the regulator and the agent tank top.

(c) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings are tight.

(d) Pressurize the agent tank(s) using the manufacturer's recommended procedure. Record the agent tank pressure.

(e) Simultaneously, fully open all discharge nozzles and keep open until only the pressurizing gas is expelled.

(f) During agent discharge, monitor agent tank pressure and record at 5-second or shorter intervals.

(g) Once the gas point has been reached for all discharge nozzles, shut down the gas supply.

4-3.30.5 The pressure regulation system shall be capable of maintaining pressure throughout the discharge. At no time shall pressure fall below or exceed the design range specified by the manufacturer.

4-3.31 AFFF Premix Piping and Valves.

4-3.31.1 Test facilities shall consist of a level, open site suitable for discharging the agent and measuring ranges.

4-3.31.2 Test equipment shall consist of the following:

(a) A calibrated scale or load cell with an accuracy of ±1.0 percent;

(b) A stopwatch.

4-3.31.3 All vehicle foam discharge piping shall be operational, and the premix tank shall be empty. The propellant gas tank(s) shall be fully charged and within proper pressure. A means of lifting the agent tank(s) for weighing without loss of agent shall be provided. Alternatively, the system shall be permitted to be tested outside of the vehicle. Where this alternative is used, the test shall be conducted with the premix tank and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

4-3.31.4 The test shall be conducted in the following manner:

(a) Weigh the empty premix tank and record as tare weight.

(b) Using the manufacturer's recommended filling procedure, charge the tank with water or premix solution. Reweigh and record as gross filled weight.

(c) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.

(d) Pull all hand line hose from the reel(s) or hose compartment(s).

(e) Pressurize the system using the manufacturer's recommended procedure.

(f) Simultaneously, start the stopwatch and fully open the turret(s), undertruck nozzles, and hand line(s).

(g) After discharging for at least 30 seconds, simultaneously stop the stopwatch and close the turret(s), undertruck nozzles, and hand line(s). Record the elapsed time on the stopwatch as discharge time.

(h) Following the manufacturer's instructions, shut off the propellant gas supply and blow down the system.

(i) Reweigh the premix tank and record this as post-discharge weight.

(j) Add the recommended flow rates from each discharge nozzle and record this sum as the designed total flow rate.

(k) Calculate the actual total flow rate as follows:

$$\frac{\text{gross filled weight} - \text{post-discharge weight}}{(\text{density}) \times \dfrac{(\text{elapsed time in seconds})}{60}} = \text{actual total flow rate}$$

4-3.31.5 The actual total flow rate shall equal the specified designed total flow rate within a tolerance of +10 percent/–0 percent.

4-3.32 Pressurized Agent Purging and Venting.

4-3.32.1 Test facilities shall consist of an open site suitable for discharging AFFF, dry chemical, or halon agent.

4-3.32.2 No special test equipment or instrumentation shall be required to conduct the test(s).

4-3.32.3 The vehicle extinguishing agent system(s) shall be fully operational, and the agent tank(s) shall be fully charged with the manufacturer's recommended agent. The propellant gas tank(s) shall be fully charged and within proper pressure. Alternatively, the extinguishing agent tank(s) shall be permitted to be tested outside of the vehicle. Where this alternative is used, the test shall be conducted with the fully charged agent tank(s) and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

4-3.32.4 The test for each of the pressurized extinguishing agent systems shall be conducted in the following manner:

(a) Pressurize the agent tank(s) using the manufacturer's recommended procedure.

(b) Pull all hose from the reel(s) or compartment(s).

(c) Fully open all discharge devices.

(d) After approximately 5 seconds to 20 seconds, close all discharge devices.

(e) Purge all discharge lines and vent the agent tank(s) using the manufacturer's recommended procedure.

4-3.32.5 Any agent beyond the tank outlet shall be purged from the discharge piping and hose as evidenced by the discharge from each nozzle of gas only. The depressurization or venting of the agent tank shall allow only minimal quantities of agent to escape.

4-3.33 Auxiliary Agent Hand Line Flow Rate and Range.

4-3.33.1 Test facilities shall consist of a level, open site suitable for discharging the dry chemical or halon agent and measuring ranges. Wind conditions shall be calm [less than 5 mph (8 km/h)].

4-3.33.2 Test equipment shall consist of the following:

(a) A calibrated scale or load cell with an accuracy of ±1.0 percent;

(b) A stopwatch;

(c) A tape measure or other device for measuring distance;

(d) A calibrated anemometer;

(e) A pan containing at least 1 ft^2 (0.09 m^2) of motor or aviation gasoline.

