NFPA 414

Standard for Aircraft Rescue and Fire-Fighting Vehicles

2001 Edition

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

IMPORTANT NOTICE ABOUT THIS DOCUMENT

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

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

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

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

NOTICES

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

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

A statement, written or oral, that is not processed in accordance with Section 5 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

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

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

Licensing Policy

This document is copyrighted by the National Fire Protection Association (NFPA). By making this document available for use and adoption by public authorities and others, the NFPA does not waive any rights in copyright to this document.

1. Adoption by Reference—Public authorities and others are urged to reference this document in laws, ordinances, regulations, administrative orders, or similar instruments. Any deletions, additions, and changes desired by the adopting authority must be noted separately. Those using this method are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. The term "adoption by reference" means the citing of title and publishing information only.

2. Adoption by Transcription—A. Public authorities with lawmaking or rule-making powers only, upon written notice to the NFPA (Attention: Secretary, Standards Council), will be granted a royalty-free license to print and republish this document in whole or in part, with changes and additions, if any, noted separately, in laws, ordinances, regulations, administrative orders, or similar instruments having the force of law, provided that: (1) due notice of NFPA's copyright is contained in each law and in each copy thereof; and (2) that such printing and republication is limited to numbers sufficient to satisfy the jurisdiction's lawmaking or rule-making process. **B.** Once this NFPA Code or Standard has been adopted into law, all printings of this document by public authorities with lawmaking or rule-making powers or any other persons desiring to reproduce this document or its contents as adopted by the jurisdiction in whole or in part, in any form, upon written request to NFPA (Attention: Secretary, Standards Council), will be granted a nonexclusive license to print, republish, and vend this document in whole or in part, with changes and additions, if any, noted separately, provided that due notice of NFPA's copyright is contained in each copy. Such license shall be granted only upon agreement to pay NFPA a royalty. This royalty is required to provide funds for the research and development necessary to continue the work of NFPA and its volunteers in continually updating and revising NFPA standards. Under certain circumstances, public authorities with lawmaking or rule-making powers may apply for and may receive a special royalty where the public interest will be served thereby.

3. Scope of License Grant—The terms and conditions set forth above do not extend to the index of this document.

(For further explanation, see the Policy Concerning the Adoption, Printing, and Publication of NFPA Documents, which is available upon request from the NFPA.)

NFPA 414

Standard for

Aircraft Rescue and Fire-Fighting Vehicles

2001 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 NFPA at its May Association Technical Meeting held May 13–17, 2001, in Anaheim, CA. It was issued by the Standards Council on July 13, 2001, with an effective date of August 2, 2001, and supersedes all previous editions.

This edition of NFPA 414 was approved as an American National Standard on August 2, 2001.

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 included the removal of requirements for a separate category of rapid intervention vehicle.

The major change for the 2001 edition is the combination of major fire-fighting vehicles and combined agent vehicles. Additionally, a table now provides many requirements concisely; they were previously covered by numerous paragraphs.

Technical Committee on Aircraft Rescue and Fire Fighting

Brian Boucher, *Chair*
Air Canada Pilots Association, Canada [L]

Lawrence V. Powers, *Secretary*
Massport, MA [U]

Tony Cash, United Kingdom Civil Aviation Authority, England [E]
Ralph Colet, John Russo Industrial Inc., CA [M]
Robert L. Darwin, Hughes Associates, Inc., MD [SE]
Roger Davis, BAA PLC, England [U]
David A. Enz, Tucson Airport Authority, AZ [U]
Rep. Airports Council International — North America
Kenneth R. Gilliam, Federal Aviation Administration, FL [E]
Fred B. Goodnight, Amerex Corporation, AL [M]
Rep. Fire Equipment Manufacturers' Association
B. V. Hewes, Airport Safety Services, GA [SE]
L. M. Krasner, FM Research, MA [I]
Paul S. Meyer, Hartsfield Atlanta International Airport, GA [U]
John J. O'Sullivan, British Airways, PLC, England [C]
Gaétan Perron, National Defense Headquarters (CFFM-2), Canada [U]
Thomas Phillips, Airline Pilots Association, PA [L]
Pam Phillips, The Port Authority of New York & New Jersey, NY [U]
Rep. American Association of Airport Executives
Hugh A. Pike, U.S. Air Force Fire Protection, FL [U]
Lee W. Prazer, Akron Brass Company, OH [M]
Michael D. Reagan, Los Angeles City Fire Department, CA [U]
Robert G. Relyea, ARFF Working Group, TX [M]
John F. Rooney, Tucson, AZ [SE]
John M. Schuster, 3M Company, MN [M]
Terry Seaborn, Oshkosh Truck Corporation, WI [M]
Robert L. Shaub, Emergency One, Inc., FL [M]
Bernard Valois, Transport Canada Civil Aviation, Canada [E]
Ronald O. Wikander, LM Aero, GA [M]

Alternates

Keith W. Bagot, U.S. Federal Aviation Administration Technical Center, NJ [RT]
(Alt. to FAA Rep.)
Darrin Barth, Hartsfield Atlanta International Airport, GA [U]
(Alt. to P. S. Meyer)
Michael P. Crowe, Oshkosh Truck Corporation, WI [M]
(Alt. to T. Seaborn)
Robert J. Donahue, Massport, MA [U]
(Alt. to L. V. Powers)
Christopher Farnaby, United Kingdom Civil Aviation Authority, England [E]
(Alt. to T. Cash)
James Hotell, U.S. Air Force Fire Protection, FL [U]
(Alt. to H. A. Pike)
Frank M. E. Hughes, British Airways, PLC, England [C]
(Alt. to J. J. O'Sullivan)
Richard B. Mills, Akron Brass Company, OH [M]
(Alt. to L. W. Prazer)
Gaétan Morinville, Canadian Forces Department of National Defence Canada, Canada [U]
(Alt. to G. Perron)
James F. O'Regan, O'Regan Consulting, MA [M]
(Alt. to R. Colet)
Richard E. Ottman, 3M Company, MN [M]
(Alt. to J. M. Schuster)
Michelle Peatross, Hughes Associates, Inc., MD [SE]
(Alt. to R. L. Darwin)
Paul R. Robinson, Chattanooga, TN [L]
(Alt. to T. Phillips)
Gary T. Schott, Omaha Airport Authority, NE [M]
(Alt. to R. G. Relyea)
Bernard Stone, BAA PLC, England [U]
(Alt. to R. Davis)
Thomas Van Mai, Federal Aviation Administration, DC [E]
(Alt. to K. R. Gilliam)
Craig Williams, American Association of Airport Executives, VA [U]
(Alt. to P. Phillips)
Bonnie Wilson, Airports Council International — North America, DC [U]
(Alt. to D. A. Enz)

Nonvoting

Mark Day, Carmichael International Ltd, England
Gary Hammack, U.S. National Transportation Safety Board, DC
(Alt. to L. D. Roman)
Thomas J. Lett, Albuquerque Fire & Safety Associates, NM
(Member Emeritus)
John E. Lodge, Lodge Fire Protection Consultancy Ltd, England
(Member Emeritus)
Lawrence D. Roman, U.S. National Transportation Safety Board, DC
David F. Short, Charlton Kings, Cheltenham, England

Mark T. Conroy, NFPA Staff Liaison

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 hand fire extinguishers and accident prevention and the saving of lives in future aircraft accidents involving fire.

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

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

Contents

NFPA 414

Standard for

Aircraft Rescue and Fire-Fighting Vehicles

2001 Edition

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. The complete title and edition of the document the material is extracted from is found in Annex F. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee.

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

Chapter 1 Administration

1.1 Scope.

1.1.1* This standard specifies the minimum design, performance, and acceptance criteria for aircraft rescue and fire-fighting (ARFF) vehicles intended to transport personnel and equipment to the scene of an aircraft emergency for the purpose of rescuing occupants and conducting rescue and fire-fighting operations.

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

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 the minimum acceptable for 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 Requirements for All Aircraft Rescue and Fire-Fighting Vehicles — Responsibility of Contractors/Suppliers.

1.3.1* Certification. 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.

1.3.2 Manuals. The manufacturer shall supply at time of delivery at least two complete copies of the following manuals:

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

These manuals shall cover the entire vehicle and shall be in accordance with 1.3.2.1 through 1.3.2.3.9.

1.3.2.1 Operator's Manual.

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

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

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

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

1.3.2.2 Service Manual.

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

1.3.2.2.2 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.

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

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

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

1.3.2.2.6 The service manual shall contain a suitable index.

1.3.2.3 Parts Manual.

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

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

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

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

1.3.2.3.5 The parts identification manual shall contain a numerical index.

1.3.2.3.6 The vehicle manufacturer shall ensure that parts critical to the mission of the vehicle are shipped to the purchaser within 48 hours.

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

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

1.3.2.3.9 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.

1.3.3 Metal Finish.

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

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

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

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

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

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

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

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

1.3.3.6 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.

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

1.3.3.8 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.

1.3.4 Lettering, Numbering, and Striping.

1.3.4.1 Vehicle numbering, lettering, and minimum 0.2-m (8-in.) wide reflective striping shall be provided in accordance with ASTM D 4956, *Standard Specification for Retroreflective Sheeting for Traffic Control.*

1.3.4.2 Striping shall be placed horizontally on the sides of the vehicle below the body centerline.

1.3.4.3 Vehicles shall display an identification number on each side and roof.

1.3.4.3.1 Side numbers shall be a minimum of 0.4 m (16 in.) in height.

1.3.4.3.2 Primary numbers shall be a minimum of 0.6 m (24 in.) in height and affixed with their base toward the front of the vehicle.

1.3.4.4 Numbering, lettering, and striping shall be in sharp contrast to the vehicle color.

1.3.5 Vehicle Information Data Plate. A data plate that contains all the information presented in Figure 1.3.5, as a minimum, shall be installed in the cab of the vehicle.

Manufacturer	________________
Vehicle (make and model year)	________ and ________
Drive type: 4 × 4 ____ 6 × 6 ____ 8 × 8 ____ 10 × 10 ____	
The vehicle was tested to ____ degrees in both directions (table angle)	
Was a trip/slip rail used? No ____ Yes ____	
If yes, height of rail (maximum 50 mm/2 in.) ________ (Millimeters/inches)	
Date of test:	________________

Front axle loading*	________ (Kilograms/pounds)
Second axle loading*	________ (Kilograms/pounds)
3rd axle loading* (if applicable)	________ (Kilograms/pounds)
4th axle loading* (if applicable)	________ (Kilograms/pounds)
5th axle loading* (if applicable)	________ (Kilograms/pounds)
Tire manufacturer	________________
Tire model	________________
Tire pressure	________ (kPa/psi)
Front wheel track	________ (Centimeters/inches)
Rear wheel track	________ (Centimeters/inches)
Crew capacity	________ (Number of personnel)
Fuel tank capacity	________ (Liters/gallons)
Equipment allowance	________ (Kilograms/pounds)
Water tank capacity	________ (Liters/gallons)
Foam tank capacity	________ (Liters/gallons)
Auxiliary agent capacity (if applicable)	________ (Kilograms/pounds)

* The "loading" shall be in accordance with the definition of a fully loaded vehicle as presented in NFPA 414.

FIGURE 1.3.5 Aircraft rescue and fire-fighting vehicle tilt table certification per NFPA 414.

Chapter 2 Referenced Publications

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

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

NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment,* 1998 edition.
NFPA 1901, *Standard for Automotive Fire Apparatus,* 1999 edition.
NFPA 1961, *Standard on Fire Hose,* 1997 edition.
NFPA 1964, *Standard for Spray Nozzles (Shutoff and Tip),* 1998 edition.

2.1.2 Other Publications.

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

ANSI S1.4, *Specification for Sound Level Meters,* 1983.

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

ASME *Boiler and Pressure Vessel Code,* 1992.

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

ASTM D 4956, *Standard Specification for Retroreflective Sheeting for Traffic Control,* 1994.

2.1.2.4 NATO Publication. Global Engineering Documents, An IHS Company, 15 Inverness Way East, Englewood, CO 80112.

NATO Document, "Dynamic Stability Report — Allied Vehicle Testing Publication (AVTP)," 03-16W.

2.1.2.5 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.

SAE J1908, *Electrical Grounding Practice*, 1996.

SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, 1993.

SAE J2181, *Steady State Circular Test Procedures for Trucks and Buses*, 1993.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

3.2.4 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1 AFFF. See 3.3.9 Aqueous Film-Forming Foam Concentrate.

3.3.2 Aggressive Tire Tread. See 3.3.63 Tread.

3.3.3 Air-Mechanical Brakes. See 3.3.14 Brakes.

3.3.4 Air-Over-Hydraulic Brakes. See 3.3.14 Brakes.

3.3.5 All-Wheel Drive. A vehicle that drives on all wheels.

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

3.3.7* Angle of Approach. The measure of the steepest ramp that a fully loaded vehicle can approach.

3.3.8* Angle of Departure. The measure of the steepest ramp from which the fully loaded vehicle can depart.

3.3.9 Aqueous Film-Forming Foam (AFFF) Concentrate. See 3.3.29 Foam Concentrate.

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

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

3.3.12 Axle Tread. See 3.3.63 Tread.

3.3.13* Bogie. A combination of two axles used to support the end of a vehicle.

3.3.14 Brakes.

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

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

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

3.3.15* Center of Gravity. The point within a vehicle at which all of its weight can be considered to be concentrated.

3.3.16* Complementary Agent. Agents that provide unique extinguishing capability beyond the primary chosen agent.

3.3.17 Component Manufacturer's Certification. A signed application approval furnished by the component manufacturer that certifies that the component is approved as being properly installed or applied, or both, in the vehicle for its intended use, or the component complies with the respective construction criteria required by the standard.

3.3.18* Cooling Preheater Device. A device for heating the engine coolant so that the engine is maintained at a constant temperature.

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

3.3.20 Differential Global Positioning System (DGPS). See 3.3.60 System.

3.3.21 Driver's Enhanced Vision System (DEVS). See 3.3.60 System.

3.3.22 Dry Air. Air that has a dew point of −51°C (−60°F) or lower.

3.3.23 Dry Nitrogen. Nitrogen that has a dew point of −51°C (−60°F) or lower.

3.3.24 Dynamic Balance. A physical condition that exists when a vehicle is driven into a turn under high speed and the vehicle displays no tendencies to pitch weight forward on the front steering wheels nor exhibits of under steer or over steer conditions which could make the vehicle unstable.

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

3.3.26 Extendable Turret. See 3.3.64 Turret.

3.3.27 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.

3.3.28 Fluoroprotein Foam Concentrate. See 3.3.29 Foam Concentrate.

3.3.29 Foam Concentrate.

3.3.29.1 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.

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

3.3.29.3 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.

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

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

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

3.3.33 Fully Loaded Vehicle. See 3.3.71 Vehicle.

3.3.34 Global Positioning System (GPS). See 3.3.60 System.

3.3.35 Ground Sweep Nozzle. See 3.3.42 Nozzle.

3.3.36 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.

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

3.3.38* 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.

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

3.3.40 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.

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

3.3.42 Nozzle.

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

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

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

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

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

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

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

3.3.48 Primary Turret. See 3.3.64 Turret.

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

3.3.50 Protein Foam Concentrate. See 3.3.29 Foam Concentrate.

3.3.51 Prototype Vehicle. See 3.3.71 Vehicle.

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

3.3.53 Ramp Angle. See 3.3.38 Interaxle Clearance Angle (Ramp Angle).

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

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

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

3.3.57 Service Brake. See 3.3.14 Brakes.

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

3.3.59* Steering Drive Ends. In the front wheel spindle in a driving–steering axle as used at the front of an all-wheel drive vehicle.

3.3.60 System.

3.3.60.1* Differential Global Positioning System (DGPS). A technique applied to a global positioning system (GPS) solution that improves the accuracy of that solution.

3.3.60.2 Driver's Enhanced Vision System (DEVS). An enhanced vision and navigation system for guiding aircraft rescue and fire-fighting vehicles at night and during certain low-visibility conditions. The DEVS is comprised of three systems: (1) *Navigation*, which displays the ARFF vehicle's position on a moving map display mounted in the cab; (2) *Tracking*, which provides two-way digital communication between the ARFF vehicle and the Emergency Command Center; (3) *Vision*, which allows the ARFF vehicle operator to see in 0/0 visibility conditions.

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

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

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

3.3.63 Tread.

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

3.3.63.2* Axle Tread. The distance between the center of two tires or wheels on one axle.

3.3.64 Turret.

3.3.64.1* 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.

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

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

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

3.3.67 Undertruck Nozzle. See 3.3.42 Nozzle.

3.3.68* Underbody Clearance Dimensions. The dimensions determined with the vehicle fully loaded and fully equipped, unless otherwise specified.

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

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

3.3.71 Vehicle.

3.3.71.1* Fully Loaded Vehicle. Consists of the fully assembled vehicle, complete with a full complement of crew, fuel, and fire-fighting agents.

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

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

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

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

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

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

Chapter 4 ARFF Vehicles

4.1* General.

4.1.1 The design criteria for the standard vehicles described by this document consider temperature extremes ranging from 0°C to 43.3°C (32°F to 110°F). For cold weather operation where temperatures periodically range from −40°C to 0°C (−40°F to 32°F) or lower, some type of winterization system is to be specified by the purchaser. Vehicles shall comply with Table 4.1.1(a), Table 4.1.1(b), Table 4.1.1(c), Table 4.1.1(d), and other requirements in this chapter.

4.1.2 The category of vehicles shall encompass a range of water capacity commencing at 250 L (60 gal) and extending to over 22,710 L (6000 gal).

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

4.1.4 Because the same performance cannot be expected of all vehicles within this range, vehicles shall be classified by water capacity as listed in Table 4.1.1(a) and Table 4.1.1(b).

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

4.2 Weights and Dimensions.

4.2.1* Weights.

4.2.1.1 The actual gross vehicle weight of a fully staffed, loaded, and equipped vehicle ready for service shall not exceed the manufacturer's tested weight rating as recorded on the vehicle information data plate.

4.2.1.2* The weight shall be distributed as equally as practical over the axles and tires of the fully loaded vehicle.

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

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

Table 4.1.1(a) Fully Loaded Vehicle Performance Parameters

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 227 to ≤1999 L	Vehicle Water Tank Capacity > 1999 to ≤ 6000 L	Vehicle Water Tank Capacity > 6000 L
Side slope stability (degrees)	30	30	30
Dynamic balance (kph), minimum speed on a (30 m) radius circle	40	35.5	35.5
Angle of approach (degrees)	30	30	30
Angle of departure (degrees)	30	30	30
Interaxle clearance (degrees)	12	12	12
Underbody clearance (cm)	33	46	46
Underaxle clearance at differential housing bowl (cm)	26.7	33	33
Diagonal opposite wheel motion (cm)	25.4	36	36
Wall-to-wall turning diameter	<Three times the vehicle's overall length	<Three times the vehicle's overall length	<Three times the vehicle's overall length
Maximum acceleration time from 0 to 80.5 kph (seconds)	30	25	35
Top speed (kph)	≥105	≥105	≥105
Service brake:			
Stopping distance			
from33 kph	≤11 m	≤11 m	≤12 m
from 64 kph	≤40 m	≤40 m	≤49 m
Percent grade holding of fully loaded vehicle:			
Ascending	≥50 percent	≥50 percent	≥50 percent
Descending	≥50 percent	≥50 percent	≥50 percent
Emergency brake stopping distance at 64 kph	≤88 m	≤88 m	≤88 m
Parking brake:			
Percent grade holding for the parking brake			
Ascending	≥20 percent	≥20 percent	≥20 percent
Descending	≥20 percent	≥20 percent	≥20 percent
Evasive maneuver test, NATO Document AVTP 03-16W	40 kph	40 kph	40 kph

Table 4.1.1(b) Fully Loaded Vehicle Performance Parameters

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥60 to ≤528 gal	**Vehicle Water Tank Capacity >528 to ≤1585 gal**	**Vehicle Water Tank Capacity >1585 gal**
Side slope stability (degrees)	30	30	30
Dynamic balance (mph) minimum speed on a (100 ft) radius circle	25	22	22
Angle of approach (degrees)	30	30	30
Angle of departure (degrees)	30	30	30
Interaxle clearance (degrees)	12	12	12
Underbody clearance (inches)	13	18	18
Underaxle clearance at differential housing bowl (inches)	10.5	13	13
Diagonal opposite wheel motion (inches)	10	14	14
Wall-to-wall turning diameter	<Three times the vehicle's overall length	<Three times the vehicle's overall length	<Three times the vehicle's overall length
Maximum acceleration time from 0 to 50 mph (seconds)	30	25	35
Top speed (mph)	≥65	≥65	≥65
Service brake:			
Stopping distance			
from 20 mph	≤35 ft	≤35 ft	≤40 ft
from 40 mph	≤131 ft	≤131 ft	≤160 ft
Percent grade holding of fully loaded vehicle:			
Ascending	≥50 percent	≥50 percent	≥50 percent
Descending	≥50 percent	≥50 percent	≥50 percent
Emergency brake stopping distance at 40 mph	≤288 ft	≤288 ft	≤288 ft
Parking brake:			
Percent grade holding for the parking brake			
Ascending	≥20 percent	≥20 percent	≥20 percent
Descending	≥20 percent	≥20 percent	≥20 percent
Evasive maneuver test, NATO Document AVTP 03-16W	25 mph	25 mph	25 mph

Table 4.1.1(c) Agent System Performance Parameters

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 227 to ≤ 1999 L	**Vehicle Water Tank Capacity > 1999 to ≤ 6000 L**	**Vehicle Water Tank Capacity > 6000 L**
1. Water tank percent of deliverable water			
a. On level ground	100 percent	100 percent	100 percent
b. On 20 percent side slope	75 percent	75 percent	75 percent
c. 30 percent ascending/ descending grade	75 percent	75 percent	75 percent
2. Roof turret(s) discharge	Total flow rate can be achieved with handlines	Total flow rate can be achieved using a roof turret, extendable turret, bumper turret, or a combination thereof	Total flow rate can be achieved using a roof turret, extendable turret, bumper turret, or a combination thereof
a. Total minimum flow rate (L/min) OR	≥946	≥2839	≥4731
Individual flow rate of the roof turret, if used in combination with a bumper turret (L/min)	N/A	≥1892	≥3785
b. Stream pattern/distances:			
i. Straight/far point (m)	≥46	≥58	≥70
ii. Dispersed/far point (m)	≥15	≥20	≥21
iii. Dispersed/width (m)	≥9	≥11	≥11
2a. Extendable turret:			
a. Individual flow rate of the extendable turret if used in combination with a bumper turret (L/min)	N/A	≥1892	≥3785
b. Stream pattern/distances:			
i. Straight/far point (m)	N/A	≥58	≥58
ii. Dispersed/far point (m)	N/A	≥20	≥21
iii. Dispersed/width (m)	N/A	≥11	≥11
2b. Bumper turret:	Can be used as the primary turret	See roof turret discharge rates	See roof turret discharge rates
a. Flow rate (L/min)	≥946	≥946	≥946
b. Straight stream distance (m)	≥46	≥46	≥46
c. Dispersed pattern distances:			
i. Far point (m)	≥15	≥15	≥15
ii. Width (m)	≥9	≥9	≥9
iii. Near point (m)	Within 9 m of front bumper	Within 9 m of front bumper	Within 9 m of front bumper
2c. Ground sweep nozzle:	Where specified	Where specified	Where specified
a. Flow rate (L/min)	N/A	≥378 to ≤1135	≥378 to ≤1135
b. Dispersed pattern distances:			
i. Far point (m)	N/A	≥9	≥9
ii. Width (m)	N/A	≥3.5	≥3.5
2d. Undertruck nozzle flow rate (L/min)	Where specified >57	Where specified >57	Where specified >57