4-3.33.3 All vehicle agent piping shall be operational, and the agent tank shall be empty. The propellant gas tank(s) shall be fully charged and within proper pressure. A means of lifting the agent tank(s) for weighing without loss of agent shall be provided. Alternatively, the system shall be permitted to be tested outside of the vehicle. Where this alternative is used, the test shall be conducted with the agent tank and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

4-3.33.4 The test shall be conducted in the following manner:

(a) Using the manufacturer's recommended agent and filling procedure, charge the agent tank.

(b) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.

(c) Pull all hand line hose from the reel(s).

(d) Pressurize the system using the manufacturer's recommended procedure and open all hand line nozzles until agent flow is observed. Close the nozzles.

(e) Weigh and record the agent tank as the "initial weight."

(f) Position the hand line nozzles at least 20 ft (6.1 m) from the fire pan so that they can be discharged onto a flat grade with no stream obstructions. Ignite the fuel.

(g) Select one of the hand line nozzles (nozzle 1). While holding it in a position 3 ft to 4 ft (0.9 m to 1.2 m) above ground level, simultaneously start the stopwatch and fully open the nozzle, and then discharge agent onto the fire.

(h) After at least 50 percent of the contents of the tank has been discharged, shut down the nozzle and stop the stopwatch. Record the time as "elapsed discharge time no. 1."

(i) Reweigh the agent tank and record as "weight after first discharge."

(j) If a second nozzle (nozzle 2) is provided, repeat 4-3.33.4(a) through (h).

(k) While holding the two hand line nozzles in a fixed horizontal position 3 ft to 4 ft (0.9 m to 1.2 m) above ground level, simultaneously start the stopwatch and fully open both nozzles.

(l) After at least 50 percent of the contents of the tank has been discharged, simultaneously shut down both nozzles and stop the stopwatch. Record the time as "elapsed discharge time no. 2."

(m) Reweigh the agent tank and record as "weight after second discharge."

(n) Calculate the flow rate from nozzle 1 as follows:

$$\frac{\text{initial weight (test 1)} - \text{initial weight (test 2)}}{\text{elapsed discharge time no. 1}} = \text{flow rate}$$

(o) Calculate the flow rate from nozzle 2 as follows:

$$\frac{\text{weight after first discharge} - \text{weight after second discharge}}{2 \times (\text{elapsed discharge time no. 2})} = \text{flow rate}$$

(p) If nozzle 2 is of a different configuration, repeat the fire test for this nozzle.

4-3.33.5 Test results shall be evaluated as follows:

(a) The flow rate from each nozzle shall meet the requirement.

(b) The range from each nozzle shall meet or exceed the requirements as evidenced by extinguishment of the fire(s).

(c) When discharged simultaneously, the flows from nozzle 1 and nozzle 2 shall be within 10 percent of each other.

4-3.34 Dry Chemical Turret Flow Rate and Range.

4-3.34.1 Test facilities shall consist of a level, open site suitable for discharging the agent and measuring range. The test shall be conducted in calm wind [less than 5 mph (8 km/h)].

4-3.34.2 Test equipment shall consist of the following:

(a) A calibrated scale or load cell with an accuracy of ±1.0 percent;

(b) A stopwatch;

(c) A tape measure or other device for measuring distance;

(d) A calibrated anemometer.

4-3.34.3 All dry chemical discharge piping shall be operational, and the dry chemical tank shall be empty. The propellant gas tank(s) shall be fully charged and within proper pressure. A means of lifting the agent tank(s) for weighing without loss of agent shall be provided. Alternatively, the system shall be permitted to be tested outside of the vehicle. Where this alternative is used, the test shall be conducted with the agent tank and related piping, fittings, valves, hose, and nozzle(s) in the same configuration in which they are installed on the vehicle.

4-3.34.4 The test shall be conducted in the following manner:

(a) Using the manufacturer's recommended agent and filling procedure, charge the tank.

(b) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.

(c) Pressurize the system using the manufacturer's recommended procedure and open the turret discharge valve until agent is observed. Close the valve.

(d) Weigh and record the agent tank as the "initial test weight."

(e) Position the dry chemical turret so that it can be discharged onto a flat grade with no stream obstructions. Position the turret to obtain maximum straight stream reach.

(f) Simultaneously, start the stopwatch and fully open the turret.

(g) During discharge, place markers at the far point where significant dry chemical strikes the ground (range marker) and at either side of the widest part of the pattern (width markers).The operator(s) placing the markers shall wear proper safety equipment for this task. The agent manufacturer's material safety data sheet shall be consulted.

(h) After discharging at least 75 percent of the contents of the tank, simultaneously stop the stopwatch and shut down the turret. Record the elapsed time in seconds as discharge time.

(i) Measure the distance from the turret to the range marker and record as the far point range.

(j) Measure the distance between the width markers and record as the pattern width.

(k) Reweigh the agent tank and record as the weight after discharge.

(l) Calculate the flow rate as follows:

$$\frac{\text{initial test weight} - \text{weight after discharge}}{\text{elapsed discharge time}} = \text{flow rate}$$

4-3.34.5 The stream range and pattern width shall equal or exceed the requirements. The discharge flow rate shall equal the requirement.

4-3.35 Cab Interior Noise Test.

4-3.35.1 Test facilities shall consist of a flat, open, paved area suitable for operating the vehicle at a constant speed of 50 mph (80.5 km/h) that is free from any large reflecting surfaces (such as other vehicles, signboards, or hills) within a 50-ft (15.2-m) distance of the vehicle. The wind speed shall not exceed 15 mph (24.1 km/h) during the test.

4-3.35.2 Test equipment shall consist of a sound level meter that meets the requirements of ANSI S1.4, *Specification for Sound Level Meters*, for Type 1 or S1A meters. The sound level meter shall have been calibrated by a certified testing laboratory within the previous 12 months.

4-3.35.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with tires inflated to their recommended inflation pressure. The cab doors, windows, and hatch openings shall be closed during this test. The vehicle shall be driven long enough to bring the drive train components up to their normal operating temperatures prior to starting the test. Thermostatically controlled shutters or cooling fans, or both, shall be allowed to function normally. The vehicle agent system(s), the communications system, and the audible warning system and emergency warning system shall be inactive during this test.

4-3.35.4 The interior noise level of the cab shall be determined as follows:

(a) Set the sound level meter to the A-weighing network, "fast" meter response, and position the meter adjacent to the driver's ear.

(b) Bring the vehicle up to a road speed of 50 mph (80.5 km/h) and maintain that speed while recording the noise measurements.

(c) Repeat 4-3.35.4(a) and (b) until four readings have been taken, bringing the vehicle to rest between each measurement. If any of the noise measurements differ from the others by more than 2 dBA, they should be replaced by another measurement, since they could be the result of extraneous ambient noises or equipment/measurement error.

(d) Average the four readings.

4-3.35.5 The average of the recorded noise readings shall be less than or equal to the cab interior noise level specification.

4-4 Operational Tests.

4-4.1 Weight/Weight Distribution.

4-4.1.1 Test facilities shall consist of an in-ground, certified weight scale large enough to accommodate the vehicle or a level test pad suitable for positioning the truck on top of portable wheel scales.

4-4.1.2 Instrumentation for this test is limited to the in-ground or portable scales. The accuracy of the scales shall be ±1.0 percent.

4-4.1.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*). Ballast shall be used for the crew and equipment as necessary.

4-4.1.4 The total weight of the vehicle and weight distribution shall be determined as follows:

(a) Determine the total weight of the vehicle by driving the fully loaded vehicle onto the scale(s).

(b) Determine the individual axle loadings by measuring the weight on each axle at the ground. Since the total vehicle weight is more accurately reflected by the single weight measurement in 4-4.1.4(a), correct the individual axle loads proportionately, as necessary, so that their total equals the total vehicle weight. Subtract the lightest loaded axle weight from the heaviest loaded axle weight, and divide the difference by the weight of the heaviest axle.

(c) Determine individual tire loadings by measuring the weight on each tire at the ground. Make proportionate corrections to the individual tire loads so that their total equals the load on the respective axle. Determine the average tire weight for each axle by adding the right-hand and left-hand tire weights for each axle and dividing by 2. Subtract the lightest loaded tire weight from the heaviest loaded tire weight for each axle, and divide the difference by the average tire load for that axle.

4-4.1.5 The data shall be evaluated on the following basis:

(a) The total weight of the vehicle shall be less than or equal to the vehicle manufacturer's gross vehicle weight rating.

(b) The difference between the heaviest loaded axle and the lightest loaded axle shall be less than or equal to the maximum difference permitted in the specification.

(c) The difference between the tire weights on any given axle shall be less than or equal to the maximum difference permitted in the specification.

4-4.2 Acceleration.

4-4.2.1 Test facilities shall consist of a dry, straight, level paved surface sufficient in length to accelerate the vehicle from rest to 50 mph (80.5 km/h) and then bring it to a safe stop.

Ambient temperatures at the test site shall be 0°F to 110°F (–17.8°C to 43.3°C), and elevations shall include heights up to 2000 ft (609.6 m) unless otherwise specified by the purchaser.

4-4.2.2 Instrumentation shall consist of the vehicle's speedometer and tachometer, as installed by the manufacturer at the time of delivery, and a stopwatch.