Table 4.1.1(c) *Continued*

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 227 to ≤ 1999 L	**Vehicle Water Tank Capacity > 1999 to ≤ 6000 L**	**Vehicle Water Tank Capacity > 6000 L**
3. Number of water/foam handlines required per vehicle (select from below)	1	2	2
3a. Woven jacket water/foam handline:			
a. Nozzle flow rate (L/min)	≥360	≥360	≥360
b. Straight stream distance (m)	≥20	≥20	≥20
c. Dispersed stream pattern:			
i. Range (m)	≥6	≥6	≥6
ii. Width (m)	≥4.5	≥4.5	≥4.5
d. Hose inside diameter (mm)	≥38	≥38	≥38
e. Hose length (m)	≥46	≥46	≥46
3b. Reeled water/foam handline:			
a. Nozzle flow rate (L/min)	360 (≥246 for dual agent lines)	360 (≥246 for dual agent lines)	360 (≥246 for dual agent lines)
b. Straight stream distance (m)	≥20	≥20	≥20
c. Dispersed stream pattern:			
i. Range (m)	≥6	≥6	≥6
ii. Width (m)	≥4.5	≥4.5	≥4.5
d. Hose length (m)	≥46 (≥30 for dual agent lines)	≥46 (≥30 for dual agent lines)	≥46 (≥30 for dual agent lines)
4. Complementary agent			
a. Capacity (kg)	≥45	≥45	≥45
4a. Dry chemical handline:	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥2.3	≥2.3	≥2.3
b. Range (m)	≥7.5	≥7.5	≥7.5
c. Hose length (m)	≥30	≥30	≥30
4b. Dry chemical turret:	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥7 ≤10	≥7 ≤10	≥7 ≤10
b. Range (m)	≥30	≥30	≥30
c. Width (m)	≥5	≥5	≥5
4c. Dry chemical extendable turret	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥5.5	≥10	≥10
b. Range (m)	≥30	≥30	≥30
c. Width (m)	≥5	≥5	≥5
4d. Halogenated agent handline:	Where specified	Where specified	Where specified
a. Discharge rate (kg/sec)	≥2.3	≥2.3	≥2.3
b. Range (m)	≥7.5	≥7.5	≥7.5
c. Hose inside diameter (mm)	≥25.4	≥25.4	≥25.4
d. Hose length (m)	≥30	≥30	≥30

Table 4.1.1(d) Agent System Performance Parameters

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 60 to ≤528 gal	**Vehicle Water Tank Capacity >528 to ≤1585 gal**	**Vehicle Water Tank Capacity >1585 gal**
1. Water tank percent of deliverable water			
a. On level ground	100 percent	100 percent	100 percent
b. On 20 percent side slope	75 percent	75 percent	75 percent
c. 30 percent ascending/descending grade	75 percent	75 percent	75 percent
2. Roof turret(s) discharge	Total flow rate can be achieved with handlines	Total flow rate can be achieved using a roof turret, extendable turret, bumper turret, or a combination thereof	Total flow rate can be achieved using a roof turret, extendable turret, bumper turret, or a combination thereof
a. Total minimum flow rate (gpm) OR	≥250	≥750	≥1250
Individual flow rate of the roof turret, if used in combination with a bumper turret (gpm)	N/A	≥500	≥1000
b. Stream pattern/distances:			
i. Straight/far point (ft)	≥150	≥190	≥230
ii. Dispersed/far point (ft)	≥50	≥65	≥70
iii. Dispersed/width (ft)	≥30	≥35	≥35
2a. Extendable turret:			
a. Individual flow rate of the extendable turret if used in combination with a bumper turret (gpm)	N/A	≥500	≥1000
b. Stream pattern/distances:			
i. Straight/far point (ft)	N/A	≥190	≥190
ii. Dispersed/far point (ft)	N/A	≥65	≥70
iii. Dispersed/width (ft)	N/A	≥35	≥35
2b. Bumper turret:	Can be used as the primary turret	See roof turret discharge rates	See roof turret discharge rates
a. Flow rate (gpm)	≥250	≥250	≥250
b. Straight stream distance (ft)	≥150	≥150	≥150
c. Dispersed pattern distances:			
i. Far point (ft)	≥50	≥50	≥50
ii. Width (ft)	≥30	≥30	≥30
iii. Near point (ft)	Within 30 ft of front bumper	Within 30 ft of front bumper	Within 30 ft of front bumper
2c. Ground sweep nozzle:	Where specified	Where specified	Where specified
a. Flow rate (gpm)	N/A	≥100 to ≤300	≥100 to ≤300
b. Dispersed pattern distances:			
i. Far point (ft)	N/A	≥30	≥30
ii. Width (ft)	N/A	≥12	≥12
2d. Undertruck nozzle Flow rate (gpm)	Where specified >15	Where specified >15	Where specified >15

Table 4.1.1(d) *Continued*

Performance Parameters	Minimum Usable Capacity		
	Vehicle Water Tank Capacity ≥ 60 to ≤528 gal	**Vehicle Water Tank Capacity >528 to ≤1585 gal**	**Vehicle Water Tank Capacity >1585 gal**
3. Number of water/foam handlines required per vehicle (select from below)	1	2	2
3a. Woven jacket water/foam handline:			
a. Nozzle flow rate (gpm)	≥95	≥95	≥95
b. Straight stream distance (ft)	≥65	≥65	≥65
c. Dispersed stream pattern:			
i. Range (ft)	≥20	≥20	≥20
ii. Width (ft)	≥15	≥15	≥15
d. Hose inside diameter (in.)	≥1.50	≥1.50	≥1.50
e. Hose length (ft)	≥150	≥150	≥150
3b. Reeled water/foam handline:			
a. Nozzle flow rate (gpm)	95 (≥65 for dual agent lines)	95 (≥65 for dual agent lines)	95 (≥65 for dual agent lines)
b. Straight stream distance (ft)	≥65	≥65	≥65
c. Dispersed stream pattern:			
i. Range (ft)	≥20	≥20	≥20
ii. Width (ft)	≥15	≥15	≥15
d. Hose length (ft)	≥150 (≥100 for dual agent lines)	≥150 (≥100 for dual agent lines)	≥150 (≥100 for dual agent lines)
4. Complementary agent			
a. Capacity (pounds)	≥100	≥100	≥100
4a. Dry chemical handline:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥5	≥5	≥5
b. Range (ft)	≥25	≥25	≥25
c. Hose length (ft)	≥100	≥100	≥100
4b. Dry chemical turret:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥16 ≤22	≥16 ≤22	≥16 ≤22
b. Range (ft)	≥100	≥100	≥100
c. Width (ft)	≥17	≥17	≥17
4c. Dry chemical extendable turret:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥12	≤22	≤22
b. Range (ft)	≥100	≥100	≥100
c. Width (ft)	≥17	≥17	≥17
4d. Halogenated agent handline:	Where specified	Where specified	Where specified
a. Discharge rate (lb/sec)	≥5	≥5	≥5
b. Range (ft)	≥25	≥25	≥25
c. Hose inside diameter (in.)	≥1.00	≥1.00	≥1.00
d. Hose length (ft)	≥100	≥100	≥100

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

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

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

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

4.2.1.5 The vehicle also shall be driven on a steering pad around a circle and the steering wheel rotation shall increase with acceleration of speed to ensure the vehicle does not exhibit over-steer characteristics. *(See 5.3.2.4 for test requirements.)*

4.2.2 Dimensions.

4.2.2.1* The axle clearances in Table 4.1.1(a) and Table 4.1.1(b) shall be measured with vehicle tires inflated to highway inflation pressure.

4.2.2.1.1 The dimensions in Table 4.1.1(a) and Table 4.1.1(b) shall be permitted to be reduced to give more stable performance on hard pavement if the suspension is designed to raise the vehicle to these clearances when vehicle is traveling off pavement.

4.2.2.1.2 If this option is used, the vehicle shall be tested in accordance with Table 4.1.1(a) and Table 4.1.1(b).

4.2.2.2* 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.

4.2.2.3 Field of Vision.

4.2.2.3.1 The vehicle shall be constructed so that a seated driver, having an eye reference point of 80.7 cm (31¾ in.) above the seat cushion and 30.5 cm (12 in.) forward from the seat back, shall be able to see the ground 6.1 m (20 ft) ahead of the vehicle and shall have a field of vision of at least 5 degrees above the horizontal plane.

4.2.2.3.2 The field of vision in the horizontal plane shall be at least 90 degrees on each side from the straight ahead position and shall not create an obstruction of more than 7 degrees per obstruction.

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

4.2.2.4.1 Each side shall be provided with a minimum 45.2-cm^2 (7-$in.^2$) wide-angle (convex) mirror.

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

4.2.2.4.3 Convex mirrors shall not be required to be motorized.

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

4.3 Engine.

4.3.1 Performance Requirements.

4.3.1.1 Engine Characteristics.

4.3.1.1.1 The vehicle engines shall have sufficient horsepower, torque, and speed characteristics to meet and maintain all vehicular performance characteristics specified in this standard.

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

4.3.1.2* The fully loaded vehicle shall be able to accelerate consistently from 0 kph to 80.5 kph (0 mph to 50 mph) on dry, level concrete pavement at the operational airport within the times specified in Table 4.1.1(a) and Table 4.1.1(b).

4.3.1.2.1 The maximum speed shall not be less than 104.6 kph (65 mph).

4.3.1.2.2 The acceleration times provided in Table 4.1.1(a) and Table 4.1.1(b) shall be achieved with the engine and transmission at their normal operating temperatures at any ambient temperature from −17.8°C to 43.3°C (0°F to 110°F) and at elevations up to 609.6 m (2000 ft) above sea level, unless a higher elevation is specified.

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

4.3.1.3 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 1.6 kph (1 mph) with extinguishing agents being discharged from the primary turret nozzle(s).

4.3.2 Engine Cooling Systems.

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

4.3.2.2 This device shall be fitted with an automatic thermostat.

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

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

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

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

4.3.3 Fuel System.

4.3.3.1 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.

4.3.3.2 Gasoline engines shall have an electric fuel pump located near the fuel tank to prevent vapor lock.

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

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

4.3.3.3.2 The fuel/water separator shall meet the engine manufacturer's requirements.

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

4.3.3.5 Fuel Capacity.

4.3.3.5.1 The fuel tank shall have sufficient capacity to provide for a minimum of 48.3 km (30 mi) of highway travel at 88.5 kph (55 mph) plus 2 hours of pumping at the full rated discharge.

4.3.3.5.2 Additional fuel capacity shall be provided for a minimum of 4 hours of operation of each accessory item (such as a generator or fuel-fired heaters) that uses the common fuel tank as a source.

4.3.4 Exhaust System.

4.3.4.1 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.

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

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

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

4.3.4.3 The tail pipe shall be designed to discharge upward or to the rear and shall not be directed toward the ground.

4.4 Vehicle Electrical System.

4.4.1 Electrical Systems and Warning Devices.

4.4.1.1 Low-voltage electrical systems and warning devices shall comply with NFPA 1901, *Standard for Automotive Fire Apparatus*, Chapter 11. *(See Annex B.)*

4.4.1.2 Line Voltage Electrical Systems. See Annex C.

4.4.2 Battery Chargers.

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

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

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

4.4.4 The fire-fighting system shall be on an independent circuit and shall not be jeopardized by the failure of the ancillary systems.

4.4.5 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 0°C (32°F) of the engine-starting battery system.

4.4.5.1 The battery charger shall be supplied from an external power source of 115 volts or 220 volts ac.

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

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

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

4.4.5.5 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.

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

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

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

4.4.7 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.

4.5 Vehicle Drive. Transmission of power from the engine to the wheels of the vehicle shall be through an automatic or a semi-automatic gearbox.

4.5.1 The entire drivetrain 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.

4.5.2 The transmission shall be matched to the engine properly and shall be approved for the application.

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

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

4.5.4.1 Positive drive either shall be permitted to be achieved 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.

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

4.5.5 All-Wheel Drive.

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

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

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

4.5.7 Axle Capacity.

4.5.7.1 Front and rear axles shall have adequate capacity to carry the maximum imposed load under all intended operating conditions.

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

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

(1) Travel at the specified speeds over improved surface
(2) Travel at moderate speeds over unimproved surface
(3) Provide diagonally opposite wheel motion above ground obstacles without raising the remaining wheels from the ground, in accordance with Table 4.1.1(a) and Table 4.1.1(b)
(4) Prevent damage to the vehicle caused by wheel movement

4.7 Rims, Tires, and Wheels.

4.7.1 Vehicles shall be required to meet the specified paved surface performance while still providing off-pavement performance compatible with the conditions encountered at the operational airport, and tires shall be selected accordingly.

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

4.7.3 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.

4.7.4 Vehicle and tire manufacturers shall be consulted for the tread design most suitable for the specific soil composition at individual airports. Only new tires shall be mounted on the vehicles; retreads shall not be permitted.

4.7.5 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. This requirement shall not apply to vehicles with a capacity of up to 500 gallons.

4.7.6 Rims, tires, and wheels shall be certified by their respective manufacturers as having sufficient capacity to meet the specified performance and shall be certified for not less than 42.9 km (25 mi) of continuous operation at 96.5 kph (60 mph) when inflated at the normal operational pressure.

4.8* 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.

4.9 Brakes.

4.9.1* 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. An ABS braking system shall be provided on the vehicle.

4.9.2* 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.

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

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

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

4.9.2.4 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 1.2 m (4 ft) without any part of the vehicle leaving the roadway.

4.9.2.5 For each vehicle, the service brakes shall provide one power-assisted stop while the vehicle engine is inoperative for the stopping distances specified in 4.9.2.2 through 4.9.2.4.

4.9.3 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 87.8 m (288 ft) at 64.4 kph (40 mph) without any part of the vehicle leaving a dry, hard, approximately level roadway that has a width equal to the vehicle width plus 1.2 m (4 ft).

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

4.9.5 Brakes — Air System.

4.9.5.1 Where the vehicle is supplied with air brakes, the air compressor shall meet the following criteria:

(1) The compressor shall be engine driven.
(2) The compressor shall have sufficient capacity to increase air pressure in the supply and service reservoirs from 586.1 kPa to 689.5 kPa (85 psi to 100 psi) when the engine is operating at the vehicle manufacturer's maximum recommended revolutions per minute (rpm) in a maximum of 25 seconds.
(3) The compressor shall have the capacity for quick buildup from 0 kPa (0 psi) to release spring brakes, and this buildup in pressure shall be accomplished within 15 seconds.
(4) The compressor shall incorporate an automatic air-drying system immediately downstream from the compressor to prevent condensation buildup in all pneumatic lines.

4.9.5.2 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 12 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:

$$\frac{\text{actual reservoir capacity} \times 25}{\text{required reservoir capacity}} = \text{buildup time}$$

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

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

4.9.5.5 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.

4.10 Steering.

4.10.1 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.

4.10.2 The power steering system shall have sufficient capacity so that no more than 66.7 N (15 lbf) 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.

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

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

4.11.1 The cab shall be fully enclosed (i.e., floor, roof, and four sides). 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. Three-point seat belts equipped with a single hand hookup 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. Each door shall be equipped with a sufficient restraint device(s) to prevent the door from being sprung by wind or jet blast. 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.

4.11.2 The cab shall meet the visibility requirements of 4.2.2.3. 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 primary turret having manual controls above the cab roof, the cab shall be designed with a quick-access passage to the primary turret(s).

4.11.3 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 80.5 kph (50 mph) on a level, hard surface without warning devices operating; and while stationary, discharging water or foam from the high-volume turrets with exterior 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.

4.11.4 Instruments, Warning Lights, and Controls.

4.11.4.1 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.

4.11.4.2* All instruments and controls shall be illuminated, and backlighting shall be used where practical.

4.11.4.3 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.

4.11.4.4 The following instruments or warning lights, or both, shall be provided as a minimum:

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

In 4.11.4.4(4), (6), (7), (8), and (9), this component shall not be applicable to small commercial chassis.

4.11.4.5 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:

(1) Accelerator pedal
(2) Brake pedal
(3) Parking brake control
(4) Steering wheel, with directional signal control and horn
(5) Transmission range selector
(6) Pump control or selector
(7) Foam control
(8) Siren switch(es)
(9) Bumper turret controls or ground sweep valve control, where specified
(10) Undertruck valve control, where specified
(11) Remote turret controls, where remote turret is provided
(12) Light switches

(13) Windshield wipers with delayed and multispeed capability and washer controls
(14) Heater/defroster controls
(15) Master electrical switch
(16) Means of starting and stopping engine
(17) Complementary agent pressurization control, where specified
(18) Windshield deluge system switch, where specified

4.11.4.6 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.

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

4.11.4.7.1 The ARFF vehicle's position shall be displayed on a moving map display that shall be mounted in the cab. The vehicle's position shall be displayed within an accuracy of 2 m (6.56 ft), as well as the direction of travel. The map shall automatically pan and reorient itself to show the area around the vehicle.

4.11.4.8 A low visibility enhanced vision system shall be installed in the vehicle. This system shall consist of a FLIR camera, monitor, and controlling devices, and shall provide the operator with a thermal image to provide assistance in driving under low-visibility conditions.

4.11.4.8.1 The FLIR shall have automatic gain and level controls and minimum horizontal (HFOV) and vertical fields of view (VFOV) of 12 degrees and 6 degrees, respectively. The FLIR shall be permitted to be a cooled or uncooled camera but shall be able to detect long waft (8 μm to 12 μm) infrared (IR) energy and have industry standard output.

4.11.5 Equipment.

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

(1) Heater/defroster
(2) Driver's suspension seat with vertical, fore and aft adjustment, with seat belt (The use of a nonsuspension driver's seat shall be permitted where recommended by the manufacturer.)
(3) Crew seats with individual retractable seat belts
(4) Windshield washers appropriate for removing foam
(5) Windshield wipers appropriate for removing foam
(6) Siren
(7) Horn
(8) Sun visors, interior transparent
(9) Outside rearview mirrors, as specified in 4.2.2.4
(10) Interior lighting
(11) Provisions for mounting self-contained breathing apparatus (SCBA) of the type specified by the purchaser at each crew seat position
(12) Low-visibility forward looking infrared device meeting suggested specifications contained in Section E.4 or equivalent

4.11.5.2 Where tools, equipment, or self-contained breathing apparatus (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.

4.11.6 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.

4.11.7* Where specified, a monitoring and data acquisition system (MADAS) shall be installed for the collection of various performance measurements to monitor, as a minimum, the following:

(1) Vehicle speed
(2) Vehicle heading
(3) Lateral acceleration
(4) Vertical acceleration
(5) Longitudinal acceleration and deceleration
(6) Engine rpm
(7) Throttle position
(8) Steering input
(9) Vehicle braking input (pedal position and brake pressure)
(10) Date, time, and location for all data collected

4.11.7.1 The data acquisition system shall be capable of storing the measurements and the time intervals, starting at least 120 seconds before and ending at least 15 seconds after any serious incident. The system shall be designed so that the data being recorded will not be lost or overwritten immediately after the incident due to the use of an emergency shut-off or a master electrical disconnect switch.

4.11.8* A lateral acceleration indicator that is adjustable for sensitivity and that provides both visual and audio signals and warnings to the driver shall be provided.

4.12 Body.

4.12.1 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.

4.12.2 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:

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

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

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

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

4.12.5 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.

4.12.6 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 be constructed of, or covered with, a slip-resistant material. The lowermost step(s) shall be no more than 558.8 mm (22 in.) above level ground when the vehicle is fully loaded. Adequate lighting shall be provided to illuminate steps and walkways.

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

4.12.8 Vehicle numbering, lettering, and minimum 20.3-cm (8-in.) wide reflective striping shall be provided in accordance with ASTM D 4956, *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.

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

4.12.9 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.

4.12.10* Each storage compartment identified by the vehicle manufacturer for use by the purchaser shall be labeled with tested weight. Compartment loading shall not be exceeded as identified at the time of vehicle manufacture. 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. Altering locations of tools and equipment will have an effect on vehicle stability.

4.13 Fire-Fighting Systems and Agents.

4.13.1 For aircraft rescue and fire-fighting purposes, vehicles using primary extinguishing agents shall be tested in accordance with NFPA 412, *Standard for Aircraft Rescue and Fire-Fighting Foam Equipment*.

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

4.13.3 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 complementary agent.

4.14 Agent Pump(s) and Pump Drive.

4.14.1 Agent Pump(s).

4.14.1.1 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.

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

4.14.1.3 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, handline nozzles, and undertruck nozzles, where specified, discharging simultaneously at designed pressures.

4.14.2 Pump Drive.

4.14.2.1 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.

4.14.2.2 While pumping at rated capacity, the drive shall allow controlled vehicle operation at speeds from 0 kph to a minimum of 16.1 kph (0 mph to a minimum of 10 mph) in forward direction and 0 kph to a minimum of 8 kph (0 mph to a minimum of 5 mph) in rearward direction. During shifting from forward to rearward drive, the pumping system shall maintain the preset discharge pressure. The pump(s) drive shall have sufficient power capacity to provide the pump(s) discharge requirements of 4.14.1.3 while the vehicle is being propelled under all operating conditions where a fire-fighting capability is needed.

4.14.2.3 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 4.3.2.

4.14.3 Tank to Pump Connections.

4.14.3.1 The tank to pump system shall be designed for efficient flow at the pumping rates required by 4.14.1.3. 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. Tank to pump lines and valves shall be constructed of corrosion-resistant materials.

4.14.3.2 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.

4.14.4 Discharge Connections. All discharge couplings shall be the standard for the airport.

4.14.5 Piping, Couplings, and Valves.

4.14.5.1 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.

4.14.5.2 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.

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

4.14.5.4 All water system piping shall be tested on the tank to pump 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.

4.14.6 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 discharge. The overheat protection system shall be automatic and operate an audible and visual alarm.

4.14.7 Pressure Relief Valves. A pressure relief system shall be provided to protect and ensure optimum performance of the system.

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

4.15 Water Tank.

4.15.1 Capacity.

4.15.1.1 A water tank shall have a usable capacity as specified in Table 4.1.1(a) and Table 4.1.1(b).

4.15.1.2 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:

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

4.15.2 Construction.

4.15.2.1 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.

4.15.2.2 The tank shall be equipped with easily removable manhole covers over the tank discharge. Tanks shall be designed to allow for internal and external inspection and service. A large capacity drain connection shall be installed at the bottom of the sump.

4.15.2.3 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.

4.15.2.4 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.

4.15.2.5 The water tank shall be equipped with at least one top fill opening of not less than 20.3 cm (8 in.) internal diameter. The top fill shall be equipped with an easily removable strainer of 6.4-mm (¼-in.) mesh construction. The top fill opening shall be equipped with a cap designed to prevent spillage.

4.15.2.6 For vehicles less than 1998.5 L (528 gal), the water tank shall be equipped with at least one top fill opening of not less than 127 mm (5 in.) internal diameter.

4.15.3 Tank Fill Connection(s).

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

4.15.3.2 All couplings shall have the standard for the airport.

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

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

4.16* Foam System.

4.16.1 Foam-Liquid Concentrate Tank(s).

4.16.1.1 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*.

4.16.1.2 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.

4.16.1.3 Tanks shall be designed to allow for internal and external inspection and service. A large capacity drain connection shall be installed at the bottom of the sump.

4.16.1.4 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 4.16.4 and with the vehicle discharging two tank loads of usable water as specified in 4.15.1.

4.16.1.5 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.