4-4.2.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with the engine and the transmission at their normal operating temperatures. The tires shall be inflated to the manufacturer's recommended pressure.

4-4.2.4 The test shall be conducted in the following manner:

(a) Start the test with the vehicle at rest, the engine at idle, and the transmission in gear.

(b) Simultaneously, start the stopwatch and accelerate the vehicle and continue accelerating to a wide-open throttle condition.

(c) At the moment the vehicle reaches 50 mph (80.5 km/h), stop the watch and record the elapsed time.

(d) To compensate for wind conditions and slope, repeat the test in the opposing direction. Record and average a minimum of three readings in each of the two directions.

4-4.2.5 The average acceleration time to 50 mph (80.5 km/h) shall be less than or equal to the requirement, as specified.

4-4.3 Top Speed.

4-4.3.1 Test facilities shall consist of a dry, paved, level surface suitable for achieving a vehicle speed of at least 65 mph (104.6 km/h) and bringing the vehicle to a safe stop.

4-4.3.2 Instrumentation shall consist of the vehicle's speedometer as installed by the manufacturer at the time of delivery.

4-4.3.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with the engine and the transmission at their normal operating temperatures. The tires shall be inflated to the manufacturer's recommended pressure.

4-4.3.4 The test shall be conducted in the following manner:

(a) Accelerate the vehicle to a speed of at least 65 mph (104.6 km/h).

(b) To compensate for wind conditions and slope, repeat the test in the opposing direction.

(c) If 65 mph (104.6 km/h) cannot be achieved in one of the directions, repeat 4-4.3.4(a) and (b), accelerating the vehicle to its maximum speed in each direction, record the speeds, and average the two numbers.

4-4.3.5 The test shall be considered successful if the average top speed equals or exceeds 65 mph (104.6 km/h).

4-4.4 Brake Operational Test.

4-4.4.1 Test facilities shall consist of any dry, smooth, paved surface adequate in length to reach the respective test speeds and stop safely. The test area shall be marked so that a lane that equals the width of the vehicle plus 4 ft (1.2 m) is established. A runway or taxiway with a marked centerline shall be permitted to be used.

4-4.4.2 Instrumentation shall consist of the vehicle's speedometer, as installed by the manufacturer, and a tape measure.

4-4.4.3 The vehicle shall be tested in its fully loaded condition (*see definition of Fully Loaded Vehicle in Section 1-3*) with the brakes adjusted to the manufacturer's recommended tolerances. The tires shall be inflated to the vehicle manufacturer's recommended inflation pressure. The vehicle's stopping distance shall have been certified by the vehicle manufacturer.

4-4.4.4 The test shall be conducted in the following manner:

(a) Maintain a constant speed of 20 mph (32.2 km/h) while driving down the centerline of the test site.

(b) Apply the brakes as if in a panic stop until the vehicle comes to rest.

(c) Measure and record the distance from the outer edge of the vehicle to the centerline of the lane.

(d) Repeat 4-4.4.4(a) through (c) at a constant speed of 40 mph (64.4 km/h).

4-4.4.5 The distance measured shall not exceed one-half the vehicle width plus 2 ft (0.6 m).

4-4.5 Air System/Air Compressor Test.

4-4.5.1 No special test facilities shall be required.

4-4.5.2 Instrumentation shall consist of the vehicle's air system pressure gauge(s), as installed by the manufacturer, and a stopwatch.

4-4.5.3 The vehicle's air system shall be fully operational for this test. The manufacturer previously shall have established the ratio of actual to required reservoir capacity and the spring brake release pressure. The test shall be conducted with the transmission in neutral and the parking brakes set.

4-4.5.4 The test shall be conducted as follows:

(a) Using the brake pedal, bleed off the air reservoir system pressure to a level below 85 psi (586 kPa) as indicated on the cab-mounted air gauge(s).

(b) Accelerate the engine to its wide-open throttle condition.

(c) When the air pressure indicator reaches 85 psi (586 kPa), start the stopwatch. If more than one air pressure indicator is installed on the vehicle, start the stopwatch when the first indicator registers 85 psi (586 kPa).

(d) Continue building air pressure with the engine at wide-open throttle until 100 psi (689.5 kPa) is registered on all air pressure indicators, stop the watch, and record the time.

(e) Using the brake pedal, bleed off the air reservoir system pressure to 0 psi (0 kPa), as indicated on the cab-mounted air gauge(s).

(f) Accelerate the engine to a wide-open throttle condition.

(g) When the wide-open throttle condition is reached, simultaneously start the stopwatch.

(h) Continue building air pressure with the engine at wide-open throttle until the previously established spring brake release pressure has been reached in the quick buildup system, stop the watch, and record the time.

4-4.5.5 The results shall be evaluated as follows:

(a) The time needed for a buildup of 85 psi to 100 psi (586 kPa to 689.5 kPa) shall be within 25 seconds or the permitted time as calculated for larger reservoir capacities.

(b) The quick buildup time shall be within 15 seconds.

4-4.6 Agent Discharge Pumping Test.

4-4.6.1 Test facilities shall consist of an open site suitable for discharging agent.

4-4.6.2 No test equipment shall be required.

4-4.6.3 The vehicle's agent system shall be fully operational for this test, and all primary hand lines shall be deployed.

4-4.6.4 The combined discharge of all nozzles shall be tested as follows:

(a) Fill both the water tank and the foam (or dyed water) tank completely with water and foam, respectively.

(b) Set the agent system to operate in the foam mode, set the system pressure for optimum performance, and engage the agent pumps. Simultaneously operate the pumps of vehicles with multiple pumps during this test.

(c) Initiate discharge first through the roof turret and then through the ground sweeps, (or optional bumper turret), primary hand lines, and undertruck nozzles until all are discharging simultaneously in a straight stream. As each nozzle is turned on, observe the range along with the system pressure.

(d) Continue to discharge until the system pressure has stabilized with all nozzles discharging.

4-4.6.5 Since measurements of actual flow rates are not practical in the field, the system shall be considered to have met the requirement in accordance with the procedures of 4-4.6.4, provided the nozzle ranges show no signs of deterioration as additional nozzles are engaged and the agent system pressure does not fluctuate by more than 10 percent where comparing the roof turret flowing by itself with the combined discharge pressure. Foam (or dyed water) shall be evident in the discharging stream from all nozzles at all times.

4-4.7 Dual Pumping System Test.

4-4.7.1 Test facilities shall consist of an open site suitable for discharging agent.

4-4.7.2 No special instrumentation shall be required for this test.

4-4.7.3 The vehicle's agent system shall be fully operational for this test.

4-4.7.4 The ability of a vehicle equipped with a dual pumping system to provide foam solution to all nozzles when only one system is active shall be tested as follows:

(a) Fill both the water tank and the foam tank completely with water, and add dye or foam concentrate to the foam tank.

(b) Set the agent system to operate in the foam mode, and set the system pressure for optimum performance.

(c) Set the primary turret(s) discharge rate in the half flow rate setting.

(d) Initiate discharge first through the primary turret(s) (at half rate) and then through the ground sweep nozzles (or alternate bumper turret), the primary hand line nozzles, and the undertruck nozzles, first with one pump operating, and then the other.

4-4.7.5 A foam or dye solution discharge stream shall be present at each nozzle tested when either pump is engaged.

4-4.8 Pump and Maneuver Test.

4-4.8.1 Test facilities shall consist of an open site suitable for discharging agent and operating the vehicle up to its maximum speed.

4-4.8.2 No test equipment shall be required.

4-4.8.3 The vehicle's agent system shall be fully operational for this test.

4-4.8.4 The positive pump and maneuver capability, along with the smooth engagement of the pump, shall be tested as follows:

(a) Fill both the water tank and the foam tank completely with water, and add dye or foam concentrate to the foam tank.

(b) With the vehicle being driven at 20 mph (32.2 km/h), engage and disengage the pump(s) without damage to the pump or pump drive system.

(c) Bring the vehicle to a stop, and prepare the primary turrets and ground sweeps (or optional bumper turret) for discharging.

(d) Place the agent selector in the foam mode, and set the agent system pressure relief to relieve at the recommended pressure for optimum performance.

(e) Initiate discharge through the primary turrets and ground sweeps/bumper turret nozzles, and drive the vehicle in a forward and reverse direction at speeds ranging up to 5 mph (8 km/h). Stop and start the vehicle, and change direction from forward to reverse while operating through this speed range without interrupting the discharge flow rate or range. Engage and disengage the pumps during the test.

(f) Repeat 4-4.8.4(e) both on and off the road.

4-4.8.5 During the test, there shall be no indication of proportioning, pressure, or flow rate instability. The operation of the pump shall not, under any conditions, cause the engine to stall. Engagement of the pump or vehicle drive shall be accomplished without introducing any unsafe vehicle dynamics such as severe lurching. Dye or foam solution shall be evident while discharging from all nozzles.

4-4.9 Hydrostatic Pressure Test.

4-4.9.1 Test facilities shall consist of an appropriate area in the vehicle manufacturer's plant.