4.16.1.6 A top fill trough shall be provided and shall be equipped with a mesh screen constructed of non-corrosive materials and container openers to allow emptying 18.9-L (5-gal) 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.

4.16.1.7 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 6.4-mm (¼-in.) 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.

4.16.1.8 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.

4.16.1.9 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.

4.16.2 Foam-Liquid Concentrate Pump.

4.16.2.1 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.

4.16.2.2 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.

4.16.3 Foam-Liquid Concentrate Piping.

4.16.3.1* 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.

4.16.3.2 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.

4.16.4 Foam Proportioning Systems.

4.16.4.1 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.

4.16.4.2 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*.

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

4.17 Premixed Foam Solutions.

4.17.1 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 aqueous film-forming foam (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 Sections 4.14 and 4.15.

4.17.2 Premixed — Pressurized System.

4.17.2.1 Liquid Agent Container(s).

4.17.2.1.1 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.

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

4.17.2.1.3 An American Society of Mechanical Engineers (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.

4.17.2.1.4 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 76.2 mm (3 in.) in diameter. Filling shall be accomplished without the removal of any of the extinguisher piping or any major component.

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

4.17.2.2 Propellant Gas.

4.17.2.2.1 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.

4.17.2.2.2 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.

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

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

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

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

4.17.2.3 Pressure Regulation.

4.17.2.3.1 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).

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

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

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

4.17.2.4 Piping and Valves.

4.17.2.4.1 All propellant piping and fittings shall conform to the appropriate ASME document 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.

4.17.2.4.2 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.

4.17.2.4.3 Drains shall be provided to allow complete draining of the system.

4.17.2.4.4 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. Valves on the gas cylinder specified in 4.17.2.2.2 shall not be required to be of the quarter-turn, quick-opening ball type.

4.17.2.4.5 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.

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

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

4.18 Turret Nozzles.

4.18.1 Aircraft rescue and fire-fighting vehicles shall have one or two primary turret nozzles.

4.18.2 Turret nozzles with liquid flow rates of 2839 L/min (750 gpm) or more shall be of the dual discharge type and arranged to allow selection of either 50 percent or 100 percent of the turret capacity. The primary turret discharge rates shall have a tolerance of +10 percent/−0 percent.

4.18.3 If a turret is visible from the operator's position, an elevation and azimuth indication shall not be required.

4.18.4 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 133.4 N (30 lbf), and an indication of turret elevation and asimuth shall be provided. Where a power-assisted turret is specified, controls shall be in the cab, operation forces shall be less than 133.4 N (30 lbf), an indicator of turret elevation and azimuth shall be provided, and, where specified, a manual override of all roof turret movement functions shall be provided in the cab. The manual override operation force shall be less than 133.4 N (30 lbf). Where turret control is at the platform, operation forces shall be less than 222.4 N (50 lbf).

4.18.5 Turrets shall be capable of being elevated at least 45 degrees above the horizontal and shall be depressed to discharge agent within 9.1 m (30 ft) 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 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. Turret controls for both foam and dry chemical turrets shall be accessible both to the driver and the crew member.

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

(1) It shall comply with Chapter 18 of NFPA 1901, *Standard for Automotive Fire Apparatus*, and shall meet the requirements of 4.2.1.3 and 4.2.1.4 of this standard while in the stowed position. The vehicle 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. Flow rates shall be in accordance with Table 4.1.1(c) and Table 4.1.1(d) for major vehicles.
   (a) It shall meet the primary water-foam agent turret discharge requirements of Table 4.1.1(c) and Table 4.1.1(d) for the applicable vehicle class while in bedded position.

(b) It shall meet the foam quality standard of NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*, for the applicable foam applicator and foam type.

(c) It shall function during ARFF operations without the need for outriggers or other ground contact stabilizers that would render the vehicle immobile or hinder its maneuverability.

(d) It shall achieve the elevation and reach needed to service the highest engine for the type of aircraft being protected and shall start application within 30 seconds of activation of the deployment cycle. The high rise, telescoping, and/or articulating movement of the boom/tower shall be accomplished with not more than two adjacent lever controls and shall be permitted to be manual or automated for preselected positioning of the elevation and reach. If automated, these functions shall be provided with a manual override positioning capability.

(e) It shall be capable of applying agent to any interior area of the most current wide-body jet, so as not to impede evacuation and for safety considerations of the vehicle operator. In addition, the device shall be capable of positioning the nozzle within 0.6 m (2 ft) of ground level in front of the vehicle and be capable of applying agent to the interior of the aircraft through cargo bay door openings, passenger doorways, and emergency exits on the type of aircraft being protected while the aircraft is in either the gear-up or gear-down landing position.

(f) It shall have a range of motion so as to permit positioning of the nozzle to direct a fire-fighting agent stream at least 90 degrees to the longitudinal axis of the fuselage for interior fire extinguishment.

(g) The turret/boom mechanism shall be capable of providing for horizontal movement along the aircraft of at least 30 degrees left and right of the vehicle centerline so as not to require repositioning or movement of the ARFF vehicle. This horizontal rotation must be accomplished without the deployment of stabilizers or outriggers that might cause a delay in positioning or emergency movement of the rescue vehicle.

(h) It shall have sufficient back-up systems to allow for override of the single lever boom control and hydraulic system (or other power source) if the primary system becomes disabled.

(2) If specified by the purchaser as the primary water/foam and dry chemical turret — that is, to function as a dual agent turret system — the device shall also be capable of meeting the agent discharge performance of Table 4.1.1(c) and Table 4.1.1(d) while in the bedded position.

(3) An adjustable or dual flow rate nozzle shall be provided that will allow flow rates and patterns suitable for interior aircraft fire fighting *[see Table 4.1.1(c) and Table 4.1.1(d)]*.

(4) Controls for the extendable turret and options shall be as specified. Where specified, it shall be fitted with accessories and devices needed for a driver or another operator to remotely perform the interior aircraft and highest engine fire-fighting functions.

(a) Where auxiliary agent lines are specified, they shall be capable of discharging either dry chemical or halocarbon agent or approved equivalent through an appropriate nozzle while the device is extended out and up to its maximum operational reach. It shall meet the minimum auxiliary agent flow rate and pattern requirements of Table 4.1.1(c) and Table 4.1.1(d).

(b) Where remote color optics are specified, they shall be capable of sufficient resolution to permit overall fire scene surveillance when fully extended and to provide the driver/operator with the detail needed for placement of the penetration device on the aircraft hull for proper piercing. The camera and associated lighting shall be designed and installed for exterior environmental operating conditions normally encountered by ARFF vehicles. A monitor 178 mm (7 in.) or larger shall be cab-mounted in a roadworthy manner and shall be readily accessible to the driver/operator.

(5) Where a skin penetrator/agent applicator is specified, it shall be movable in conjunction with the water/foam nozzle to allow proper placement of the nozzle control. Where a skin penetrator/agent applicator is specified, it shall be capable of the minimum water/foam flow rate and pattern requirements of Table 4.1.1(c) and Table 4.1.1(d).

(6)*The penetrating nozzle shall be capable of a minimum flow rate of 946 L/min (250 gpm). The nozzle system shall be constructed to direct or spray agent and water on both sides of the aircraft at the same time after the penetration is made. [Concept-delivery shall be multiple holes causing a spray to cover 7.6 m to 9.1 m (25 ft to 30 ft) each side of the aircraft interior and aircraft aisleway.] From a bedded position, penetration and agent discharge shall take place 20 seconds after positioning the vehicle at the aircraft fuselage and providing water to the floor and ceiling levels beyond the overhead storage bin area.

4.19 Preconnected Handlines. Preconnected handlines shall be those handlines for discharging water or foam, or both, that are specified by the purchaser as intended for use as primary ARFF equipment. All other handlines that are installed on the vehicle shall not be considered as being preconnected handlines.

4.19.1 Combined agent vehicles shall have at least one preconnected handline and nozzle for each agent. Handlines and nozzles shall be permitted to be separate or twinned together for simultaneous agent discharge. Handlines shall be permitted to be reeled handlines as specified in Table 4.1.1(a), Table 4.1.1(b), Table 4.1.1(c), and Table 4.1.1(d).

4.19.2 Each preconnected handline compartment shall be located so that the distance between the handline nozzle and the ground, step, or surface upon which the operator stands to initiate the pulling of the handline from the reel or top layer of collapsible hose is not more than 1.8 m (6 ft) above the surface.

4.19.3 Preconnected Reeled Handlines and Nozzles.

4.19.3.1 Handlines for reels shall have a minimum burst rating three times the nominal working pressure of the system and shall be able to discharge the flow required in Table 4.1.1(c) and Table 4.1.1(d) without unreeling the hose.

4.19.3.2 Each handline shall be equipped with a pistol grip shutoff-type nozzle designed to discharge both foam and water in accordance with the performance criteria in Table 4.1.1(c) and Table 4.1.1(d) and shall meet the requirements of NFPA 1964, *Standard for Spray Nozzles (Shutoff and Tip)*.

4.19.3.3 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 to the person using the hose reel.

4.19.3.4 The discharge control to each handline shall be adjacent to the handline and accessible to the person using the handline.

4.19.4 Preconnected Collapsible Handlines and Nozzles.

4.19.4.1 Collapsible handlines shall meet the requirements of NFPA 1961, *Standard on Fire Hose*, and Table 4.1.1(c) and Table 4.1.1(d).

4.19.4.2 Each handline shall be equipped with a pistol grip shutoff-type nozzle designed to discharge foam and water in accordance with the performance criteria in Table 4.1.1(c) and Table 4.1.1(d) and shall meet the requirements of NFPA 1964, *Standard for Spray Nozzles (Shutoff and Tip)*.

4.19.4.3 Hose storage areas shall be fabricated from noncorrosive material and shall be designed to drain effectively. The storage area 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.

4.19.4.4 The discharge control to each handline shall be adjacent to the handline and accessible to the person using the handline.

4.20 Turret, Ground Sweep, and Undertruck Nozzles.

4.20.1 Where a bumper turret or ground sweep nozzle(s) is provided, the controls shall be mounted inside the cab within easy reach of the driver and a crew position. Where the extendable, or boom, turret is capable of supplying agent as specified as a primary turret, as a bumper turret, or as a ground sweep nozzle(s), the requirement for a bumper turret or ground sweep nozzle(s) shall be permitted to be omitted at the option of the purchaser.

4.20.2 The turret shall have a horizontal rotation of 180 degrees and vertical travel of +45 degrees/−20 degrees.

4.20.3 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.

4.20.4 Turrets, handlines, 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.

4.21* Complementary Agent System. Where specified, the vehicle shall be equipped with a complementary agent system using either dry chemical (potassium bicarbonate) or halogenated agent.

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

4.21.1.1 All piping and fittings shall conform to the appropriate ASME, or equivalent, 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.

4.21.1.2 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.

4.21.1.3 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.

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

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

4.21.1.6 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.

4.21.1.7 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 handline.

4.21.2 Propellants.

4.21.2.1 The propelling agent shall be dry nitrogen, dry air, argon, or carbon dioxide.

4.21.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. DOT requirements or regulations or equivalent. Cylinders shall bear the DOT marking or equivalent markings.

4.21.2.3 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 allow the complete purging of all piping and hose lines after each use.

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

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

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

4.21.3 Pressure Regulation.

4.21.3.1 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).

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

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

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

4.22 Halogenated Agent.

4.22.1 Halogenated Agent Container.

4.22.1.1 The storage container shall be designed for pressurization and shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code*, or equivalent, and shall be so marked.

4.22.1.2 The material of construction shall be resistant to corrosion by the halogenated agent to be stored.

4.22.1.3 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.

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

4.22.2 Propellant Gas.

4.22.2.1 The propellant gas shall be provided in sufficient quantity to expel the halogenated agent as well as to purge all piping and hose lines after use.

4.22.2.2 All propellant gas cylinders and valves shall be in accordance with U.S. DOT, or equivalent, requirements or regulations. Cylinders shall bear the DOT marking or equivalent markings.

4.22.2.3 Pipes and valves connected to the halogenated agent container shall conform to the appropriate ASME, or equivalent, code and shall be designed to withstand the working pressure of the system.

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

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

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

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

4.22.3 Pressure Regulation.

4.22.3.1 An ASME, or equivalent, 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.

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

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

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

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

4.22.4 Halogenated Agent Delivery Piping and Valves.

4.22.4.1 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.

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

4.22.4.3 All discharge piping shall be tested at 50 percent above the system operating pressure.

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

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

4.22.4.6 A quick-acting control to be operated by the driver to pressurize the halogenated agent system from the cab of the vehicle shall be provided, with a similar control at the handline.

4.23 Dry Chemical Turret.

4.23.1 Auxiliary Agent Discharge. Where specified, a turret shall have an auxiliary agent discharge mounted parallel to the foam solution discharge, or entrained within the foam solution discharge stream and controlled the same way and with the same travel requirements as the turret.

4.23.1.1 The dry chemical turret performance shall be in accordance with Table 4.1.1(c) and Table 4.1.1(d).

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

4.23.2 Complementary Agent Handlines.

4.23.2.1 Handlines for complementary agents shall have a minimum burst pressure rating three times the nominal working pressure of the system and in accordance with the performance criteria in Table 4.1.1(c) and Table 4.1.1(d). The complementary agent handline shall be equipped with a nozzle that allows a fully open to a fully closed position in a single, simple movement. Nozzle construction shall be of nonferrous metal or stainless steel.

4.23.2.2 Twinned handlines and nozzles shall be designed so that each agent can be discharged separately or simultaneously, parallel to or entrained with the water stream. The barrels shall be linked together to provide coordinated application by one operator.

4.23.2.2.1 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 to the person using the hose reel.

4.23.2.2.2 The discharge control to each handline shall be adjacent to the handline and accessible to the person using the handline.

4.24 Lighting and Electrical Equipment.

4.24.1* Lighting equipment shall be installed in conformity with local road regulations, where practicable, and shall include the following:

(1) Headlights with upper and lower driving beams. A control switch that is readily accessible to the driver shall be provided for beam selection.
(2) In addition to dual taillights and dual stop lights, a minimum of one additional stop light located high up on the rear of the vehicle.
(3) Self-canceling turn signals, front and rear, with a steering column–mounted control and a visual and audible indicator. A four-way flasher switch shall be provided.
(4) Adequate reflectors and marker and clearance lights furnished to describe the overall length and width of the vehicle.
(5) Engine compartment lights, nonglare type, arranged to illuminate both sides of the engine, with individual switches located in the engine compartment. Service lighting shall be provided for all areas described in 4.12.2(1), (2), and (3), as well as for the engine compartment.
(6) Lighting for all top deck working areas.
(7) At least one backup 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.

4.24.2* A warning siren shall be provided that has a sound output of not less than 95 dBA at 30.5 m (100 ft) when measured directly ahead of the siren and not less than 90 dBA at 30.5 m (100 ft), 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. The siren unit shall consist of the following functions as minimum public address, wail, and yelp. A selector switch shall be mounted within reach of the driver that will allow the operation of the vehicle's horn or the siren from the horn button in the steering wheel.

4.24.3 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.

4.24.4 Exterior Emergency Warning Lights.

4.24.4.1 A master switch for all exterior emergency warning lights shall be provided in the cab within easy reach of the driver.

4.24.4.2 Emergency warning light(s) shall be mounted on the top of the vehicle and shall be visible for 360 degrees in a horizontal plane. The mounting of the emergency warning light(s) shall also provide good visibility from the air. The purchaser shall provide the vehicle manufacturer with the proper color of the light(s) and indicate whether the emergency warning lights shall be of the rotating beacon type or the strobe type.

4.24.4.3 Two alternating flashing emergency warning lights shall be mounted at the rear of the vehicle as far apart as practical. These lights shall not be mounted any higher than 1828.8 mm (72 in.) above the ground level. The purchaser shall provide the vehicle manufacturer with the proper color of the light and indicate whether the emergency warning lights shall be of the sealed beam type or the strobe type.

4.24.4.4 Two alternating flashing emergency warning lights shall be mounted at the front of the vehicle as far apart as practical. These lights shall not be mounted any higher than 1828.8 mm (72 in.) above the ground level. The purchaser shall provide the vehicle manufacturer with the proper color of the light and indicate whether the emergency warning lights shall be of the sealed beam type or the strobe type.

4.24.4.5 The complete emergency warning light system shall require no more than a combined total of 12 volt 40 amps or equivalent for other voltages.

4.24.5 Radios.

4.24.5.1 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.

4.24.5.2 The purchaser shall specify all necessary radios and frequencies that are to be provided.

4.24.6 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.

4.25 Application. Where any part of a line voltage electrical system is provided as a fixed installation, the applicable requirements of this chapter shall apply.

Chapter 5 Acceptance Criteria

5.1 General.

5.1.1 Compliance with the requirements of this standard shall be verified by the following methods:

(1) The component manufacturer's certification
(2) Prototype vehicle tests
(3) Operational tests

5.1.2 The component manufacturer's certification shall be provided where specified in Section 5.2. The manufacturer shall certify that the component is approved for use in the ARFF application.

5.1.3 Prototype vehicle tests shall be conducted by the manufacturer in accordance with the standardized procedures found in Section 5.3 to ensure that the performance requirements have been achieved with the design. Calculated performance capability shall not be substituted for an actual prototype test.

5.1.4 Operational tests shall be performed either at the airport or the manufacturer's facility as specified in Section 5.4. The test shall be conducted by the manufacturer on every vehicle built.

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

5.2 Component Manufacturer's Certification.

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

(1) Engine
(2) Transmission
(3) Axles
(4) Transfer case
(5) Wheels
(6) Tires
(7) Handline hose with couplings attached
(8) Premixed storage container
(9) Premixed system pressure relief valve
(10) Propellant gas cylinder
(11) Propellant gas cylinder regulating device
(12) Complementary agent storage container
(13) Complementary agent pressure relief device

5.2.2 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.

5.2.3 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.

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

(1) Total reservoir capacity
(2) Total required volume (12 times the total combined brake chamber volume at full stoke)
(3) Quick buildup system capacity
(4) Quick buildup system pressure needed to release the spring brakes

5.3 Prototype Vehicle Tests. Where the vehicle is fitted with an extendable turret *(see 3.3.64.1)*, the test shall be conducted with the extendable turret in the stowed position.

5.3.1 Rated Water/Foam Tank Capacity Test.

5.3.1.1 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.

5.3.1.2 Test equipment shall consist of the following:

(1) A calibrated sight gauge
(2) A liquid volume measuring device accurate to within ± 1.0 percent
(3) Alternative: A stopwatch and a scale capable of measuring the total vehicle weight accurate to within ± 1.0 percent

5.3.1.3 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.

5.3.1.4 The rated water and foam tank capacity shall be determined as follows:

(1) Park the vehicle on level ground.
(2) If necessary, attach a calibrated site gauge to both the water tank and the foam tank.
(3) Fill the water piping up to a level even with the bottom of the tank. Do not record the water quantity used.
(4) While filling both tanks with a liquid volume measuring device, correlate and record the amount of water added to each tank with the site gauge calibrations. When the tanks are filled to the top, record the total liquid capacity for each tank.
(5) Alternative: After completion of (3), record the weight of the vehicle. Fill the water tank and foam tank and record the weight of the vehicle.
(6) Add dye to the foam tank.
(7) Set the agent system to discharge at the specified foam solution rate, and adjust the system discharge pressure to the recommended pressure.
(8) Starting with tanks that are completely full, discharge at maximum rate through the primary turret(s) until the agent pump(s) shows a drop in discharge pressure, and then stop immediately. Verify that dye is apparent in the discharge stream throughout the test. Record the discharge time if using the weight measurement method.
(9) Alternative: Record the weight of the vehicle after discharging. Calculate the pump-out capacity of the water tank using the weight of the water plus the foam discharged, the foam proportioning rate as verified in 5.3.1.3, and the discharge time.
(10) Measure the amount of liquid remaining in both tanks and convert to gallons using the conversion established in 5.3.1.4(5). Subtract the amount remaining from the total capacity to determine the amount pumped out. Record the total amount of liquid pumped out of the tanks.
(11) Refill the water tank only (not the foam tank). Discharge the water tank as in 5.3.1.4(8). Verify that dye is apparent throughout the test. Measure and record the additional amount of liquid discharged from the foam tank. Fill the water tank and discharge as many times as necessary to eliminate all usable liquid from the foam tank.
(12) Total and record the amount of liquid discharged from the foam tank from the time of initial fill.
(13) Refill both tanks and repeat 5.3.1.4(6) through (11) with the vehicle parked in the attitudes listed in 5.3.1.4(13)(a) through (d). After pumping on a slope, with the vehicle in each of the four slope conditions, return the vehicle to level ground to measure the water volume discharged.
    (a) A 20-percent side slope, left side up
    (b) A 20-percent side slope, right side up
    (c) A 30-percent slope, ascending
    (d) A 30-percent slope, descending
(14) Divide the volume of liquid discharged from each tank on the four slope conditions by 0.75 and record.

5.3.1.5 The rated or usable water tank capacity shall be the lesser of the volumes calculated in 5.3.1.4(10) or 5.3.1.4(14). The rated or usable foam tank capacity shall be the lesser of the volumes calculated in 5.3.1.4(12) or 5.3.1.4(14).

5.3.2 Cornering Stability.

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

5.3.2.2 A calibrated speedometer and a means of indicating steering wheel angle shall be required.

5.3.2.3 The vehicle shall be tested in its fully loaded condition. *(See 3.3.71.)*

5.3.2.4 A speed as outlined in Table 4.1.1(a) shall be obtained and maintained for one full revolution of the circle in accordance with SAE J2181, *Steady State Circular Test Procedures for Trucks and Buses*, as follows:

(1) Slowly drive the vehicle around the 30.5-m (100-ft) radius circle while keeping the centerline of the front of the vehicle directly over the marked line.
(2) Establish a reference position on the steering wheel position indicator at a slow speed.
(3) Gradually increase the speed until the maximum safe speed, as judged by the driver, is reached.
(4) Record the maximum speed and the corresponding position of the steering wheel.
(5) Repeat (1) through (4) while driving the vehicle in the opposite direction.

5.3.2.5 The speed achieved shall be greater than 35 kph (22 mph) for all classes of vehicles, and the steering angle shall not decrease with increasing speed. The truck shall not have oversteer or understeer characteristics in this test.

5.3.2.6 A double lane change test shall be conducted in accordance with NATO AVTP 03-160W. The vehicle shall be driven through the cones at a 40 kph (25 mph) speed without loss of control or vehicle stability in two directions. The vehicle shall not display oversteer or understeer characteristics. This test shall be accomplished for all prototype first article vehicles only. The vehicle shall be fully loaded and equipped for this test.

5.3.3 Vehicle Dimensions.

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

5.3.3.2 Test equipment shall consist of a tape measure and a protractor.

5.3.3.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* with tires inflated to their recommended operating pressure.

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

(1) Angle of approach
(2) Angle of departure
(3) Interaxle clearance angle
(4) Underbody clearance
(5) Underaxle clearance

5.3.3.5 Linear dimensions shall be rounded down to the nearest 12.7 mm (½ in.), and angular dimensions shall be rounded down to the nearest ½ degree and compared against the vehicle specifications.

5.3.4 Driver Vision Measurement.

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

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

5.3.4.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* with tires inflated to their recommended operating pressure.

5.3.4.4 The driver's vision shall be determined as follows:

(1) Adjust the driver's seat to its mid position with respect to height, weight, and fore and aft adjustments.
(2) Place a suitable structure on the seat cushion for locating an eye height of 806.5 mm (31¾ in.) and a position 304.8 mm (12 in.) forward from the seat back. Place the seat back in a vertical position.
(3) Establish the features that limit the upward and downward line of vision that are located directly in front of the driver's seat.
(4) Measure and record the angle above the horizon at which upward vision is obstructed from the eye height point established in (2).
(5) Establish the lowest possible line of vision below the horizon directly in front of the eye height point and project this line forward of the cab until it intersects with the ground. Project this line of vision by using a light beam, or, if the windshield is removed, use a string line. Measure and record the distance from this intersection with the ground and the front face of the bumper at the front of the truck.
(6) Stretch a line from the eye height point laterally across the cab in order to establish and record the 90-degree line of vision to the left and right of the straight ahead position. Note obstructions within these angles.

5.3.4.5 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.

5.3.5 Pump and Roll on a 40-Percent Grade.

5.3.5.1 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 drawbar pull.

5.3.5.2 Test equipment shall consist of the following:

(1) A calibrated speedometer
(2) A vehicle equipped pump pressure gauge
(3) A load cell accurate to within ± 227 kg (± 500 lb) (applicable only to the alternate drawbar method)
(4) A variable load dynamometer sled (applicable only to the alternate drawbar method)

5.3.5.3 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 3.3.71)* with tires inflated to their recommended operating pressure.

5.3.5.4 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 drawbar test as follows:

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

(2) Set the agent system to discharge in the foam mode, and set the system discharge pressure for optimum performance.
(3) Position the vehicle at the bottom of a 40-percent grade and initiate discharge at full output through the primary turret nozzles. Verify that dye is apparent in the discharge stream throughout the test.
(4) Initiate the vehicle's ascent of the grade and achieve a speed of at least 1.6 kph (1 mph). During the ascent, bring the vehicle to a stop and resume the ascent at a speed of at least 1.6 kph (1 mph) without interruption in the discharge stream. Record the vehicle speed and any variation in discharge pressure.
(5) If an actual 40-percent grade is not available, repeat 5.3.5.4(1) through (4) with the vehicle coupled to a 40-percent grade equivalent drawbar load determined as follows:
   (a) A 40-percent grade — 21.8-degree angle.
   (b) The loaded vehicle weight × sin 21.8 degrees (0.371) equals the necessary drawbar pull to simulate ascending a 40-percent grade.
   (c) The area of the load cell can be determined at the time of the test.
   (d) The load cell reading, in kPa (psi), that simulates a 40-percent grade can be calculated by the following:

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

5.3.5.5 The vehicle shall negotiate the grade or drawbar pull smoothly while maintaining an operating pressure of at least 50 percent of the specified design pressure for the primary turret(s) at speeds of at least 1.6 kph (1 mph).

5.3.6 Electrical Charging System.

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

5.3.6.2 Test instrumentation shall consist of the following:

(1) A laboratory quality voltmeter with a scale range compatible with the design voltage of the vehicle's electrical system. The scale on the voltmeter shall be graduated to allow reading voltages with a ± 0.1-volt accuracy.
(2) 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.
(3) The tachometer installed in the vehicle.

5.3.6.3 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 10°C to 32.2°C (50°F to 90°F).

5.3.6.4 The test shall be conducted as follows:

(1) Check each battery cell to verify that voltage and specific gravity are at the battery manufacturer's specifications.
(2) Install a voltmeter to monitor the battery charge continuously during the test.
(3) 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.
(4) Record voltage and ampere readings under the following conditions:
   (a) Battery (engine off, no load).
   (b) 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.
      i. Engine at idle and all electrical loads that normally run simultaneously turned on.
      ii. Engine at 50 percent of governed speed with all electrical loads that normally run simultaneously turned on.
   (c) Engine at governed speed with all electrical loads that normally run simultaneously turned on.

5.3.6.5 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.

5.3.7 Radio Suppression.

5.3.7.1 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.

5.3.7.2 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.

5.3.7.3 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:

(1) All vehicle lighting shall be on.
(2) All heating, defrosting, and air conditioning systems shall be on with their respective fans adjusted to the maximum speed setting.
(3) Complementary power generating devices (where applicable) shall be running.
(4) Intermittent warning devices, such as hazard flashers, warning buzzers, and horns, shall be turned off.

5.3.7.4 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.

5.3.7.5 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.

5.3.8 Gradability Test.

5.3.8.1 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 drawbar pull.

5.3.8.2 Test equipment shall consist of the following:

(1) A load cell accurate to within ± 227 kg (± 500 lb) (applicable only to the alternate drawbar method)
(2) A variable load dynamometer sled (applicable only to the alternate drawbar method)

5.3.8.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71.1)* with tires inflated to their recommended operating pressure.

5.3.8.4 The capability of the fully loaded vehicle *(see 3.3.71.1)* to ascend a 50-percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 50 percent grade is not available, then the vehicle shall be coupled to a 50 percent equivalent drawbar load, determined as follows:

(1) A 50-percent grade, 26.57-degree angle
(2) The loaded vehicle weight × sin 26.57 degrees (0.447) equals the necessary drawbar pull to simulate ascending a 50-percent grade
(3) The area of the load cell determined at the time of the test
(4) The load cell reading, in kPa (psi), that simulates a 50 percent grade, calculated by the following:

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

5.3.8.5 The vehicle shall negotiate the grade or draw pull smoothly and safely.

5.3.9 Body and Chassis Flexibility Test.

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

5.3.9.2 Test equipment shall consist of two to four 355.6-mm (14-in.) ramps with flat tops large enough for the tire footprint and graduated on both sides to allow the vehicle to ascend and descend safely.

5.3.9.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* with tires inflated to their recommended operating pressure.

5.3.9.4 The vehicle shall be tested as follows:

(1) For a 4 × 4, drive the fully loaded vehicle onto 355.6-mm (14-in.) blocks positioned under the diagonally opposite front and rear wheels. For a 6 × 6, block positions correspond to axle 1 and axle 3. For an 8 × 8, block positions correspond to axle 1 and axle 4.
(2) With the vehicle in the position given in (1), take the following steps:
    (a) Inspect the vehicle thoroughly to ensure that there are no sheet-metal interferences and that all moving parts are free to function.
    (b) Demonstrate all systems to ensure that they function normally, including discharge from all orifices.
(3) For vehicles with bogie-type construction, add a block under the second wheel of the bogie axle(s) so that both wheels on one side of the bogie are elevated simultaneously and diagonally opposite front and rear, and then repeat (2)(a) and (2)(b).
(4) Switch the blocks to the opposite sides of the truck and repeat (1) through (3).

5.3.9.5 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.

5.3.10 Service/Emergency Brake Test.

5.3.10.1 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 1.2 m (4 ft) is established.

5.3.10.2 Instrumentation shall consist of the following:

(1) A calibrated fifth-wheel-type speed measuring device that is accurate to within ± 0.8 kph (± 0.5 mph) or ± 0.5 percent of the actual vehicle speed
(2) A ground speed readout device controlled by the fifth wheel
(3) A trigger device that detects brake pedal movement
(4) A strip chart recorder suitable for recording distance traveled, vehicle speed, and the point at which actuation of the brake system occurs

5.3.10.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* 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.

5.3.10.4 The service and emergency brake stopping distances shall be determined in the following manner:

(1) While traveling down the center of the lane established by the width of the vehicle plus 1.2 m (4 ft), attain a speed slightly above the desired test speed and release the throttle.
(2) With the strip chart recorder running, at the instant that the vehicle reaches the desired test speed, actuate the brake pedal as if in a panic stop and continue applying the brakes until the vehicle comes to a complete stop. While 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.
(3) Observe whether or not the vehicle leaves the established lane during the brake stop.
(4) Repeat (1) through (3) for a total of five stops from each test speed.
(5) Repeat (1) through (4) to obtain results at speeds of 32.2 kph (20 mph) and 64.4 kph (40 mph).
(6) Disable the front service brakes and repeat (1) through (4) at a test speed of 64.4 kph (40 mph).
(7) Reconnect the front service brakes and disable the rear service brakes and repeat (1) through (4) at a test speed of 64.4 kph (40 mph).

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

5.3.11 Service/Parking Brake Grade Holding Test.

5.3.11.1 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 or a level, paved test pad adequate for an extended drawbar pull.

5.3.11.2 Test equipment shall consist of the following:

(1) A load cell accurate to within ± 227 kg (± 500 lb) (applicable only to the alternate drawbar method)
(2) A variable load dynamometer sled (applicable only to the alternate drawbar method)

5.3.11.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* 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.

5.3.11.4 The capability of the vehicle's parking brake to hold the vehicle stationary on a 20 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 20 percent grade is available, the tests shall be conducted as follows:

(1) Drive the vehicle in a forward direction onto the 20 percent grade, stop, and set the parking brake.
(2) Shift the transmission to neutral, and release the service brakes and verify that there is no wheel rotation.
(3) Repeat (1) and (2) with the vehicle facing the opposite direction.

5.3.11.4.1 If an actual 20 percent grade is not available, the tests shall be conducted as follows:

(1) Drive the vehicle in a forward direction onto the 50 percent grade, apply the service brakes, and shift the transmission to neutral.
(2) Verify that there is no wheel rotation.
(3) Repeat (1) and (2) with the vehicle facing the opposite direction.

5.3.11.5 The capability of the vehicle's service brake to hold the vehicle stationary on a 50 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 50 percent grade is available, the tests shall be conducted as follows:

(1) Drive the vehicle in a forward direction onto the 50 percent grade, apply the service brakes, and shift the transmission to neutral.
(2) Verify there is no wheel rotation.
(3) Repeat (1) and (2) with the vehicle facing the opposite direction.

5.3.11.5.1 If an actual 50 percent grade is not available, the tests shall be conducted as follows:

(1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
(2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
(3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the service brakes until a 50 percent equivalent drawbar is generated. A 50 percent equivalent drawbar load is determined as follows:
    (a) A 50 percent grade, 26.57 degree angle
    (b) The loaded vehicle weight × sin 26.57 degrees (0.447) equals the necessary drawbar pull to simulate holding on a 50 percent grade
    (c) The area of the load cell determined at the time of the test
    (d) The load cell reading, in kPa (psi), that simulates a 50 percent grade, calculated by the following:

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

(4) Repeat (1) through (3) with a drawbar force applied in the rearward direction.

5.3.11.6 The capability of the vehicle's service brake to hold the vehicle stationary on a 50 percent grade shall be demonstrated either on an actual grade or by means of an equivalent drawbar pull test. If an actual 50 percent grade is available, the tests shall be conducted as follows:

(1) Drive the vehicle in a forward direction onto the 50 percent grade, apply the service brakes, and shift the transmission to neutral.
(2) Verify that there is no wheel rotation.
(3) Repeat (1) and (2) with the vehicle facing the opposite direction.

5.3.11.6.1 If an actual 50 percent grade is not available, the tests shall be conducted as follows:

(1) Drive the vehicle onto the level test pad. Shift the transmission to neutral.
(2) Couple the vehicle to the horizontal force device so that forward drawbar force can be generated. Release the parking brake.
(3) Pull the vehicle forward at a speed of at least 1.6 kph (1 mph). As the vehicle is being pulled, apply the service brakes until a 20 percent equivalent drawbar is generated. A 20 percent equivalent drawbar load is determined as follows:
    (a) A 20 percent grade, 11.31 degree angle
    (b) The loaded vehicle weight × sin 11.31 degrees (0.196) equals the necessary drawbar pull to simulate holding on a 20 percent grade
    (c) The area of the load cell shall be determined at the time of the test
    (d) The load cell reading, in kPa (psi), that simulates a 20 percent grade, calculated by the following:

$$\text{load cell reading} = \frac{\sin 11.31 \text{ degrees} \times \text{vehicle weight}}{\text{area of load cell}}$$

(4) Repeat (1) through (3) with a drawbar force applied in the rearward direction.

5.3.11.7 The brakes shall lock the wheels and hold the vehicle stationary on both the 20 percent and 50 percent grade (or the brakes shall generate an equivalent drawbar pull), with the vehicle pointed either uphill or downhill.

5.3.12 Steering Control Test.

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

5.3.12.2 Test equipment shall consist of a steering wheel and a torque meter or a spring scale.

5.3.12.3 The vehicle shall be tested in a fully loaded condition *(see 3.3.71)*, with tires inflated to their normal operating pressure.

5.3.12.4 The vehicle shall be tested as follows:

(1) Set the road wheels in the straight ahead position; engage neutral, and release the brakes, ensuring that there is no vehicle movement.
(2) With the engine at idle speed, measure and record the force applied to the steering rim that is necessary to turn the steering linkage from stop to stop.

5.3.12.5 The measured force shall not exceed the design specifications.

5.3.13 Vehicle Clearance Circle Test.

5.3.13.1 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.

5.3.13.2 A tape measure, markers or a marking device, and a calculator shall be required.

5.3.13.3 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.

5.3.13.4 The vehicle shall be tested as follows:

(1) 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.
(2) Slowly drive the vehicle in the full cramp turn.
(3) Stop the vehicle in three locations around the turning circle, applying the brake smoothly and gradually.
(4) At each stop, mark the outermost projected point of the vehicle on the ground.
(5) Measure and record the straight line distances between the marks for each of the stop locations (length 1, length 2, and length 3).
(6) Calculate the vehicle clearance circle radius *(R)* as follows:

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

where:
S = length 1 + length 2 + length 3

(7) Repeat (1) through (6) while turning the vehicle in the opposite direction.

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

5.3.14 Agent Pump(s)/Tank Vent Discharge Test.

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

5.3.14.2 Test equipment shall consist of a liquid level measuring device accurate to within ±1.0 percent.

5.3.14.3 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.

5.3.14.4 The test shall be conducted as follows:

(1) Fill the water and the foam tank to the top.
(2) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.
(3) Set the agent system pressure relief to the recommended pressure.
(4) Engage the agent pumps, and operate them at maximum pumping speed with all discharge outlets closed.
(5) Simultaneously initiate discharge of the primary turret(s), primary handlines, ground sweeps/bumper turret, and undertruck nozzles. After approximately 75 percent of the contents from the water tank has been discharged, simultaneously stop discharge through all nozzle outlets. Record the time of discharge.
(6) Measure and then add together the total amount of liquid discharged from the water tank and the foam tank. Calculate the average discharge rate using the discharge time from (5).
(7) Calculate the quantity of liquid used from the foam tank as a percentage of the total liquid discharged.

5.3.14.5 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.

5.3.15 Water Tank Fill and Overflow Test.

5.3.15.1 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 551.6 kPa (80 psi).

5.3.15.2 Instrumentation shall consist of calibrated mechanical or electronic pressure measuring devices with an accuracy of ±3 percent and a stopwatch.

5.3.15.3 The water tank shall be empty, and the water tank fill and vent system shall be fully operational for this test.

5.3.15.4 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:

(1) Park the vehicle on level ground.
(2) Attach one pressure measuring device at the inlet to the tank fill piping, and attach the other pressure measuring device to the tank body or an extension of the tank body.
(3) Simultaneously initiate flow to the tank and start the stopwatch. The water supply pressure shall be maintained at 551.6 kPa (80 psi) throughout the test.
(4) At the moment water begins to flow from the overflow piping, stop the watch and record the elapsed time.
(5) While maintaining a 551.6 kPa (80 psi) supply pressure and an overflow condition, record the internal tank pressure. After recording this pressure, shut off the water supply.

5.3.15.5 The results of this test shall be evaluated as follows:

(1) The time to fill the tank to the overflow condition shall be 2 minutes or less.
(2) The internal tank pressure shall not exceed the tank design pressure.

5.3.16 Flushing System Test.

5.3.16.1 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.

5.3.16.2 No special instrumentation shall be required for this test.

5.3.16.3 The vehicle's agent system and flushing system shall be fully operational for this test.

5.3.16.4 The vehicle's flushing system shall be tested as follows:

(1) Fill the water tank and foam tank with clean water, and add dye to the foam tank.
(2) Discharge agent through each discharge orifice on the vehicle while operating in the foam mode until dye is present in the discharge stream.
(3) Mark the liquid level in the foam tank.
(4) Set the agent system in the flush mode, and discharge through each discharge orifice until clear water is present in the discharge stream.
(5) Shut the agent system down, and drain the piping.
(6) Recheck the foam tank level.

5.3.16.5 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.

5.3.17 Primary Turret Flow Rate Test.

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

5.3.17.2 Test equipment shall consist of the following:

(1) A calibrated sight gauge
(2) A liquid volume measuring device accurate to within ± 1.0 percent
(3) A calibrated pressure gauge, if not already provided on the truck
(4) Alternative: A stopwatch and a scale capable of measuring total vehicle weight accurate to within ± 1.0 percent of the scale capacity

5.3.17.3 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

5.3.17.4 The primary turret discharge rate shall be determined as follows:

(1) Set the primary turret pattern for straight stream operation.
(2) Fill the water tank completely.
(3) Engage the pump, and operate it at design speed.
(4) Open the turret flow control valve.
(5) If necessary, at this stage perform the following procedures:
    (a) If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.
    (b) If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. 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 L/min by dividing the difference in gallons by the time of discharge.
    (c) If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch, and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge and calculate the flow rate.
(6) Reset the primary turret pattern to the dispersed setting, and repeat (2) through (5).
(7) Reset the primary turret to the half flow rate setting (if applicable) and repeat (1) through (6).

5.3.17.5 The measured turret flow rates shall equal the specified flow rate within a tolerance of +10 percent/–0 percent.

5.3.18 Primary Turret Pattern Test. The primary 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.

5.3.19 Primary Turret Control Force Measurement.

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

5.3.19.2 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.

5.3.19.3 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 primary turret at the full flow rate setting. The turret power-assist system, if applicable, shall be fully operational.

5.3.19.4 The test shall be conducted as follows:

(1) Set the turret pattern control for straight stream, and, where applicable, engage the power assist.
(2) Engage the pump, and operate it at design speed.
(3) Open the turret flow control valve.
(4) Using a spring scale attached to the end of the turret aiming handle, rotate the turret to the right and to the left, recording the needed force for each direction. Again, using the spring scale attached to the end of the turret aiming handle, elevate and depress the turret, and record the force needed to elevate and depress.
(5) Repeat (2) through (4) with the pattern control set at the maximum dispersed position after refilling the water tank as necessary.

5.3.19.5 The forces recorded shall not exceed the forces specified.

5.3.20 Primary Turret Articulation Test.

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

5.3.20.2 The test equipment shall consist of a tape measure, a level, and a protractor.

5.3.20.3 The water tank shall be filled prior to the test, and the turret power-assist system, if applicable, shall be fully operational.

5.3.20.4 The test shall be conducted as follows:

(1) With the turret pointed ahead, raise the turret barrel to the maximum elevated position. With a level held horizontal at the vertical rotation axis, measure the angle between the level and the turret barrel with the protractor and record.
(2) Rotate the primary turret barrel to the right and left to the angle needed.
(3) Place a marker 9.1 m (30 ft) in front of the vehicle. Aim the turret straight ahead with the rate control at full flow, with the pattern control in the maximum dispersed position and with the turret in the maximum depressed position. When water discharges, observe whether water strikes the marker or strikes closer to the vehicle.

5.3.20.5 Turret articulation shall be considered acceptable if the measurements meet or exceed the specifications.

5.3.21 Handline Nozzle Flow Rate Test.

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

5.3.21.2 Test equipment shall consist of the following:

(1) A calibrated sight gauge
(2) A liquid volume measuring device accurate to within ± 1.0 percent
(3) A calibrated pressure gauge, if not already provided on the truck
(4) Alternative: A stopwatch and a scale capable of measuring total vehicle weight accurate to within ± 1.0 percent

5.3.21.3 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

5.3.21.4 The handline nozzle flow rate shall be determined as follows:

(1) Set the handline nozzle pattern for straight stream operation.
(2) Fill the water tank completely.
(3) Engage the pump, and operate it at design speed.
(4) Open the handline nozzle flow control valve.
(5) If necessary, at this stage perform the following procedures:
   (a) If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.
   (b) If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. 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 L/min by dividing the difference in gallons by the time of discharge.
   (c) 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.
   (d) 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.
(6) If the nozzle is the nonair-aspirated type, repeat (2) through (5) with the nozzle pattern setting in the fully dispersed position.

5.3.21.5 The measured handline nozzle flow rates shall equal the specified flow rate within a tolerance of +10 percent/ –0 percent.

5.3.22 Handline Nozzle Pattern Test. The handline 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.

5.3.23 Ground Sweep/Bumper Turret Flow Rate Test.

5.3.23.1 Test facilities shall consist of an open site suitable for discharging agent. Access to a refill water supply shall be required.

5.3.23.2 Test equipment shall consist of the following:

(1) A calibrated sight gauge
(2) A liquid volume measuring device accurate to within ±1.0 percent
(3) A calibrated pressure gauge, if not already provided on the truck
(4) Alternative: A stopwatch and a scale capable of measuring total vehicle weight accurate to within ±1.0 percent

5.3.23.3 It shall have been verified that the vehicle's pumping system is capable of operating at full rate.

5.3.23.4 The ground sweep/bumper turret discharge rate shall be determined as follows:

(1) Set the ground sweep/bumper turret pattern for straight stream operation.
(2) Fill the water tank completely.
(3) Engage the pump, and operate it at design speed.
(4) Open the ground sweep/bumper turret flow control valve.
(5) If necessary, at this stage perform the following procedures:
   (a) If flow meters are used, read and record the flow rate once the discharge pressure stabilizes.
   (b) If a sight gauge is used, read and record the tank volume in gallons while simultaneously starting a stopwatch after the discharge pressure stabilizes. Read and record the tank volume in gallons when the watch is stopped after allowing flow for at least 1 minute. Determine the flow rate in L/min by dividing the difference in gallons by the time of discharge.
   (c) If a scale is used, record the vehicle weight prior to discharge. Start a stopwatch, and discharge water at stabilized pressure for 1 minute. Record the vehicle weight after discharge, and calculate the flow rate.
(6) If the ground sweep/bumper turret is the nonair-aspirated type, repeat (2) through (5) with the nozzle pattern setting in the fully dispersed position.

5.3.23.5 The measured flow rates shall equal the specified flow rate within a tolerance of +10 percent/–0 percent.

5.3.24 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.

5.3.25 Undertruck Nozzle Test.

5.3.25.1 Test facilities shall consist of an open site suitable for discharging agent.

5.3.25.2 Markers shall be available for use in defining the pattern boundaries.

5.3.25.3 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.

5.3.25.4 The test shall be conducted as follows:

(1) Set the agent system to operate in the foam mode
(2) Engage the agent pump, and operate it at design speed
(3) Open the undertruck nozzles to discharge simultaneously, and continue to discharge until a definite pattern outline is apparent
(4) Close the discharge and mark and record the boundaries of the pattern

5.3.25.5 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.

5.3.26 Foam Concentration/Foam Quality Test.

5.3.26.1 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.

5.3.26.2 The test equipment described in NFPA 412, *Standard for Aircraft Rescue and Fire-Fighting Foam Equipment*, shall be used for this test.

5.3.26.3 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.

5.3.26.4 The test shall be conducted as follows:

(1) Fill the water tank and the foam tank to the top, and refill as necessary throughout the test.
(2) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.
(3) Set the agent system pressure relief to the recommended pressure.
(4) Engage the agent pumps, and operate them at maximum pumping speed with all discharge outlets closed.
(5) Test each foam delivery system first for the individual nozzle/flow rate specified in the following list and then for a total combined simultaneous discharge in accordance with NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*:
    (a) Primary turret(s) full rate
    (b) Primary turret(s) half rate
    (c) Ground sweep/bumper turret
    (d) Handline nozzles
    (e) Undertruck nozzles

5.3.26.5 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.

5.3.27 Warning Siren Test.

5.3.27.1 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 61-m (200-ft) radius of the vehicle.