4-4.9.2 Test equipment shall consist of the following:

(a) A hydraulic pressure gauge with a scale adequate for monitoring a pressure equal to $1^1/_2$ times the normal agent system pressure of the vehicle;

(b) A pressure charging device capable of developing a pressure equal to $1^1/_2$ times the normal agent system pressure of the vehicle and sustaining it for 15 minutes or longer;

(c) Miscellaneous plates or caps to isolate the suction side of the agent system, as necessary, from the hydrostatic test pressure.

4-4.9.3 The vehicle's agent system shall be fully assembled at the time of the test. As it is sometimes desirable to perform this test before the body is completely assembled and fire-fighting system controls are in place, the agent system shall not be required to be fully operational during the hydrostatic portion of the test.

4-4.9.4 The water and foam concentrate or foam solution discharge piping shall be tested as follows:

(a) Isolate all suction piping components that cannot tolerate the hydrostatic test pressures from the discharge piping and pump(s) by installing temporary plates or caps between these items and the discharge piping. Include the agent pumps in the test.

(b) Close all discharge nozzles, and seal any bypass lines from the pressure piping to the agent tanks.

(c) Connect a pressure charging device (e.g., electric motor-driven water pump or hand pump) into the discharge piping.

(d) Activate the pressure charging device, fill the agent pumps and discharge piping with water, and pressurize to at least $1^1/_2$ times the maximum recommended agent system operating pressure.

(e) Close the supply line from the pressure charging system, thereby sealing the discharge piping in a pressurized condition.

(f) Maintain the test pressure for at least 15 minutes without degradation.

(g) If leaks exist that cause the pressure to drop, repair the leaks and repeat the test.

(h) On completion of the hydrostatic test, disconnect the charging device and reassemble the suction piping.

(i) Fill the agent tanks and piping with water, and inspect the suction piping for leaks after the agent system has been operated in the foam mode.

4-4.9.5 No pressure decay shall be permitted during the 15-minute test, and no discharge or suction piping water leaks shall be permitted during or after agent system operation.

4-4.10 Foam Concentration Test.

4-4.10.1 Test facilities shall consist of an open site suitable for discharging agent. Access to a refill water supply and foam concentrate supply shall be required.

4-4.10.2 The test equipment described in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, shall be used for this test.

4-4.10.3 Each discharge nozzle on the vehicle shall have been individually verified as discharging at a flow rate within the tolerance specified. The agent system shall have been verified as capable of operating at full rate.

4-4.10.4 The test shall be conducted as follows:

(a) Fill the water and foam tank to the top, and refill as necessary throughout the test.

(b) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.

(c) Set the agent system pressure relief to the recommended pressure.

(d) Engage the agent pumps and bring them up to maximum pumping speed with all discharge outlets closed.

(e) Each foam delivery system shall be tested in accordance with NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, for the individual nozzle/flow rate as follows:

1. Roof turret(s) full rate;
2. Roof turret(s) half rate;
3. Ground sweep/bumper turret;
4. Hand line nozzles;
5. Undertruck nozzles.

4-4.10.5 The foam concentrations measured shall fall within the permitted tolerances specified in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, for each nozzle.

4-4.11 Roof Turret Flow Rate Test.

4-4.11.1 Test facilities shall consist of a level, open site suitable for discharging agent.

4-4.11.2 A stopwatch shall be required for this test.

4-4.11.3 The agent system shall be fully operational, and the agent system pressure shall be set in accordance with the manufacturer's recommendations. The water tank shall be filled completely.

4-4.11.4 The test shall be conducted as follows:

(a) Simultaneously initiate discharge through the primary turret(s) at the maximum flow rate and start the stopwatch.

(b) Continue discharging until the pump cavitates, as indicated by a significant drop in discharge pressure, and stop the watch when this occurs. Record the elapsed time.

(c) Divide the rated water tank capacity, in gallons, by the elapsed discharge time to determine the average discharge rate.

4-4.11.5 The average measured discharge rate shall be in reasonable agreement with the nominal discharge rate specified, and the total elapsed discharge time shall be no less than 1 minute nor greater than 2 minutes.

Chapter 5 Referenced Publications

5-1 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.

5-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 403, *Standard for Aircraft Rescue and Fire Fighting Services at Airports*, 1993 edition.

NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*, 1993 edition.

NFPA 1901, *Standard for Pumper Fire Apparatus*, 1991 edition.

NFPA 1961, *Standard for Fire Hose*, 1992 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1993 edition.

5-1.2 Other Publications.

5-1.2.1 ANSI Publication. American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

ANSI S1.4, *Specification for Sound Level Meters*, 1983.

5-1.2.2 ASME Publication. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME *Boiler and Pressure Vessel Code*, 1992.

5-1.2.3 ASTM Publication. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D4956, *Standard Specification for Retroreflective Sheeting for Traffic Control*, 1994.