5.3.27.2 Test equipment shall consist of the following:

(1) A sound level meter that meets the requirements of ANSI S1.4, *Specification for Sound Level Meters*, for Type 1 or S1A meters and has been calibrated by a certified testing laboratory within the previous 12 months
(2) A tape measure

5.3.27.3 The vehicle's siren speaker shall be mounted in its proper location and shall be in working order.

5.3.27.4 The capability of the warning siren on the vehicle to project sound forward and to the sides shall be determined as follows:

(1) Set the sound level meter to the A-weighing network, "fast" meter response, and position the meter directly ahead of the vehicle at a distance of 30.5 m (100 ft) from the front bumper, with the microphone at ear level.
(2) Energize the siren, and record the meter reading.
(3) Repeat (1) and (2) with the sound level meter 30.5 m (100 ft) from the vehicle, first at a position 45 degrees to the right and then at 45 degrees to the left of the longitudinal centerline of the vehicle.

5.3.27.5 The recorded noise level shall equal or exceed the specifications.

5.3.28 Propellant Gas.

5.3.28.1 Test facilities shall consist of an open site suitable for discharging Aqueous Film-Forming Foam Concentrate (AFFF), dry chemical, or halogenated agent.

5.3.28.2 Test equipment shall consist of a calibrated scale or load cell with an accuracy of ±1.0 percent.

5.3.28.3 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.

5.3.28.4 The test for each of the extinguishing agents shall be conducted in the following manner:

(1) Weigh the empty tank(s), and record as tare weight.
(2) Using the manufacturer's recommended filling procedure, charge the tank(s) with the manufacturer's recommended extinguishing agent to the upper fill weight/volume tolerance. Reweigh and record this as gross filled weight.
(3) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
(4) Pressurize the agent tank(s) using the manufacturer's recommended procedure.
(5) Simultaneously, fully open all discharge nozzles, and keep open until only the pressurizing gas is expelled.
(6) Shut down the propellant gas supply.
(7) Reweigh the agent tank(s), and record this as post-discharge weight.
(8) Calculate and record the total agent discharged as follows: Gross filled weight minus post-discharge weight equals total agent discharge.

5.3.28.5 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.

5.3.29 Pressure Regulation.

5.3.29.1 Test facilities shall consist of an open site suitable for discharging the AFFF, dry chemical, or halogenated agent.

5.3.29.2 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 ±34.5 kPa (±5.0 psi).

5.3.29.3 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.

5.3.29.4 The test for each of the extinguishing agents shall be conducted in the following manner:

(1) Using the manufacturer's recommended filling procedure, charge the tank(s) with the manufacturer's recom-

mended extinguishing agent to the upper fill weight/ volume tolerance.
(2) Install a pressure gauge or transducer between the downstream (low pressure) side of the regulator and the agent tank top.
(3) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings are tight.
(4) Pressurize the agent tank(s) using the manufacturer's recommended procedure. Record the agent tank pressure.
(5) Simultaneously, fully open all discharge nozzles, and keep open until only the pressurizing gas is expelled.
(6) During agent discharge, monitor agent tank pressure, and record at 5-second or shorter intervals.
(7) Once the gas point has been reached for all discharge nozzles, shut down the gas supply.

5.3.29.5 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.

5.3.30 AFFF Premix Piping and Valves.

5.3.30.1 Test facilities shall consist of a level, open site suitable for discharging the agent and measuring ranges.

5.3.30.2 Test equipment shall consist of the following:

(1) A calibrated scale or load cell with an accuracy of ±1.0 percent
(2) A stopwatch

5.3.30.3 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.

5.3.30.4 The test shall be conducted in the following manner:

(1) Weigh the empty premix tank, and record as tare weight.
(2) Using the manufacturer's recommended filling procedure, charge the tank with water or premix solution. Reweigh and record as gross filled weight.
(3) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
(4) Pull all handline hose from the reel(s) or hose compartment(s).
(5) Pressurize the system using the manufacturer's recommended procedure.
(6) Simultaneously, start the stopwatch and fully open the turret(s), undertruck nozzles, and handline(s).
(7) After discharging for at least 30 seconds, simultaneously stop the stopwatch and close the turret(s), undertruck nozzles, and handline(s). Record the elapsed time on the stopwatch as discharge time.
(8) Following the manufacturer's instructions, shut off the propellant gas supply, and blow down the system.
(9) Reweigh the premix tank, and record this as post-discharge weight.
(10) Add the recommended flow rates from each discharge nozzle, and record this sum as the designed total flow rate.
(11) Calculate the actual total flow rate (TFR) as follows:

$$\text{TFR} = \frac{\text{gross filled weight} - \text{post-discharge weight}}{(\text{density}) \times \dfrac{(\text{elapsed time in seconds})}{60}}$$

5.3.30.5 The actual total flow rate (TFR) shall equal the specified designed total flow rate within a tolerance of +10 percent/−0 percent.

5.3.31 Pressurized Agent Purging and Venting.

5.3.31.1 Test facilities shall consist of an open site suitable for discharging AFFF, dry chemical, or halogenated agent.

5.3.31.2 No special test equipment or instrumentation shall be required to conduct the test(s).

5.3.31.3 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.

5.3.31.4 The test for each of the pressurized extinguishing agent systems shall be conducted in the following manner:

(1) Pressurize the agent tank(s) using the manufacturer's recommended procedure.
(2) Pull all hose from the reel(s) or compartment(s).
(3) Fully open all discharge devices.
(4) After approximately 5 seconds to 20 seconds, close all discharge devices.
(5) Purge all discharge lines, and vent the agent tank(s) using the manufacturer's recommended procedure.

5.3.31.5 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.

5.3.32 Complementary Agent Handline Flow Rate and Range.

5.3.32.1 Test facilities shall consist of a level, open site suitable for discharging the dry chemical or halogenated agent and measuring ranges. Wind conditions shall be calm [less than 8 kph (5 mph)].

5.3.32.2 Test equipment shall consist of the following:

(1) A calibrated scale or load cell with an accuracy of ± 1.0 percent
(2) A stopwatch
(3) A tape measure or other device for measuring distance
(4) A calibrated anemometer
(5) A pan containing at least 0.09 m^2 (1 ft^2) of motor or aviation gasoline

5.3.32.3 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.

5.3.32.4 The test shall be conducted in the following manner:

(1) Using the manufacturer's recommended agent and filling procedure, charge the agent tank.
(2) 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.
(3) Pull all handline hose from the reel(s).
(4) Pressurize the system using the manufacturer's recommended procedure, and open all handline nozzles until agent flow is observed. Close the nozzles.
(5) Weigh and record the agent tank as the "initial weight."
(6) Position the handline nozzles at least 6.1 m (20 ft) from the fire pan so that they can be discharged onto a flat grade with no stream obstructions. Ignite the fuel.
(7) Select one of the handline nozzles (nozzle 1). While holding it in a position 0.9 m to 1.2 m (3 ft to 4 ft) above ground level, simultaneously start the stopwatch and fully open the nozzle; then discharge agent onto the fire.
(8) 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."
(9) Reweigh the agent tank, and record as "weight after first discharge."
(10) If a second nozzle (nozzle 2) is provided, repeat (1) through (8).
(11) While holding the two handline nozzles in a fixed horizontal position 0.9 m to 1.2 m (3 ft to 4 ft) above ground level, simultaneously start the stopwatch, and fully open both nozzles.
(12) 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."
(13) Reweigh the agent tank, and record as "weight after second discharge."
(14) Calculate the flow rate(FR) from nozzle 1 as follows:

$$FR = \frac{\text{initial weight (test 1)} - \text{initial weight (test 2)}}{\text{(elapsed discharge time no. 1)}}$$

(15) Calculate the flow rate (FR) from nozzle 2 as follows:

$$FR = \frac{\begin{matrix}\text{weight after} \\ \text{first discharge}\end{matrix} - \begin{matrix}\text{weight after} \\ \text{second discharge}\end{matrix}}{2 \times \text{(elapsed discharge time no. 2)}}$$

(16) If nozzle 2 is of a different configuration, repeat the fire test for this nozzle.

5.3.32.5 Test results shall be evaluated as follows:

(1) The flow rate from each nozzle shall meet the requirement.
(2) The range from each nozzle shall meet or exceed the requirements as evidenced by extinguishment of the fire(s).
(3) When discharged simultaneously, the flows from nozzle 1 and nozzle 2 shall be within 10 percent of each other.

5.3.33 Dry Chemical Turret Flow Rate and Range.

5.3.33.1 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 8 kph (5 mph)].

5.3.33.2 Test equipment shall consist of the following:

(1) A calibrated scale or load cell with an accuracy of ±1.0 percent
(2) A stopwatch
(3) A tape measure or other device for measuring distance
(4) A calibrated anemometer

5.3.33.3 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.

5.3.33.4 The test shall be conducted in the following manner:

(1) Using the manufacturer's recommended agent and filling procedure, charge the tank.
(2) Ensure that all fill caps are tightened securely, all propellant gas lines are connected, the discharge nozzle(s) is in the closed position, and all fittings and connections are tight.
(3) Pressurize the system using the manufacturer's recommended procedure, and open the turret discharge valve until agent is observed. Close the valve.
(4) Weigh and record the agent tank as the "initial test weight."
(5) Position the dry chemical turret so that it can be discharged onto a flat grade with no stream obstructions. Position the turret to obtain maximum straight stream reach.
(6) Simultaneously, start the stopwatch and fully open the turret.
(7) During discharge, place markers at the far point where significant dry chemical strikes the ground (range marker) and at either side of the widest part of the pattern (width markers).
   (a) The operator(s) placing the markers shall wear proper safety equipment for this task.
   (b) The agent manufacturer's material safety data sheet shall be consulted.
(8) After discharging at least 75 percent of the contents of the tank, simultaneously stop the stopwatch, and shut down the turret. Record the elapsed time in seconds as discharge time.
(9) Measure the distance from the turret to the range marker, and record as the far point range.
(10) Measure the distance between the width markers, and record as the pattern width.
(11) Reweigh the agent tank, and record as the weight after discharge.
(12) Calculate the flow rate (FR) as follows:

$$FR = \frac{\text{initial test weight} - \text{weight after discharge}}{\text{elapsed discharge time}}$$

5.3.33.5 The stream range and pattern width shall equal or exceed the requirements. The discharge flow rate shall equal the requirement.

5.3.34 Cab Interior Noise Test.

5.3.34.1 Test facilities shall consist of a flat, open, paved area suitable for operating the vehicle at a constant speed of 80.5 kph (50 mph) that is free from any large reflecting surfaces (such as other vehicles, sign boards, or hills) within a 15.2-m (50-ft) distance of the vehicle. The wind speed shall not exceed 24.1 kph (15 mph) during the test.

5.3.34.2 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.

5.3.34.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* 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 drivetrain 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.

5.3.34.4 The interior noise level of the cab shall be determined as follows:

(1) Set the sound level meter to the A-weighing network, “fast” meter response, and position the meter adjacent to the driver’s ear.
(2) Bring the vehicle up to a road speed of 80.5 kph (50 mph) and maintain that speed while recording the noise measurements.
(3) Repeat (1) and (2) until four readings have been taken, bringing the vehicle to rest between each measurement. If any of the noise measurements differ from the others by more than 2 dBA, they should be replaced by another measurement, since they could be the result of extraneous ambient noises or equipment/measurement error.
(4) Average the four readings.

5.3.34.5 The average of the recorded noise readings shall be less than or equal to the cab interior noise level specification.

5.3.34.5.1 Halon 1211 systems shall not be tested.

5.4* Operational Tests.

5.4.1 Vehicle Testing, Side Slope.

5.4.1.1 This test shall be accomplished on vehicle prior to the vehicle being delivered to the end user. It shall be accomplished with all requested equipment properly placed and installed as ordered by the end user. The tilt table angle shall be recorded on a metal data plate affixed to the left-hand door of the vehicle. This data plate shall list the following items: vehicle empty weight, maximum gross weight, special equipment installed prior to test, and front and rear axle weights with weight distribution calculation. The actual tilt table angle achieved in the test shall be recorded on the plate for left and right directions.

5.4.1.1.1 This test shall be conducted on a tilt table facility meeting SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks.* This tilt table shall contain a suitable surface to resist truck sliding during test sequences. The vehicle shall be restrained and tilted until the vehicle tilt or side slope angle can be positively determined.

5.4.1.2 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* with tires inflated to their recommended operating pressure. A suitable ballast shall be used in place of the crew for safety.

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

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

5.4.1.4 The side slope capability of the vehicle shall be determined in accordance with SAE J2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, and as follows:

(1) Tilt the vehicle on a table to the angle specified for the vehicle being tested.
(2) Once the vehicle is positioned at the required angle, check the vehicle restraints to ensure that no tension is applied.

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

5.4.1.6 Where multiple vehicles are purchased under the same contract and built to exactly the same specifications, the purchaser shall be permitted to have a single unit or a random sample of units tested and the result(s) applied to the other identical units.

5.4.2 Weight/Weight Distribution.

5.4.2.1 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.

5.4.2.2 Instrumentation for this test is limited to the in-ground or portable scales. The accuracy of the scales shall be ±1.0 percent of the scale capacity.

5.4.2.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)*. Ballast shall be used for the crew and equipment as necessary.

5.4.2.4 The total weight of the vehicle and weight distribution shall be determined as follows:

(1) Determine the total weight of the vehicle by driving the fully loaded vehicle onto the scale(s).
(2) Determine the individual axle loadings by measuring the weight on each axle at the ground. Since the total vehicle weight is more accurately reflected by the single weight measurement in (1), correct the individual axle loads proportionately, as necessary, so that their total equals the total vehicle weight. Subtract the lightest loaded axle weight from the heaviest loaded axle weight, and divide the difference by the weight of the heaviest axle.
(3) Determine individual tire loadings by measuring the weight on each tire at the ground. Make proportionate corrections to the individual tire loads so that their total equals the load on the respective axle. Determine the av-

erage 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.

5.4.2.5 The data shall be evaluated on the following basis:

(1) The total weight of the vehicle shall be less than or equal to the vehicle manufacturer's gross vehicle weight rating.
(2) The difference between the heaviest loaded axle and the lightest loaded axle shall be less than or equal to the maximum difference permitted in the specification.
(3) The difference between the tire weights on any given axle shall be less than or equal to the maximum difference permitted in the specification.

5.4.3 Acceleration.

5.4.3.1 Test facilities shall consist of a dry, straight, level paved surface sufficient in length to accelerate the vehicle from rest to 80.5 kph (50 mph) and then bring it to a safe stop.

5.4.3.1.1 Ambient temperatures at the test site shall be –17.8°C to 43.3°C (0°F to 110°F), and elevations shall include heights up to 609.6 m (2000 ft) unless otherwise specified by the purchaser.

5.4.3.2 Instrumentation shall consist of a fifth wheel device, or equivalent, designed to measure and record (at least visibility as a minimum) vehicle speed and time from the time the vehicle begins to move until it reaches a predetermined top speed.

5.4.3.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* with the engine and the transmission at their normal operating temperatures. The tires shall be inflated to the manufacturer's recommended pressure.

5.4.3.4 The test shall be conducted in the following manner:

(1) Start the test with the vehicle at rest, the engine at idle, and the transmission in gear.
(2) Simultaneously, start the stopwatch and accelerate the vehicle, and continue accelerating to a wide-open throttle condition.
(3) At the moment the vehicle reaches 80.5 kph (50 mph), stop the watch and record the elapsed time.
(4) To compensate for wind conditions and slope, repeat the test in the opposing direction. Record and average a minimum of three readings in each of the two directions.

5.4.3.5 The average acceleration time to 80.5 kph (50 mph) shall be less than or equal to the requirement, as specified.

5.4.4 Top Speed.

5.4.4.1 Test facilities shall consist of a dry, paved, level surface suitable for achieving a vehicle speed of at least 104.6 kph (65 mph) and bringing the vehicle to a safe stop.

5.4.4.2 Instrumentation shall consist of the vehicle's speedometer as installed by the manufacturer at the time of delivery.

5.4.4.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* with the engine and the transmission at their normal operating temperatures. The tires shall be inflated to the manufacturer's recommended pressure.

5.4.4.4 The test shall be conducted in the following manner:

(1) Accelerate the vehicle to a speed of at least 104.6 kph (65 mph).
(2) To compensate for wind conditions and slope, repeat the test in the opposing direction.
(3) If 104.6 kph (65 mph) cannot be achieved in one of the directions, repeat (1) and (2), accelerating the vehicle to its maximum speed in each direction; record the speeds, and average the two numbers.

5.4.4.5 The test shall be considered successful if the average top speed equals or exceeds 104.6 kph (65 mph).

5.4.5 Brake Operational Test.

5.4.5.1 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 1.2 m (4 ft) is established. A runway or taxiway with a marked centerline shall be permitted to be used.

5.4.5.2 Instrumentation shall consist of the vehicle's speedometer, as installed by the manufacturer, and a tape measure.

5.4.5.3 The vehicle shall be tested in its fully loaded condition *(see 3.3.71)* 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.

5.4.5.4 The test shall be conducted in the following manner:

(1) Maintain a constant speed of 32.2 kph (20 mph) while driving down the centerline of the test site.
(2) Apply the brakes as if in a panic stop until the vehicle comes to rest.
(3) Measure and record the distance from the outer edge of the vehicle to the centerline of the lane.
(4) Repeat (1) through (3) at a constant speed of 64.4 kph (40 mph).

5.4.5.5 The distance measured shall not exceed one-half the vehicle width plus 0.6 m (2 ft).

5.4.6 Air System/Air Compressor Test.

5.4.6.1 No special test facilities shall be required.

5.4.6.2 Instrumentation shall consist of the vehicle's air system pressure gauge(s), as installed by the manufacturer, and a stopwatch.

5.4.6.3 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.

5.4.6.4 The test shall be conducted as follows:

(1) Using the brake pedal, bleed off the air reservoir system pressure to a level below 586 kPa (85 psi) as indicated on the cab-mounted air gauge(s).
(2) Accelerate the engine to its wide-open throttle condition.
(3) When the air pressure indicator reaches 586 kPa (85 psi), start the stopwatch. If more than one air pressure indicator is installed on the vehicle, start the stopwatch when the first indicator registers 586 kPa (85 psi).
(4) Continue building air pressure with the engine at wide-open throttle until 689.5 kPa (100 psi) registers on all air pressure indicators, stop the watch, and record the time.

(5) Using the brake pedal, bleed off the air reservoir system pressure to 0 kPa (0 psi), as indicated on the cab-mounted air gauge(s).
(6) Accelerate the engine to a wide-open throttle condition.
(7) When the wide-open throttle condition is reached, simultaneously start the stopwatch.
(8) Continue building air pressure with the engine at wide-open throttle until the previously established spring brake release pressure has been reached in the quick buildup system; stop the watch, and record the time.

5.4.6.5 The results shall be evaluated as follows:

(1) The time needed for a buildup of 586 kPa to 689.5 kPa (85 psi to 100 psi) shall be within 25 seconds or the permitted time, as calculated for larger reservoir capacities.
(2) The quick buildup time shall be within 15 seconds.

5.4.7 Agent Discharge Pumping Test.

5.4.7.1 Test facilities shall consist of an open site suitable for discharging agent.

5.4.7.2 No test equipment shall be required.

5.4.7.3 The vehicle's agent system shall be fully operational for this test, and all primary handlines shall be deployed.

5.4.7.4 The combined discharge of all nozzles shall be tested as follows:

(1) Fill both the water tank and the foam (or dyed water) tank completely with water and foam, respectively.
(2) Set the agent system to operate in the foam mode, set the system pressure for optimum performance, and engage the agent pumps. Simultaneously operate the pumps of vehicles with multiple pumps during this test.
(3) Initiate discharge first through the primary turret and then through the ground sweeps (or optional bumper turret), primary handlines, and undertruck nozzles until all are discharging simultaneously in a straight stream. As each nozzle is turned on, observe the range along with the system pressure.
(4) Continue to discharge until the system pressure has stabilized with all nozzles discharging.

5.4.7.5 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 5.4.6.4, 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 primary 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.

5.4.8 Dual Pumping System Test.

5.4.8.1 Test facilities shall consist of an open site suitable for discharging agent.

5.4.8.2 No special instrumentation shall be required for this test.

5.4.8.3 The vehicle's agent system shall be fully operational for this test.

5.4.8.4 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:

(1) Fill both the water tank and the foam tank completely with water, and add dye or foam concentrate to the foam tank.
(2) Set the agent system to operate in the foam mode, and set the system pressure for optimum performance.
(3) Set the primary turret(s) discharge rate in the half flow rate setting.
(4) Initiate discharge first through the primary turret(s) (at half rate) and then through the ground sweep nozzles (or alternate bumper turret), the primary handline nozzles, and the undertruck nozzles, first with one pump operating, and then the other.

5.4.8.5 A foam or dye solution discharge stream shall be present at each nozzle tested when either pump is engaged.

5.4.9 Pump and Maneuver Test.

5.4.9.1 Test facilities shall consist of an open site suitable for discharging agent and operating the vehicle up to its maximum speed.

5.4.9.2 No test equipment shall be required.

5.4.9.3 The vehicle's agent system shall be fully operational for this test.

5.4.9.4 The positive pump and maneuver capability, along with the smooth engagement of the pump, shall be tested as follows:

(1) Fill both the water tank and the foam tank completely with water, and add dye or foam concentrate to the foam tank.
(2) With the vehicle being driven at 32.2 kph (20 mph), engage and disengage the pump(s) without damage to the pump or pump drive system.
(3) Bring the vehicle to a stop, and prepare the primary turrets and ground sweeps (or optional bumper turret) for discharging.
(4) Place the agent selector in the foam mode, and set the agent system pressure relief to relieve at the recommended pressure for optimum performance.
(5) Initiate discharge through the primary turrets and ground sweeps/bumper turret nozzles, and drive the vehicle in a forward and reverse direction at speeds ranging up to 8 kph (5 mph). Stop and start the vehicle, and change direction from forward to reverse while operating through this speed range without interrupting the discharge flow rate or range. Engage and disengage the pumps during the test.
(6) Repeat (5) both on and off the road.

5.4.9.5 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.

5.4.10 Hydrostatic Pressure Test.

5.4.10.1 Test facilities shall consist of an appropriate area in the vehicle manufacturer's plant.

5.4.10.2 Test equipment shall consist of the following:

(1) A hydraulic pressure gauge with a scale adequate for monitoring a pressure equal to 1½ times the normal agent system pressure of the vehicle
(2) A pressure charging device capable of developing a pressure equal to 1½ times the normal agent system pressure of the vehicle and sustaining it for 15 minutes or longer
(3) Miscellaneous plates or caps to isolate the tank-to-pump side of the agent system, as necessary, from the hydrostatic test pressure

5.4.10.3 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.

5.4.10.4 The water and foam concentrate or foam solution discharge piping shall be tested as follows:

(1) Isolate all tank to pump piping components that cannot tolerate the hydrostatic test pressures from the discharge piping and pump(s) by installing temporary plates or caps between these items and the discharge piping. Include the agent pumps in the test.
(2) Close all discharge nozzles, and seal any bypass lines from the pressure piping to the agent tanks.
(3) Connect a pressure charging device (e.g., electric motor-driven water pump or hand pump) into the discharge piping.
(4) Activate the pressure charging device, fill the agent pumps and discharge piping with water, and pressurize to at least 1½ times the maximum recommended agent system operating pressure.
(5) Close the supply line from the pressure charging system, thereby sealing the discharge piping in a pressurized condition.
(6) Maintain the test pressure for at least 15 minutes without degradation.
(7) If leaks exist that cause the pressure to drop, repair the leaks and repeat the test.
(8) On completion of the hydrostatic test, disconnect the charging device, and reassemble the tank-to-pump piping.
(9) Fill the agent tanks and piping with water, and inspect the tank-to-pump piping for leaks after the agent system has been operated in the foam mode.

5.4.10.5 No pressure decay shall be permitted during the 15-minute test, and no discharge or tank-to-pump piping water leaks shall be permitted during or after agent system operation.

5.4.11 Foam Concentration Test.

5.4.11.1 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.

5.4.11.2 The test equipment described in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*, shall be used for this test.

5.4.11.3 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.

5.4.11.4 The test shall be conducted as follows:

(1) Fill the water and foam tank to the top, and refill as necessary throughout the test.
(2) Set the foam proportioning system to proportion foams at the concentration specified, and set the agent selector for the foam mode.
(3) Set the agent system pressure relief to the recommended pressure.
(4) Engage the agent pumps and bring them up to maximum pumping speed with all discharge outlets closed.
(5) Test each foam delivery system in accordance with NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*, for the individual nozzle/flow rate as follows:
    (a) Primary turret(s) full rate
    (b) Primary turret(s) half rate
    (c) Ground sweep/bumper turret
    (d) Handline nozzles
    (e) Undertruck nozzles

5.4.11.5 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.

5.4.12 Primary Turret Flow Rate Test.

5.4.12.1 Test facilities shall consist of a level, open site suitable for discharging agent.

5.4.12.2 A stopwatch shall be required for this test.

5.4.12.3 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.

5.4.12.4 The test shall be conducted as follows:

(1) Simultaneously initiate discharge through the primary turret(s) at the maximum flow rate and start the stopwatch.
(2) Continue discharging until the pump cavitates, as indicated by a significant drop in discharge pressure, and stop the watch when this occurs. Record the elapsed time.
(3) Divide the rated water tank capacity, in gallons, by the elapsed discharge time to determine the average discharge rate.

5.4.12.5 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.

5.4.13 Piercing/Penetration Nozzle Testing.

5.4.13.1* The manufacturer shall demonstrate the ability to penetrate a sandwiched metal sample of two pieces of 0.090 5052 grade soft aluminum material with the penetration device in under 3 seconds.

5.4.13.2* The manufacturer shall demonstrate the ability to penetrate a sandwiched metal sample of two pieces of 0.090 2024–T3 grade aircraft aluminum in under 3 seconds.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1 The basic NFPA recommendations on the use and provision of this equipment are contained in NFPA 402, *Guide 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.1.3.1 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 Figure D.1(a) through Figure D.1(d) also should be required.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.3 Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

A.3.3.7 Angle of 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.

A.3.3.8 Angle of Departure. 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.

A.3.3.13 Bogie. 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.

A.3.3.15 Center of Gravity. Where a vehicle is tipped to such a degree that a vertical line passing through the center of gravity falls on the ground outside the tire track, it is unstable and can turn over.

A.3.3.16 Complementary Agent. These agents can extinguish by means of chemical reaction, cooling or removal of oxygen and are applied to special fire situations such as three-dimensional running fuel fires.

A.3.3.18 Cooling Preheater Device. 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.

A.3.3.19 Diagonal Opposite Wheel Motion. This measurement is compared diagonally — from right front to left rear wheels of the vehicles — or opposing corners of the vehicle.

A.3.3.32 Forward-Looking Infrared (FLIR). The FLIR system, which consists of FLIR camera, monitor, and controlling devices, provides the operator with an image that can be used to drive aircraft rescue and fire-fighting (ARFF) vehicles under 0/0 visibility conditions.

A.3.3.37 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.

A.3.3.38 Interaxle Clearance Angle (Ramp Angle). It is determined by the horizontal ground line and whichever of the following lines forms the smaller angle:

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

A.3.3.43 Off-Pavement Performance. "Other than paved surfaces" includes dirt roads and trails and open cross-country of all kinds. This ability sometimes is referred to as off-road mobility or cross-country mobility. All of these terms are synonymous.

A.3.3.45 Overall Height, Length, and Width. These dimensions include all fixed protrusions that could in any way hinder the passage of the vehicle. Dimensions that include a movable protrusion are determined with the protrusion in its normally stored position.

A.3.3.46 Percent Grade. A change in elevation of 15.2 m (50 ft) over a horizontal distance of 15.2 m (50 ft) is equivalent to a grade of 100 percent.

A.3.3.49 Propellant Gas. Nitrogen, air, argon, and carbon dioxide are propellant gases that can be used with an agent. The quality of these gases is specified according to guidelines provided by the manufacturer of the agent. The guidelines can include moisture and dew point qualifications. During discharge, the gas provides an energy source, which aids in propelling the agent to meet its performance standards.

A.3.3.55 Rubber-Gasketed Fitting. It incorporates a rubber seal held in place by a two-piece clamp that also engages annular grooves near the end of each pipe to prevent pullout under pressure.

A.3.3.59 Steering Drive Ends. 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. Steering drive ends are also known as stub shafts.

A.3.3.60.1 Differential Global Positioning System (DGPS). DGPS works on the principle that position errors will be about the same for GPS receivers operating in the same general area. If one of these receivers has an antenna positioned at a precisely known location, the error in that receiver's determined position can be computed. This computed position error can then be broadcast to other GPS receivers in the area and used to improve the accuracy of their position solutions. The driver's enhanced vision system (DEVs) utilizes differential GPS.

A.3.3.60.3 Global Positioning System (GPS). The user equipment — that is, GPS receiver — provides the user with position, velocity, and time information. Aircraft rescue and fire-fighting (ARFF) vehicle position provided by the driver's enhanced vision system (DEVS) is derived from the system's GPS receiver and displayed on the moving map display.

A.3.3.63.2 Axle Tread. 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.

A.3.3.64.1 Extendable Turret. 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.

A.3.3.65 Twenty-Five Percent Drainage Time. A method of measuring drainage time is provided in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment.*

A.3.3.68 Underbody Clearance Dimensions. These dimensions include all components of the vehicle, except those that are part of the axle assemblies, that could hinder the passage of the vehicle.

A.3.3.71.1 Fully Loaded Vehicle. The crew allowance is 102 kg (225 lb) per seating position. Unless otherwise specified, the equipment allowance is 113.3 kg (250 lb) per storage compartment, up to a maximum of 453.6 kg (1000 lb). Where the customer specifications require that more equipment be carried, the actual weight of the equipment is to be included.

A.3.3.71.2 Prototype Vehicle. A given chassis, body, and fire-fighting system and fully loaded weight condition constitute a vehicle configuration. Product improvements and customer options negate previously conducted prototype tests only if they substantially affect a performance factor.

A.3.3.72 Vehicle Types. The term "wheel" in this designation is interpreted to mean either a single tire or a set of dual tires operating as one tire. The first number is the number of wheels, the second number is the number of driving wheels.

A.3.3.73 Wall-to-Wall Turning Diameter. It is, therefore, the diameter of the smallest circle that can be described by the outermost point on the vehicle as it negotiates a 360-degree turn to the right or left.

A.3.3.74 Weather Resistant. This term is not intended to describe items that are watertight or submersible.

A.4.1 The minimum size of the firehouse garage door(s) for a major fire-fighting vehicle should be at least 5.5 m (18 ft) wide by 5.5 m (18 ft) high.

When creating the response roadways from the firehouse to the incident area(s), the airport designer should consider the information in Table A.4.1(a)and Table A.4.1(b)when sizing the radius of curves. ARFF vehicles accelerate much faster than over-the-road vehicles and are very capable of obtaining higher speeds in a very short distance.

A.4.1.5 The following is a list of available options that can be ordered from the ARFF vehicle manufacturers:

(1) General ARFF vehicle options
   (a) Winterization system providing sufficient insulation and heating capacity, by means of hot circulating liquids and forced air exchangers, to permit satisfactory operation of the vehicle and fire-fighting systems for a period of at least 4 hours at ambient temperatures as low as −40°C (−40°F) with the vehicle fully operational and the engine running. At the end of the 4-hour period, the vehicle shall be capable of successfully discharging its agent(s). The winterization system shall not detract from the performance of the vehicle and fire-fighting system in ambient temperatures up to −43.5°C (−115°F)
      i. Training video tape covering the operation of the vehicle
      ii. Pintle-hook-type towing connection rated at 13,607 kg (30,000 lb) gross trailer weight, attached to the vehicle's frame at the rear of the vehicle
      iii. Roll-up-type compartment doors (other than service doors)
      iv. Windshield deluge system *(see 4.11.4.6)*
      v. Navigation system of a driver's enhanced vision system (DEVS) *(see 4.11.4.7)*
   (b) Monitoring and data acquisition system (MADAS) *(see 4.11.7)*
(2) Dimensional, safety, and stability enhancement options
   (a) Added payload capacity (GVWR) to carry special equipment where the purchaser identifies added equipment
   (b) Increased overall width of the vehicle to facilitate increased performance and maneuverability with no concern for movement on public highway(s)
   (c) Audiovisual devices that meet or exceed the field of vision provided by wide-angle mirrors
(3) Engine(s) with related options
   (a) Engine that operates at necessary performance above 609.6 m (2000 ft) elevation
   (b) Radiator shutters *(see 4.3.2.3.3)*

Table A.4.1(a) Vehicle Speed over Distance from a Standing Start

Distance Traveled from a Standing Start of the Vehicle		Speed of Vehicle at the Given Distance					
		Vehicle Water Tank Capacity ≥227 to ≤1999 L ≥60 to ≤528 gal		Vehicle Water Tank Capacity >1999 to ≤6000 L >528 to ≤1585 gal		Vehicle Water Tank Capacity >6000 L >1585 gal	
(m)	(ft)	kph	mph	kph	mph	kph	mph
30.5	100	29.0	18	32.2	20	29.0	18
76.2	250	40.2	25	48.3	30	40.2	25
152.4	500	48.3	30	64.4	40	48.3	30
228.6	750	64.4	40	72.4	45	64.4	40
304.8	1000	72.4	45	80.5	50	72.4	45

Table A.4.1(b) Minimum Radius of a Curve Based on Speed

Speed		Minimum Radius of a Curve with a 0.04 Superelevation (Almost Flat)*	
kph	mph	m	ft
32.2	20	39.6	130
48.3	30	92.0	302
64.4	40	174.6	573
80.5	50	291.1	955
88.5	55	436.5	1432
96.6	60	498.9	1637

* Values were extracted from "A Policy on Geometric Design of Highways and Streets," 1990 edition.

(c) Engine coolant filter
(d) Silicone coolant and heater hoses
(e) Heated diesel fuel water separator
(f) Automatic drain(s) for the diesel fuel water separator
(g) Auxiliary fuel tank(s) commensurate with need to meet local requirements
(h) Stainless steel exhaust systems and muffler(s)

(4) Vehicle electrical and lighting options
(a) Automatic eject-type electrical receptacles
(b) On-board battery charger/conditioner *(see 4.4.5)*
(c) Auxiliary generator(s) installed in accordance with NFPA 1901, *Standard for Automotive Fire Apparatus*, Chapter 21
(d) High-intensity spotlight(s) on the left and right side of the windshield, hand adjustable type, with controls for beam adjustment inside the truck cab
(e) High-intensity spotlight(s) mounted on the primary turret nozzle(s), with controls located in the cab instrument group
(f) Two high-intensity floodlights, mounted on each side of the vehicle
(g) Two high-intensity fog-type driving lights mounted on the front bumper
(h) Two high-intensity driving lights mounted on the front bumper
(i) Two high-intensity floodlights on the rear of the vehicle
(j) Map lights on each side of the dash; a control switch on the instrument group panel in the cab for control of the lights
(k) Rotating beacon-type lights on the top roof deck and visible for 360 degrees in the horizontal plane; a control switch on the instrument group panel in the cab for control of the light
(l) Strobe-type light(s) on the top roof deck and visible for 360 degrees in the horizontal plane; a control switch on the instrument group panel in the cab for control of the light(s)
(m) Fused radio electrical connection in the cab adjacent to the radio mounting location (Power ratings are to be provided by purchaser.)

(5) Suspension, mobility and tire options
(a) Reduced underaxle and underbody clearances to provide a more stable performance on pavement when the vehicle suspension is designed to permit instantaneous adjustment to the required height for off-pavement travel
(b) Tag or other non-powered axle(s) to assist in weight distribution and/or stability requirements
(c) Passive or active suspension components to increase the stability of the vehicle while decreasing the roll over threshold
(d) Spare tire(s)
(e) Bead locks on tires and rims
(f) Run flat devices in all tires and wheels mounted on the vehicle

(6) Vehicle brake options
(a) Air brake reservoirs drain valve(s) actuated by the driver from a location or compartment not requiring a creeper to access the actuator
(b) Auto-eject-type connectors air connection used to change brake air tanks from an external air source

(7) Vehicle cab, operating and driving options
(a) Tilt and telescoping steering wheel
(b) Supplementary designated seat positions for additional crew members
(c) Quick access passage to the roof
(d) FLIR heads up display located in the cab
(e) Cab air-conditioning meeting current automotive-truck and environmental protection standards for vehicle air-conditioning (The use of air conditioning does not change the acceptable pass/fail criteria.)

(f) Air-suspension-type driver [passenger(s)] seat(s), with vertical, fore, and aft adjustment
(g) Crew seat back(s), with storage of self-contained breathing apparatus (SCBA) with quick-release-type holders incorporated into the seat cushion

(8) Fire-fighting systems options

(a) Water tank design that allows access with each baffled compartment of the tank for internal and external inspection/service
(b) Automatic foam proportioning system, permitting use of 3 percent and 6 percent foam concentrates automatically when selected (change of proportioning plates not required)
(c) Electronic foam proportioning system
(d) Foam tank drain valve(s), drain line and hose(s) that facilitate draining the tank into specified container(s) positioned on the ground within 3 m (10 ft) in either horizontal direction of the foam tank drainage system
(e) Manually operated roof turret with controls located in the cab, the operation force of the controls requiring less than 134.4 N (30 ft-lb) including in-cab indicator of turret elevation and azimuth
(f) Manually operated roof turret with controls located on the cab roof platform, the operation force of the controls requiring less than 224 N (50 ft-lb)
(g) Turret controls located in the cab or on the roof platform
(h) Manual override of roof turret functions in the cab not exceeding 134.4 N (30 ft-lb) operation forces
(i) Turret(s) controls accessible both to the driver and the crew member
(j) Turret(s) equipped with an auxiliary agent discharge *(see 4.23.1)*
(k) Extendable-type primary turret *(see 4.18.6)*
(l) Color camera mounted on the extendable turret *(see 4.18.6)*
(m) Video recorder for color and/or FLIR camera(s)
(n) Aircraft skin penetrator/agent applicator mounted on the extendable turret *(see 4.18.6)*
(o) Pre-connect handlines and nozzles (water/foam/combined/auxiliary agent/mounted parallel entrained streams)
(p) Bumper turret *(see Section 4.20)*
(q) High-capacity bumper turret
(r) Two or more undertruck nozzles *(see 4.20.1 and 4.20.3)*
(s) Fire system pressure gauge/light/warning on the cab instrument panel grouping and/or on the side structural) control panel
(t) Foam liquid tank level gauge/light/warning on the cab instrument panel grouping
(u) Remote foam/water liquid level gauge/light/warning on the side panel and/or supply/service locations
(v) Bumper turret and/or ground sweep valve controls located in the cab
(w) Undertruck nozzle valve control in the cab
(x) Auxiliary agent pressurization control on the cab instrument grouping
(y) Remote mounted instrument and control panel (structural panel)

A.4.2.1 The carrying capacity of a vehicle is one of the least understood features of design and one of the most important. All vehicles are designed for a maximum gross vehicle weight rating (GVWR) or maximum total weight, which should not be exceeded by the apparatus manufacturer or by the purchaser after the vehicle has been placed in service. For tractor-drawn vehicles, the in-service weight of the apparatus should not exceed the GVWR. There are many factors that make up the rated GVWR, including the design of the springs or suspension system, the rated axle capacity, the rated tire and wheel loading, and the distribution of the weight between the front and rear wheels. [**1901:** A.10.1]

One of the most critical factors is the size of the water tank. Water weighs approximately 1 kg/L (8.3 lb/gal). A value of 1.2 kg/L (10 lb/gal) can be used when estimating the weight of the tank and its water, making a 1900-L (500-gal) tank and its water about 2268 kg (2.5 tons). [**1901:** A.10.1]

If the finished apparatus is not to be overloaded, the purchaser should provide the contractor with the weight of equipment to be carried if it is in excess of the allowance. [**1901:** A.10.1]

Overloading the vehicle by the manufacturer through design or by the purchaser adding a great deal of equipment after the vehicle is in service will materially reduce the life of the vehicle and will undoubtedly result in increased maintenance costs, particularly with respect to the transmissions, clutches, and brakes. Overloading can also seriously affect handling characteristics, making steering particularly difficult. [**1901:** A.10.1]

Fire apparatus should be able to perform its intended service under adverse conditions that might require operation off paved streets or roads. Chassis components should be selected with the rigors of service in mind. [**1901:** A.10.1]

A.4.2.1.2 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 complementary agent systems) might necessitate that the 5 percent allowance for the front axle be exceeded. Where these situations occur, the vehicle manufacturer needs to be consulted to determine the final weight distribution and to confirm that none of the established component weight ratings is exceeded and that the brake performance of the vehicle still complies with this standard.

A.4.2.2.1 Although the measurement of the axle clearance is with tires inflated to highway inflation pressure, it is understood that the actual clearance in soft soil and rough terrain could be less as tires could be deflated somewhat in order to achieve better off-road mobility.

A.4.2.2.2 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:

(1) Fire station restrictions
(2) Access within the airport boundaries

(3) Access outside the airport boundaries, if necessary
(4) Requirements that affect the dimensions of local construction, if applicable
(5) Use regulations, if applicable

A.4.3.1.2 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.4.6 The physical characteristics of an airport can require special suspensions, such as active, passive, or semi-passive, to meet required response times.

A.4.7.2 The mobility and handling characteristics of the vehicle greatly depend on tire selection. The off-pavement tractive limit of a tire is related to the strength of the soil, power available, load, number of driving wheels, tire diameter, tire deflection, contact area, and tread pattern.

To assist the purchaser in providing a site-specific tire description, the following guidelines are recommended:

(1) Facilities with hard off-pavement conditions and small snow accumulations require a low level of flotation. For these conditions the purchaser can specify tires of a relatively small diameter and narrow sectional width operating at a high inflation pressure. This configuration can be made to maximize high-speed performance and handling while the small contact area and resulting poor off-pavement performance will have little if any impact on the effectiveness of the vehicle. A typical example of this configuration is a tire of size 16.00R20 operating within a load range of 4535.9 kg to 5443.1 kg (10,000 lb to 12,000 lb) at an inflation pressure of approximately 586 kPa (85 psi).
(2) Experience has demonstrated that tires with a relatively large diameter and wide sectional width and operating at medium inflation pressure can provide a reasonable compromise between off-pavement mobility needs and on-pavement performance and handling. Tires meeting these specifications are considered to provide reasonable flotation and are suitable for many facilities where soil is not extremely soft or wet and snow accumulations are moderate. A typical example of this configuration is a tire of size 24R21 operating within a load range of 4535.9 kg to 5443.1 kg (10,000 lb to 12,000 lb) at an inflation pressure of approximately 448.2 kPa (65 psi).
(3) Where local conditions require very high flotation to traverse obstacles of deep mud, sand, or snow, the purchaser can specify an even larger tire diameter, a larger tire cross section, a greater tire deflection, lower wheel loads, and reduced tire inflation pressure. These specifications can be made to maximize off-pavement performance, but they can also result in some degradation of high-speed performance and handling characteristics. While such a vehicle has a higher probability of traversing difficult off-road terrain, its effectiveness should also be judged based on the longer response time needed over the paced portion of the access route. A typical example of this configuration is a tire of size 24R21 operating within a load range of 4535.9 kg to 5443.1 kg (10,000 lb to 12,000 lb) at an inflation pressure below 275.8 kPa (40 psi) with severe restrictions to top speed capability. The purchaser can also consider devices capable of providing reliable control of the tire inflation pressure while the vehicle is in motion as a means of broadening the overall performance envelope.

A.4.8 Recovery of the vehicle from adverse conditions should be made by attaching the vehicle to the axles.

A.4.9.1 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.4.9.2 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.4.11.4.2 The illuminated instruments and backlighting should not reflect on the windshield or distract the driver operators with a direct reflection.

A.4.11.4.7 A detailed description of the navigation system of the DEVS is provided in Annex E. A detailed description of the low visibility enhanced vision system is provided in Annex E.

A.4.11.7 The data acquisition system should be designed to accommodate ARFF specific requirements for on- and off-road, high-shock, high-contaminant operating environments, and the extremely high-data sampling rates that are utilized to provide enough data to historically analyze an accident or incident and for enhancement of driver training and vehicle maintenance information.

A.4.11.8 Where specified, a lateral acceleration force indicator that provides both visual and audio signals and warnings to the driver shall be provided. The sensitivity of the indicator shall be adjustable by the fire department to account for the individual operating capabilities of different vehicles.

A.4.12.10 It is important to consider the need to conserve weight and space on initial response ARFF vehicles. Rapid response, acceleration, top speed, and vehicle stability are vital to the mission. It is, therefore, preferable that tools and equipment above what is necessary to perform initial operations be transported by other means, as needed.

A.4.16 An around-the-pump proportioning system operates with an eductor installed between the water pump discharge and intake. A small flow of water from the water pump discharge passes through the eductor, which creates a vacuum causing foam concentrate to be inducted and discharged into the pump intake. Around-the-pump systems are available with fixed or variable rate proportioning. Manual variable proportioning *[see Figure A.4.16(a)]* is accomplished by an operator controlled metering valve that corresponds to a calibrated rating chart. With this system the operator must determine flow in order to set the metering valve. Automatic variable proportioning systems *[see Figure A.4.16(b)]* rely on a flowmeter monitoring system for total solution flow and foam concentrate flow. The flow data is fed into a microprocesser that provides readout and operator control of the foam solution percentage. Around-the-pump systems are relatively inexpensive, but they have the following limitations:

(1) Water pump intake pressure cannot exceed approximately 69 kPa (10 psi).
(2) Water and foam solution cannot be discharged simultaneously from the pump. Once activated, the system produces foam solution from all open pump discharge outlets.
(3) It is difficult to match foam concentrate with the performance required.
(4) Internal components require frequent maintenance.

Premixed foam systems utilize a separate tank to contain the foam solution that has been premixed at a specific percentage. There are two types of premix systems.

Pressure-type systems use a pressure vessel for the tank and compressed gas, usually nitrogen, to propel the premixed foam solution from the discharge device. These systems are usually installed on quick attack-type apparatus to take advantage of the instant activation feature of this type of foam system. Pressure-type premix systems *[see Figure A.4.16(c)]* have the following limitations:

(1) Fixed foam solution percentage, once the foam solution is prepared.
(2) Size and weight of the pressure vessel.
(3) Pressure limitation of the pressure vessel.
(4) System cannot be recharged while the system is in operation.

Suction-type systems use an atmospheric tank that is connected to the water pump intake. The premixed foam solution is drawn directly into the pump and discharged as required. A suction system can be created by adding the correct amount of foam concentrate to the water tank on the fire apparatus. Suction-type premix systems have the following limitations:

(1) Fixed foam solution percentage, once foam solution is prepared.
(2) Water and foam solution cannot be discharged simultaneously from the pump. Once activated, the system produces foam solution from all open pump discharge outlets.
(3) System is difficult to recharge when system is in operation.
(4) Foam concentrates must be mechanically mixed with water to create foam solution.