5-1.2.4 SAE Publications. Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J551, *Standard on Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices (30-1000 MHz)*, 1990.

SAE J994, *Standard on Alarm-Backup-Electric Laboratory Performance Testing*, 1993.

5-1.2.5 U.S. Department of Transportation Publications. U.S. Government Printing Office, Superintendent of Documents, Mail Stop SSOP, Washington, DC 20402.

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-1-1.1 The basic NFPA recommendations on the use and provision of this equipment are contained in NFPA 402M, *Manual for Aircraft Rescue and Fire Fighting Operations*, and NFPA 403, *Standard for Aircraft Rescue and Fire Fighting Services at Airports*. Field testing procedures for aircraft rescue and fire-fighting vehicles utilizing foam are provided in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire Fighting Foam Equipment*. NFPA 422, *Guide for Aircraft Accident Response*, is designed, in part, to provide technical data useful in evaluating the effectiveness of these vehicles.

A-1-3 Definitions

Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards.

In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Intended Airport Service. See also NFPA 403, *Standard for Aircraft Rescue and Fire Fighting Services at Airports*, for further information concerning aircraft rescue and fire-fighting services at airports.

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-1-4.1 A minimum 1-year warranty should be supplied by the contractor. Purchasers should require that bids be submitted with a detailed description of the vehicles offered and drawings showing general arrangements, weights, and dimensions. Data similar to that provided in the questionnaire contained in Appendix B also should be required.

A-2-2.1.2 The intent of the weight distribution requirements is to produce the most equally divided weight distribution possible across all axles and wheels. Ideally, the front axle should not be the heaviest loaded axle. It is important to realize, however, that certain customized features not covered in the major fire-fighting vehicle chapter (such as auxiliary agent systems) might necessitate that the 5-percent allowance for the front axle be exceeded. Where these situations occur, the vehicle manufacturer needs to be consulted to determine the final weight distribution and to confirm that none of the established component weight ratings is exceeded and that the brake performance of the vehicle still complies with this standard.

A-2-2.2.2 Compromise might be necessary on overall vehicle dimensions, since the dimensions selected for optimum operational performance could be in conflict with other requirements. In order to eliminate unnecessary design restrictions, specification of vehicle dimensions should be undertaken only where a particular requirement exists.

Consideration should be given to the following factors at the time of specification to determine whether vehicle dimensions should be restricted:

(a) Fire station restrictions;

(b) Access within the airport boundaries;

(c) Access outside the airport boundaries, if necessary;

(d) Requirements that affect the dimensions of local construction, if applicable;

(e) Use regulations, if applicable.

A-2-3.1.2 At higher altitudes, the performance of a vehicle can be affected due to the reduced density of the air drawn into the engine. The resulting reduction in power is more noticeable on a normally aspirated engine, (e.g., nonturbo charged).

To assess the difference in performance at higher altitudes, it is important to obtain from the manufacturer the reduced power rating of the engine at the operating altitude. From this rating, the reduced level of acceleration performance or reduced water capacity extinguishing agent can be estimated.

A-2-7.3 The mobility and handling characteristics of the vehicle greatly depend on tire selection. The tractive limit of a tire is related to the strength of the soil, power available, wheel diameter, load, number of driving wheels, tire deflection, contact area, and tread pattern.

The following guidelines are recommended:

(a) Facilities with hard, off-pavement conditions and small snow accumulations might find it desirable to wish to specify high pressure tires with small contact area to maximize high speed performance and handling.

(b) Experience has demonstrated that tires having a large diameter, a wide base, and medium pressure can provide a reasonable compromise between mobility needs and hard surface performance and handling and are suitable for many facilities where soil is not extremely soft or wet and snow accumulations are moderate.

(c) Where local conditions require high flotation, (e.g., sand, mud) mobility traction can be improved by specifying larger wheel and tire diameters, larger tire cross section, greater tire deflection, and lower wheel loads or tire pressure. Specifications result in some degradation of high speed performance and handling characteristics. Actual performance testing could be necessary to ensure the suitability of such specifications.

A-2-8 Recovery of the vehicle from adverse conditions should be made by attaching the vehicle to the axles.

A-2-9.1 It is customary for manufacturers of rescue and fire-fighting vehicles to provide a braking system based on normal commercial practice, usually connected to a recognized standard that might have legal status in worldwide territories. These standards offer certain advantages and disadvantages that can vary from one another. Operators should consider these advantages and disadvantages with respect to their particular operating conditions and legal requirements.

A-2-9.2 By preventing wheel lock-up, anti-lock braking systems (ABS) can significantly enhance driver control and vehicle stability under certain conditions. The purchaser should consider the applicability of this option.