CAUTION: Adding foam directly to the water tank on a piece of apparatus that was not specifically designed for premix usage will cause damage to the tank, plumbing, and pump.

Balanced pressure foam proportioning systems are installed on the discharge side of the water pump. Two orifices discharge water and foam concentrate into a common ratio controller (proportioned) located in the water pump discharge. By adjusting the area of the orifices to a particular ratio, the percent of injection can be adjusted if inlet pressures are equal. The method of controlling or balancing the foam concentrate pressure with the water pressure varies with different balanced pressure system designs. The two basic methods of balancing the pressures are systems without a foam concentrate pump and systems with a concentrate pump.

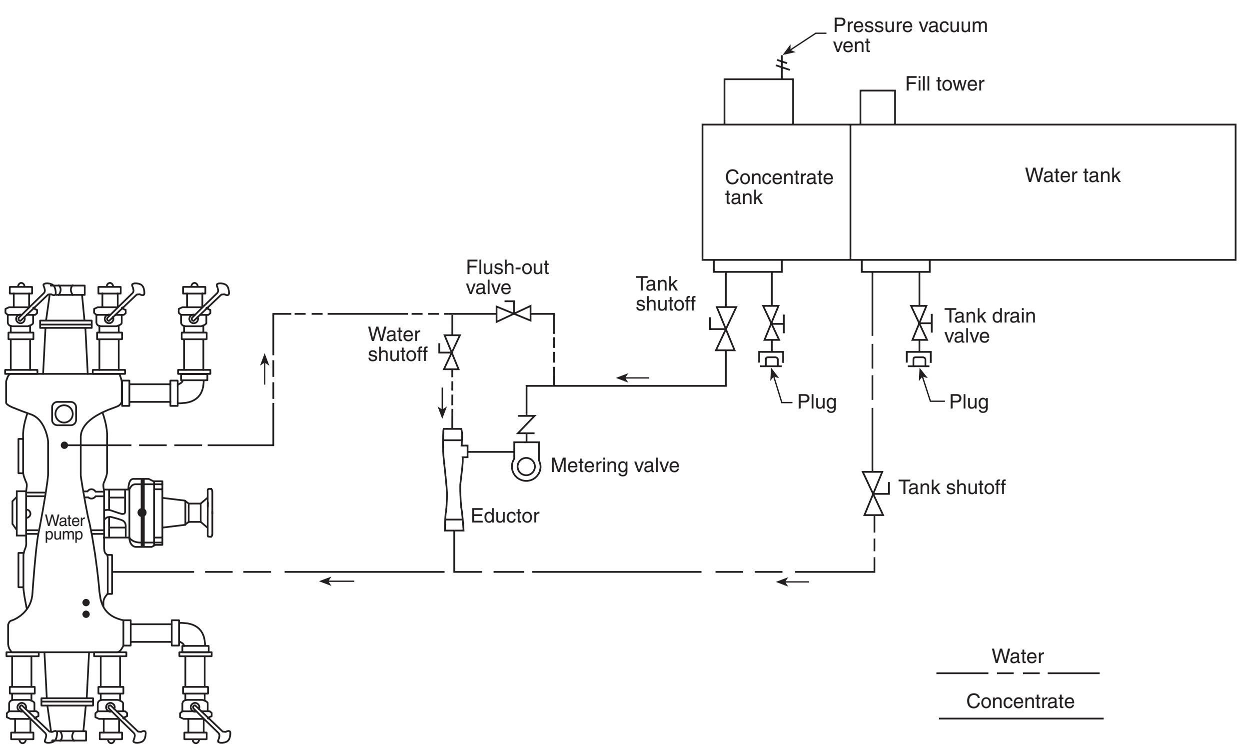

FIGURE A.4.16(a) Manual variable metering, around-the-pump proportioning system.

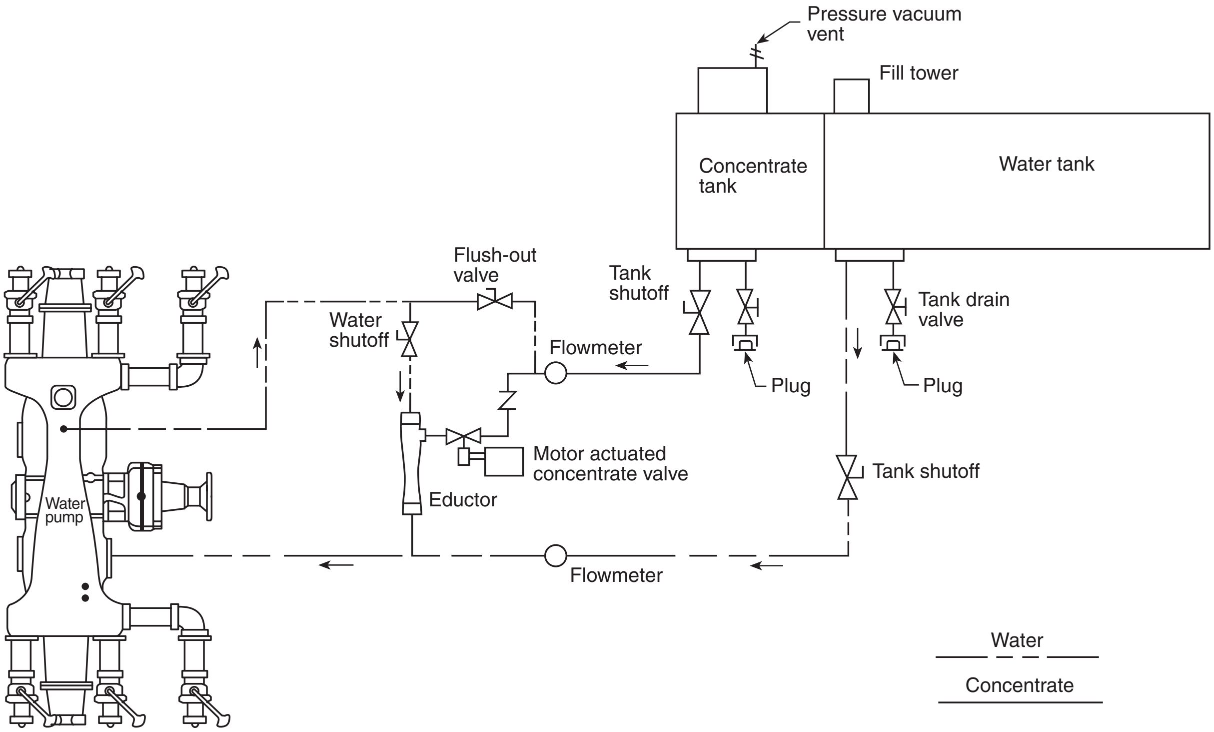

FIGURE A.4.16(b) Automatic variable metering, around-the-pump proportioning system.

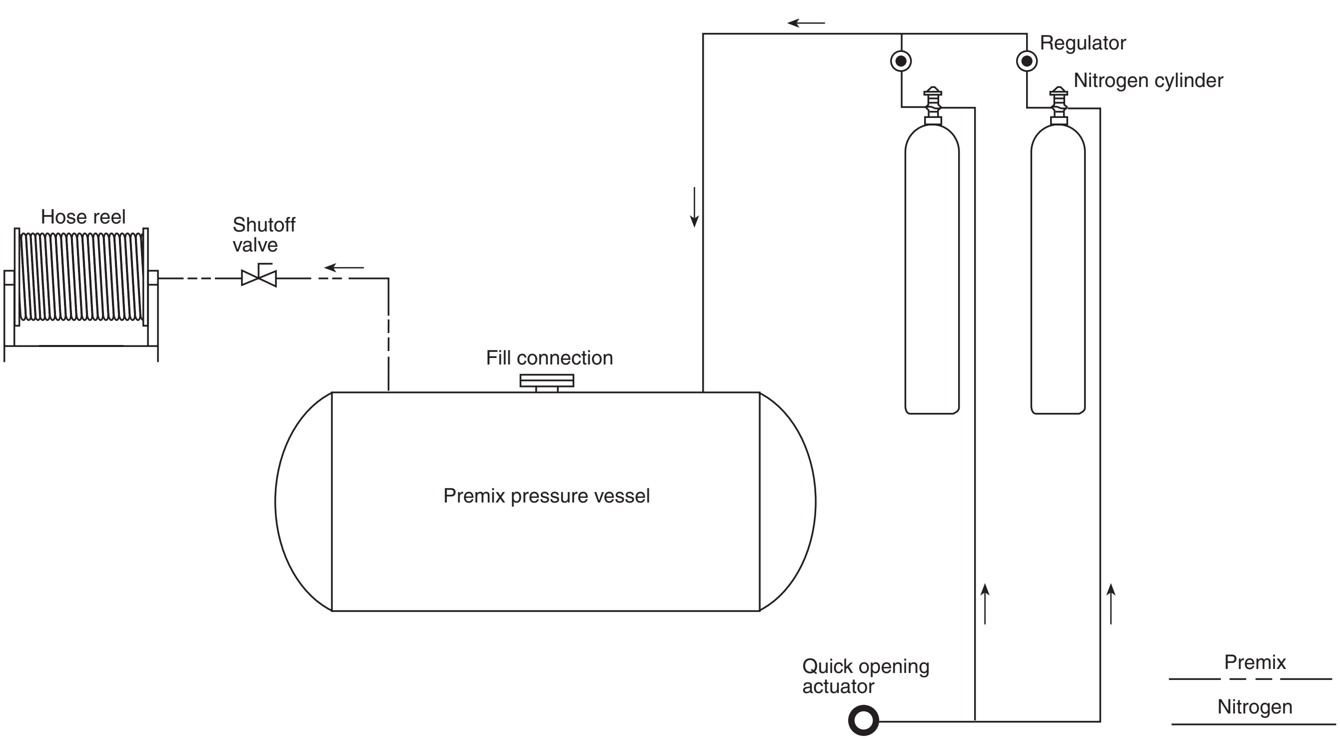

FIGURE A.4.16(c) Pressure-type premix system.

Balanced pressure systems without a foam concentrate pump are referred to as "pressure proportioning systems." *[see Figure A.4.16(d)]*. These systems utilize a pressure vessel with an internal bladder to contain the foam concentrate. When in operation, water pump pressure is allowed to enter the pressure vessel and exert pressure on the internal bladder. The foam concentrate is forced out of the bladder to the foam proportioner at a pressure equal to the water pressure. These systems are easy to operate and offer fixed or variable rate proportioning. Pressure proportioning systems have the following limitations:

(1) Size and weight of the pressure vessel
(2) Capacity of the pressure vessel
(3) Pressure limitation of the pressure vessel
(4) Unit cannot be recharged when the system is in operation

A balanced pressure system with a foam concentrate pump can be one of two basic types. A "bypass" *[see Figure A.4.16(e)]* system utilizes a diaphragm valve in the concentrate pump-to-tank line that automatically controls foam pump pressure by bypassing excess foam concentrate back to the tank. A "demand" system *[see Figure A.4.16(f)]* controls the pump speed, which controls pump pressure. Balanced pressure systems have no real operating limitations except by specific design. These systems have no water intake limitations, and discharge capacity and pressure are limited only by design. Foam solution can be discharged from any water pump outlet, equipped with a proportioning device, at various percentage rates up to system design capacity. Water and foam solution can be discharged simultaneously from the water pump. Accurate foam proportioning is available over a wide range of flow and pressure. The foam concentrate pump can be used to refill the foam concentrate tank at any time, even when the system is operating.

Balanced pressure foam proportioning systems are more complex than other types of systems and generally more expensive. However, they have the following advantages:

(1) There is no water inlet pressure limitation.
(2) Discharge capacity is limited only by design.
(3) Foam solution can be discharged from any water pump outlet equipped with a proportioning device at various percentage rates up to the system design capacity.
(4) Water and foam solution can be discharged simultaneously.

Direct injection foam proportioning systems *[see Figure A.4.16(g)]* utilize a foam concentrate pump to inject foam concentrate directly into the water pump discharge. A flowmeter(s) is installed into the water pump discharge to measure the water flow rate. The flowmeter(s) signal is used by a microprocessor to control the output of the foam concentrate pump. A measurement of the foam concentrate pump output is fed back to the microprocessor to maintain the foam concentrate flow rate at the proper proportion to the water flow rate. Direct injection systems have no real operating limitations except by specific design. Water and foam solution can be discharged simultaneously from the water pump. Accurate foam proportioning is available over a wide range of flow and pressure. Direct injection systems have the following advantages:

(1) They do not introduce a pressure loss into the water pump discharge.
(2) They automatically adapt to changing water pump inlet or discharge pressure conditions.
(3) They are simple to operate.
(4) The foam concentrate can be refilled during operation.
(5) Injection rates are operator adjustable.

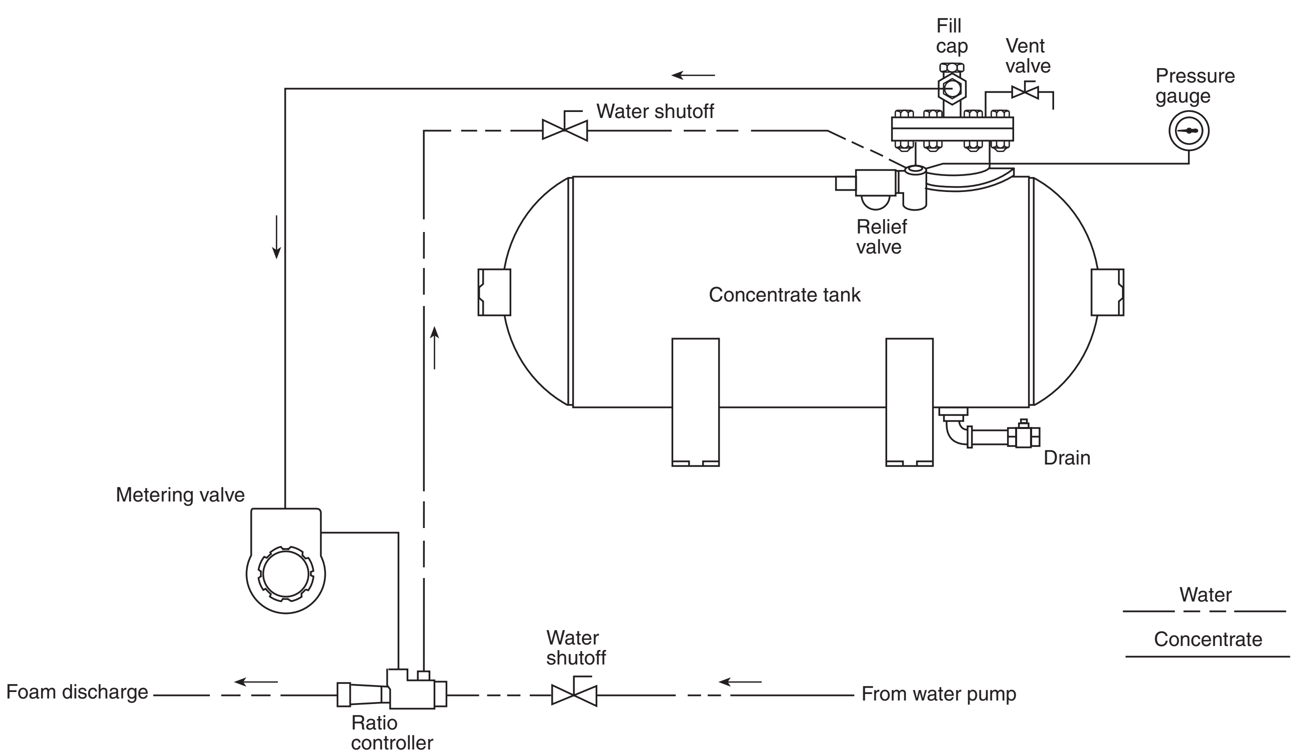

FIGURE A.4.16(d) Pressure proportioning system.

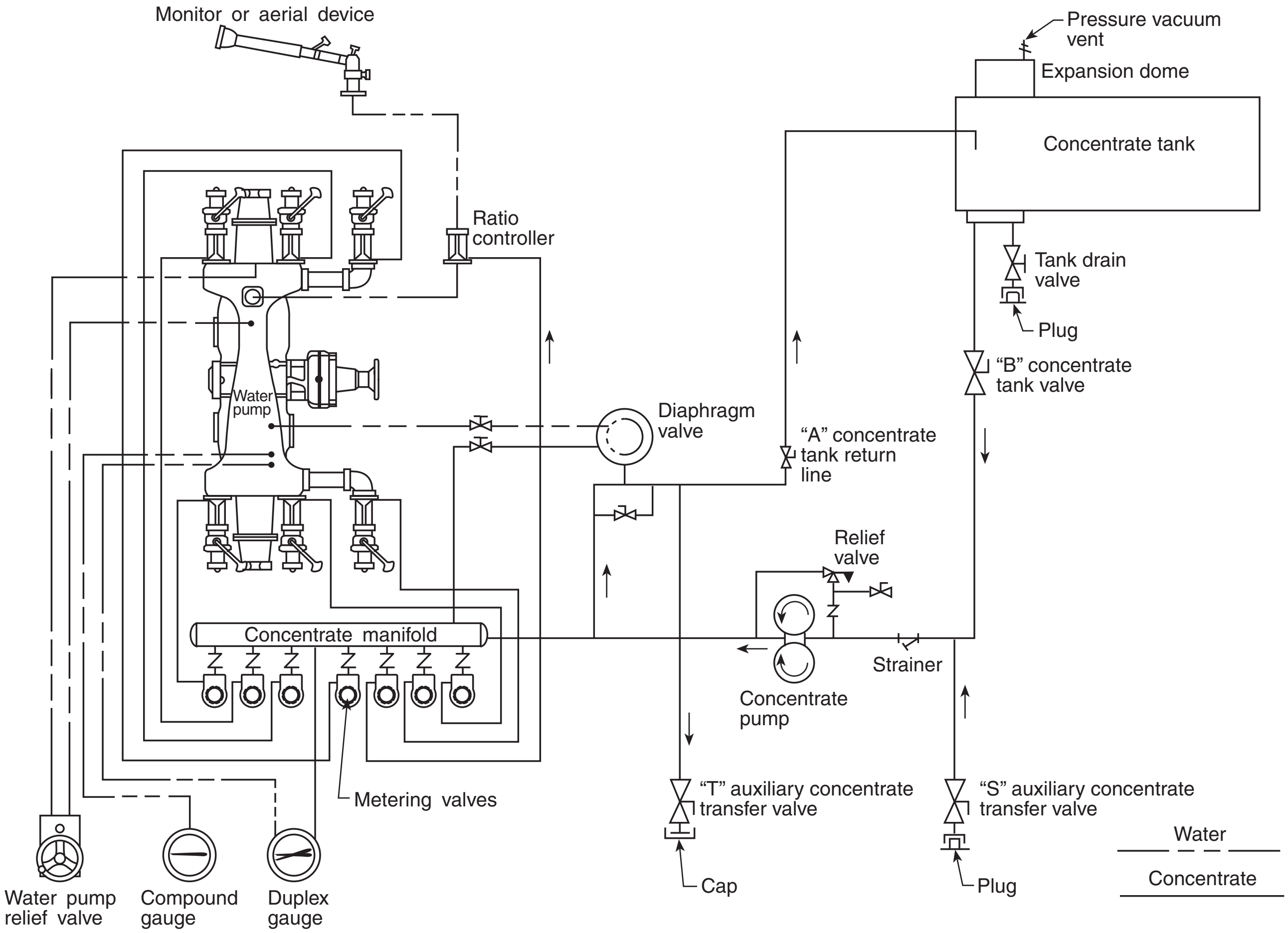

FIGURE A.4.16(e) Bypass balanced pressure proportioning system.

Compressed air foam systems (CAFS) *[see Figure A.4.16(h)]* are a derivation of the direct injection foam proportioning system. This type of system incorporates an onboard foam agent pump and air compressor in conjunction with a water pump. The foam agent system monitors water flow with a flow meter installed in the water pump discharge. Foam agent pump output is regulated by an agent metering control unit that provides accurate control of the foam agent percent of injection. Air injection is controlled by an air pressure regulator. Foam agent and compressed air are properly mixed by a mixer unit installed in the water pump discharge.

A.4.16.3.1 Polyvinyl chloride, epoxies, and polyesters are among the acceptable classes of resins.

A.4.18.6 The need for a practical, high-rise/high-reach/elevating/extendable waterway (device) to replace conventional turrets as the principal fire extinguishing agent applicator on ARFF vehicles has been recognized for over two decades. Equipment intended to provide the capability for ARFF vehicles has been under development for the past decade, and devices that are operationally practical in the ARFF service environment have become available.

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 4.18.6 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 might 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. Pre-

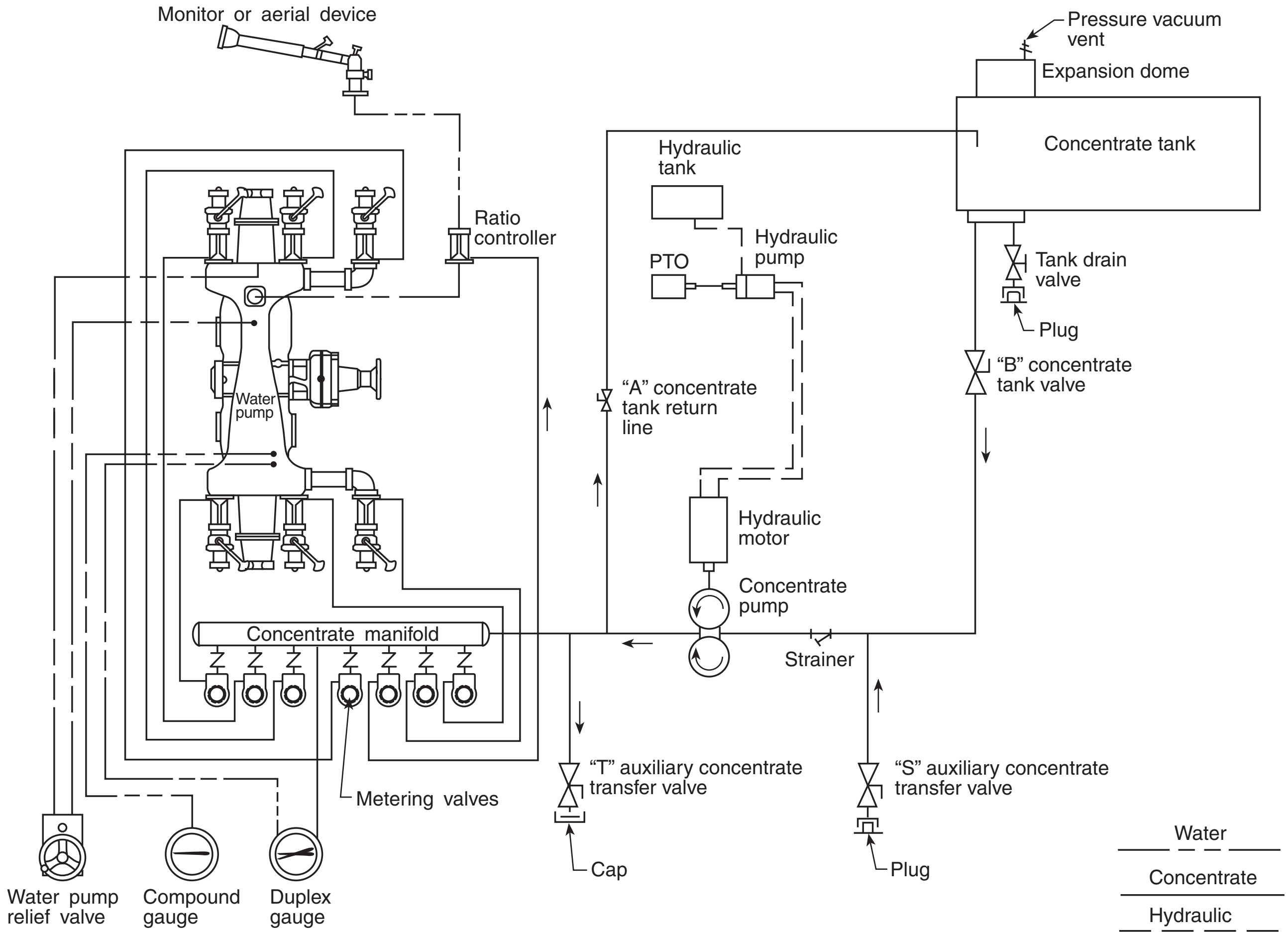

FIGURE A.4.16(f) Demand balanced pressure proportioning system.

liminary 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 primary 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 handlines (as specified in 4.16.4.3) 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.4.18.6(6) The proposed concept would be to penetrate above overwing window areas, above interior seat back height, and below baggage storage bins. Providing water extinguishment from ceiling to floor for a distance of 9.1 m to 12.2 m (30 ft to 40 ft) along the fuselage left and right of the centerline of the penetration point would stop fire growth and protect the interior until other vehicles could extinguish the outside exterior fuel fire.