A-2-16.3.1 Polyvinyl chloride, epoxies, and polyesters are among the acceptable classes of resins.

A-2-16.5.7 The development of the extendable turret for aviation fire protection is a recent development. As such, the design and functional requirements, as well as the tactics and procedures for its use, are not well developed. Training curricula also need to be developed. The intent of the requirements of 2-16.5.7 is to provide minimum performance criteria so that

there is no degradation in the basic turret performance, while allowing individual flexibility for specific user needs. These needs can be affected by the type of aircraft being protected, the ability to access the aircraft interior, and the ability to access shielded fires.

As now envisioned, the extendable turret can be used for primary agent application as part of a first-arriving vehicle. As such, the vehicle should be capable of applying agent quickly without the need to deploy supporting outriggers. In the future, other design features or functions might be incorporated. For example, man-rated devices for use in accessing the interior cabin after fire knockdown might be incorporated. These devices might or might not require stabilizing devices; depending on the function of the vehicle, the time to deploy such devices may be permitted. In any event, there should be a maximum time for total deployment of the boom/tower device. A maximum of 30 seconds is recommended. The requirements do not prohibit the development of an advanced device or a unit with a different function, recognizing that the primary turret performance should not be compromised.

It is not recommended that agent be applied from a vertically extended position before knockdown of the exterior exposure fire, unless the fire cannot otherwise be accessed. Preliminary data from demonstrations of extendable turrets, plus data from earlier turret testing, suggest that AFFF discharged at a low level is the most effective technique. The extendable turret should be designed to extend below the roof level of the cab to take advantage of low-level AFFF application. Extension of the extendable turret below the cab level also should provide advantages in accessing shielded/obstructed areas such as wheel-well incidents and "gear down" scenarios.

To improve operator efficiency, the movement of the boom/tower should be accomplished with a single lever located within the cab. Elevation/azimuth indicators are not needed if the turret is in the line of sight of the operator.

Where specified, the extendable turret should be fitted with the appropriate tools/devices needed for a driver/operator to perform interior aircraft and tail-mounted engine fire-fighting functions remotely. These could include a skin penetrator/agent applicator for penetration of the fuselage to access interior fires from outside the aircraft. Tactics and procedures for these evolutions are not well developed and should be given careful consideration, preplanning, and training, particularly for situations where surviving passengers/crew might still be in the aircraft. Where a penetrator/agent applicator is used, a minimum flow equal to two hand lines (as specified in 2-16.6.4.3) is recommended. Airports planning to use the device for indirect attack with a skin penetrator should preplan appropriate access locations on aircraft served and the conditions under which the device is to be used.

A-2-20.2 If desired, the driver's siren control can be wired for selective control on the steering wheel horn button. If a combination public address-type siren is desired, an electronic type having an equivalent sound output should be substituted.

A-2-21 The purchaser should specify the particular item required for the following:

(a) One ground ladder that meets the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*;

(b) One section of hose of minimum $2^1/_2$-in. (6.4-cm) diameter for tank fill;

(c) Appropriate spanner wrenches for the fittings on the vehicle;

(d) One hydrant wrench or other wrench necessary to activate the local water supply;

(e) A SCBA meeting the requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, and NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, available for each assigned fire fighter;

(f) Skin penetrator/agent applicator;

(g) Appropriate wheel chocks;

(h) 100 ft (30.5 m) of utility rope;

(i) Two axes, non-wedge type;

(j) Fire-resistant blanket;

(k) Bolt cutters, minimum 24 in. (61 cm);

(l) Multipurpose, forcible entry tool;

(m) Intrinsically safe handlight(s);

(n) Two harness cutting tools;

(o) Hook, grab, or salving tool;

(p) First aid kit;

(q) 4-lb (1.8-kg) hammer.

For a detailed discussion of rescue tools, see NFPA 402M, *Manual for Aircraft Rescue and Fire Fighting Operations*.

It is important that additional features such as structural fire-fighting equipment do not interfere with the basic ability of the vehicle to perform its primary aircraft rescue and fire-fighting function. It is considered preferable to have separate vehicles for structural fire fighting equipped with the needed complement of hose and tools, since the quantity of such equipment carried on an aircraft rescue and fire-fighting vehicle needs to be limited to conserve weight and space.

A-3-2.2.2 See A-2-2.2.2.

A-3-3.1.2 See A-2-3.1.2.

A-3-7.3 See A-2-7.3.

A-3-9.1 See A-2-9.2.

A-3-9.7 See A-2-9.2.

A-3-13.4.2.1 See A-2-16.3.1.

A-3-14.2 See A-2-20.2.

A-3-15 See A-2-21.