A.4.21 It is important to consider the need to conserve weight and space on initial response ARFF vehicles. Rapid response, acceleration, top speed, and vehicle stability are vital to the mission.

It is, therefore, preferable that tools and equipment above what is necessary to perform initial operations be transported by other means, as needed.

The purchaser should specify the particular item required for the following:

(1) One ground ladder that meets the requirements of NFPA 1931, *Standard on Design of and Design Verification Tests for Fire Department Ground Ladders*
(2) One section of hose of minimum 63.5-mm (2½-in.) diameter for tank fill

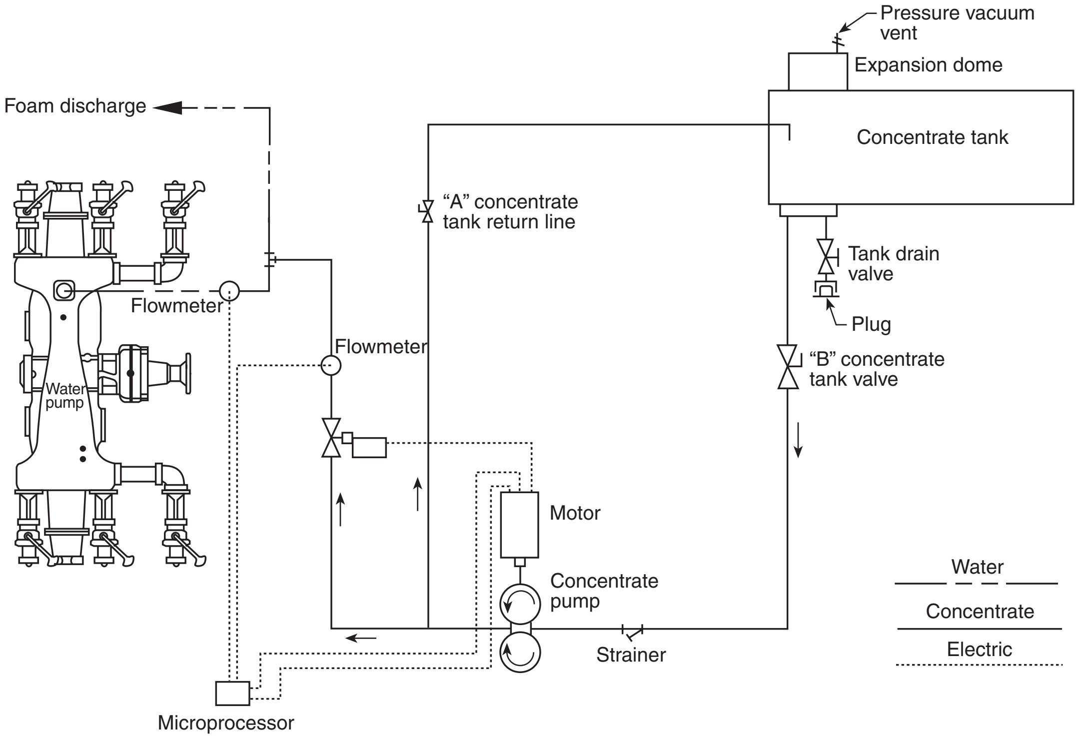

FIGURE A.4.16(g) Direct injection foam proportioning system.

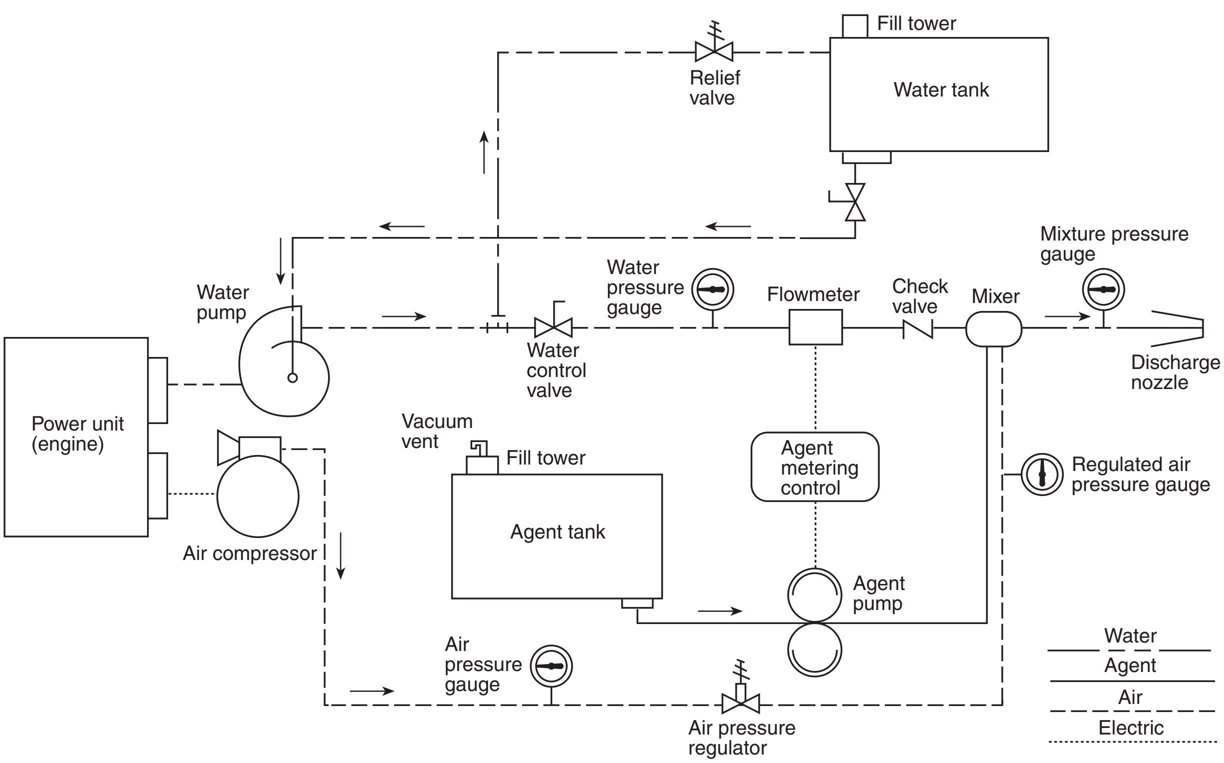

FIGURE A.4.16(h) Compressed air foam system.

(3) Appropriate spanner wrenches for the fittings on the vehicle
(4) One hydrant wrench or other wrench necessary to activate the local water supply
(5) A SCBA meeting the requirements of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, and NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, available for each assigned fire fighter
(6) Skin penetrator/agent applicator
(7) Appropriate wheel chocks
(8) 30.5 m (100 ft) of utility rope
(9) Two axes, non-wedge type
(10) Fire-resistant blanket
(11) Bolt cutters, minimum 609.6 mm (24 in.)
(12) Multipurpose, forcible entry tool
(13) Intrinsically safe handlight(s)
(14) Two harness cutting tools
(15) Hook, grab, or salvage tool
(16) First aid kit
(17) 1.8-kg (4-lb) hammer

For a detailed discussion of rescue tools, see NFPA 402, *Guide 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.4.24.1 The following are lighting options:

(1) Where specified, a minimum 152.4-mm (6-in.) spotlight on both left and right sides of the windshield, hand-adjustable type, with controls for beam adjustment inside the truck cab.
(2) Where specified, a minimum 152.4-mm (6-in.) spotlight mounted on a turret nozzle with a control switch that is readily accessible to the driver.
(3) Where specified, two high-intensity floodlights mounted one on each side of the vehicle to provide illumination of the work area adjacent to the vehicle.
(4) Where specified, two high-intensity fog-type driving-type lights. A protective brush guard shall be provided around each lamp. A switch shall be mounted on the dash in the cab.
(5) Where specified, in addition to the normal vehicle headlight system, two high-intensity driving-type lights. A protective brush guard shall be provided around each lamp. A switch shall be mounted on the dash in the cab.
(6) Where specified, two high-intensity floodlights mounted at the rear of the vehicle that are controlled by a switch in the cab.
(7) Where specified, one map light mounted on each side of the dash.

A.4.24.2 If desired, the driver's siren control can be wired for selective control on the steering wheel horn button. If a combination public address-type siren is desired, an electronic type having an equivalent sound output should be substituted.

A.5.4 Due to the high tilt-table angle that is required in this standard per SAE J 2180, *A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks*, testing to 30 degree tilt angle, vehicle slipping on the table surface can occur. Research has shown that an "open grid deck" product specified as follows resists vehicle traction slippage without impacting the tilt-table angle achieved: IKG Greulich 5-in., 4-way standard open steel grid with 4183# main bars @ 645 mm (7.5 in.) on center, 6.35 mm × 50.8 mm (¼ in. × 2 in.) crossbars @ 95.3 mm (3.75 in.) on center, on 6.35 mm × 25.4 mm (¼ in. × 1 in.) diagonal and supplemental bars.

This product is available from IKG Industries, Harsco Company, P.O. Box 100930, 860 Visco Drive, Nashville, TN 37224-0930; (615)782-4794; (800)467-2346; fax: (615)256-7881.

A.5.4.13.1 This demonstration need not have the penetration device mounted to the finished boom system. This demonstration is a laboratory test to show that the manufacturer understands the requirements of the penetration task requirement.

A.5.4.13.2 This demonstration need not have the penetration device mounted to the finished boom system. This demonstration is a laboratory test to show that the manufacturer understands the requirements of the penetration task requirement.

Annex B Requirements for Low-Voltage Electrical Systems and Warning Devices

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

B.1 Requirements for low-voltage electrical systems and warning devices are covered in NFPA 1901, *Standard for Automotive Fire Apparatus*. The following material is extracted verbatim from Chapter 11, Low-Voltage Electrical Systems and Warning Devices, from the 1999 edition of NFPA 1901, and is included here as a convenience for users of this standard. Any requests for Formal Interpretations (FI) or Tentative Interim Amendments (TIA) on the following material must be directed to the Technical Committee on Fire Department Apparatus.

B.2 General. Any 12-volt or 24-volt electrical systems or warning devices installed on the fire apparatus shall be appropriate for the service intended and shall meet the specific requirements of this chapter. [**1901:**11.1]

B.3 Wiring. All electrical circuit feeder wiring supplied and installed by the apparatus manufacturer shall meet the requirements of this section. [**1901:**11.2]

The wire shall be stranded copper or copper alloy conductors of a gauge rated to carry 125 percent of the maximum current for which the circuit is protected. Voltage drops in all wiring from the power source to the using device shall not exceed 10 percent. The use of star washers for circuit ground connections shall not be permitted. All circuits shall otherwise be wired in conformance with SAE J1292, *Automobile, Truck, Truck-Tractor, Trailer, and Motor Coach Wiring*. [**1901:**11.2.1]

B.3.1 Wiring and Wire Harness Construction. [**1901:**11.2.2]

B.3.1.1 Insulated Wire and Cable. All insulated wire and cable shall conform to SAE J1127, *Battery Cable*; SAE J1128, *Low Tension Primary Cable*, type SXL, GXL, or TXL; or SAE J1560, *Low Tension Thin Wall Primary Cable*. [**1901:**11.2.2.1]

B.3.1.1.1 All conductors shall be constructed in accordance with SAE J1127, *Battery Cable;* SAE J1128, *Low Tension Primary*

Cable; or SAE J1560, *Low Tension Thin Wall Primary Cable,* except when good engineering practice dictates special strand construction. Conductor materials and stranding, other than copper, shall be permitted if all applicable requirements for physical, electrical, and environmental conditions are met as dictated by the end application. [**1901:**11.2.2.1.1]

B.3.1.1.2 Physical and dimensional values of conductor insulation shall be in conformance with the requirements of SAE J1127, *Battery Cable;* SAE J1128, *Low Tension Primary Cable;* or SAE J1560, *Low Tension Thin Wall Primary Cable,* except when good engineering practice dictates special conductor insulation. [**1901:**11.2.2.1.2]

B.3.1.1.3 The overall covering of conductors shall be moisture-resistant loom or braid. This covering shall have a minimum continuous rating of 90°C (194°F) except when good engineering practice dictates special consideration for loom installations exposed to higher temperatures. [**1901:**11.2.2.2]

B.3.1.1.4 The overall covering of jacketed cables shall be moisture resistant and have a minimum continuous temperature rating of 90°C (194°F) except when good engineering practice dictates special consideration for cable installations exposed to higher temperature. [**1901:**11.2.3]

B.3.2 All wiring connections and terminations shall use a method that provides a positive mechanical and electrical connection and shall be installed in accordance with the device manufacturer's instructions. Wire nut insulation displacement and insulation piercing connections shall not be used. [**1901:**11.2.4]

B.3.3 Wiring shall be restrained to prevent damage caused by chafing or ice buildup, and protected against heat, liquid contaminants, or other environmental factors. [**1901:**11.2.5]

B.3.4 Wiring shall be uniquely identified at least every 0.6 m (2 ft) by color coding or permanent marking with a circuit function code. The identification shall reference a wiring schema. *[See 2.11.3(2) of NFPA 1901.]* [**1901:**11.2.6]

B.3.5 Circuits shall be provided with properly rated low-voltage overcurrent protective devices. Such devices shall be readily accessible and protected against heat in excess of the overcurrent device's design range, mechanical damage, and water spray. Circuit protection shall be accomplished by utilizing fuses, circuit breakers, fusible links, or solid state equivalent devices. If a mechanical-type device is used, it shall conform to one of the following SAE standards:

(1) SAE J156, *Fusible Links*
(2) SAE J553, *Circuit Breakers*
(3) SAE J554, *Electric Fuses (Cartridge Type)*
(4) SAE J1888, *High Current Time Lag Electric Fuses*
(5) SAE J2077, *Miniature Blade Type Electrical Fuses*
[**1901:**11.2.7]

B.3.6 Switches, relays, terminals, and connectors shall have a direct current (dc) rating of 125 percent of maximum current for which the circuit is protected. [**1901:**11.2.8]

B.4 Power Supply. [**1901:**11.3]

B.4.1 A 12-volt or 24-volt electrical alternator shall be provided. It shall have a minimum output at idle to meet the minimum continuous electrical load of the apparatus as defined in 11.3.2 of NFPA 1901, at 93°C (200°F) ambient temperature within the engine compartment, and shall be provided with full automatic regulation. [**1901:**11.3.1]

B.4.2 The minimum continuous electrical load shall consist of the total amperage required to simultaneously operate the following in a stationary mode during emergency operations:

(1) The propulsion engine and transmission.
(2) All clearance and marker lights, headlights, and other electrical devices mandated by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, "Lamps, reflective devices, and associated equipment," and other laws or regulations.
(3) The radio(s) at a duty cycle of 10 percent transmit and 90 percent receive. For calculation and testing purposes, a default value of 5 amps continuous shall be used.
(4) The lighting necessary to produce 11 lx (1 footcandle) of illumination on all walking surfaces on the apparatus and on the ground at all egress points onto and off the apparatus, 54 lx (5 footcandles) of illumination on all control and instrument panels, and 50 percent of the total compartment lighting loads.
(5) The minimum optical warning system required in Section 11.8 of NFPA 1901, where the apparatus is blocking the right-of-way.
(6) The continuous electrical current required to simultaneously operate any fire pumps, aerial devices, and hydraulic pumps.
(7) Other warning devices and electrical loads defined by the purchaser as critical to the mission of the apparatus. [**1901:**11.3.2]

B.4.3 The condition of the low-voltage electrical system shall be monitored by a system that provides an audible and visual warning to persons on, in, or near the apparatus of an impending electrical system failure caused by the excessive discharge of the battery set. The charge status of the battery shall be determined either by direct measurement of the battery charge or indirectly by monitoring the system voltage. If system voltage is monitored, the alarm shall sound if the system voltage at the battery or at the master load disconnect switch drops below 11.8 volts for 12-volt nominal systems or 23.6 volts for 24-volt nominal systems for more than 120 seconds. [**1901:**11.3.3]

B.4.4 A voltmeter shall be mounted on the driver's instrument panel to allow direct observation of the system voltage. [**1901:**11.3.4]

B.5 Load Management. [**1901:**11.3.5]

B.5.1 If the total connected electrical load exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 11.3.1 of NFPA 1901, an automatic electrical load management system shall be required. [**1901:**11.3.5.1]

B.5.2 The minimum continuous electrical loads defined in 11.3.2 of NFPA 1901 shall not be subject to automatic load management. [**1901:**11.3.5.2]

B.6 Batteries. [**1901:**11.4]

B.6.1 Batteries shall be of the high-cycle type. [**1901:**11.4.1]

B.6.2 The battery system shall be able to restart the engine after providing the minimum continuous electrical load for at least 10 minutes with the engine off. The minimum continuous electrical load shall not discharge the battery system by more than 50 percent of the reserve capacity rating during the 10-minute period. [**1901:**11.4.2]

B.6.3 The battery system Cold Cranking Amperes (CCA) rating shall meet or exceed the minimum CCA recommendations of the engine manufacturer. [**1901:**11.4.3]

B.6.4 The batteries shall be mounted to prevent movement during apparatus operation and shall be protected against road spray. [**1901:**11.4.4]

B.6.5 The batteries shall be readily accessible for examination, test, and maintenance. [**1901:**11.4.4.1]

B.6.6 Where an enclosed battery compartment is provided, it shall be ventilated to the exterior to prevent the buildup of heat and explosive fumes. The batteries shall also be protected against vibration and temperatures that exceed the battery manufacturer's recommendation. [**1901:**11.4.4.2]

B.6.7 An onboard battery conditioner or charger, or a polarized inlet, shall be provided for charging all batteries. Where an onboard conditioner or charger is supplied, the associated line voltage electrical power system shall be installed in accordance with Chapter 21 of NFPA 1901. [**1901:**11.4.5]

B.6.8 A master load disconnect switch shall be provided between the starter solenoid(s) and the remainder of the electrical loads on the apparatus. The batteries shall be connected directly to the starter solenoid(s). Electronic control systems and similar devices shall be permitted to be otherwise connected if so specified by their manufacturer. [**1901:**11.4.6]

B.6.9 The alternator shall be wired directly to the batteries through the ammeter shunt(s), if one is provided, and not through the master load disconnect switch. [**1901:**11.4.6.1]

B.6.10 A green "battery on" pilot light that is visible from the driver's position shall be provided. [**1901:**11.4.6.2]

B.6.11 To minimize the load placed on the electrical system during apparatus start-up for an emergency response, a sequential switching device shall be permitted to energize the optical warning devices required in 11.3.2 of NFPA 1901 and other high-current devices. Where incorporated, the switching device shall first energize the electrical devices required in 11.3.2 of NFPA 1901 within 5 seconds. [**1901:**11.4.7]

B.7 Starting Device. [**1901:**11.5]

B.7.1 An electrical starting device shall be provided for the engine. [**1901:**11.5.1]

B.7.2 Where the electrical starting device is operating under maximum load, the voltage drop of the conductors between the battery and the starting device shall be in accordance with SAE J541, *Voltage Drop for Starting Motor Circuits.* [**1901:** 11.5.2]

B.8 Temperature Exposure. Any alternator, electrical starting device, ignition wiring, distributor, or ignition coil shall be moisture resistant and protected such that it is not exposed to a temperature that exceeds the component manufacturer's recommendations. [**1901:**11.6]

B.9 Electromagnetic Interference. Electromagnetic interference suppression shall be provided, as required, to satisfy the radiation limits specified in SAE J551-2, *Test Limits and Methods of Measurement of Radio Disturbance Characteristics of Vehicles, Motorboats, and Spark-Ignited Engine-Driven Devices.* The purchaser shall indicate if testing and certification under SAE J551-2 is required. [**1901:**11.7]

B.10 Optical Warning Devices. Each apparatus shall have a system of optical warning devices that meets or exceeds the requirements of this section. [**1901:**11.8]

B.10.1 The optical warning system shall consist of an upper and lower warning level. The requirements for each level shall be met by the warning devices in that particular level without consideration of the warning devices in the other level. [**1901:**11.8.1]

B.10.2 For the purpose of defining and measuring the required optical performance, the upper and lower warning levels shall each be divided into four warning zones. The four zones shall be determined by drawing lines through the geometric center of the apparatus at 45 degrees to a line lengthwise of the apparatus through the geometric center. The four zones shall be designated A, B, C, and D in a clockwise direction with zone A to the front of the apparatus. *(See Figure B.10.2.)* [**1901:**11.8.2]

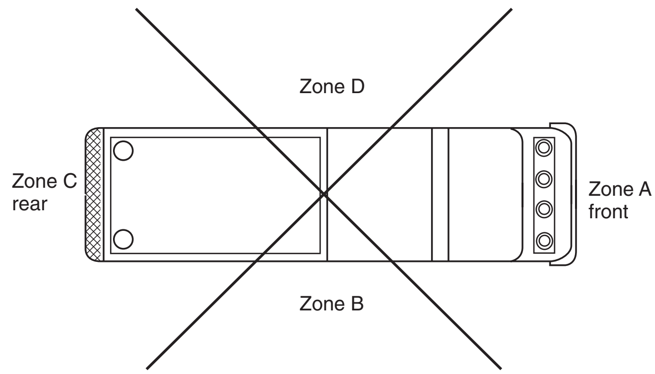

FIGURE B.10.2 Warning zones for optical warning devices. [**1901:**11.8.2]

B.10.3 Each optical warning device shall be installed on the apparatus and connected to the apparatus's electrical system in accordance with the requirements of this standard and the requirements of the manufacturer of the device. [**1901:**11.8.3]

B.10.4 A master optical warning device switch that energizes all of the optical warning devices shall be provided. [**1901:**11.8.4]

B.10.5 The optical warning system on the fire apparatus shall be capable of two separate signaling modes during emergency operations. One mode shall signal to drivers and pedestrians that the apparatus is responding to an emergency and is calling for the right-of-way. The other mode shall signal that the apparatus is stopped and is blocking the right-of-way. [**1901:**11.8.5]

B.10.6 A switching system shall be provided that senses the position of the parking brake or the park position of an automatic transmission. When the master optical warning system switch is closed and the parking brake is released or the automatic transmission is not in park, the warning devices signaling the call for the right-of-way shall be energized. When the master optical warning system switch is closed and the parking brake is on or the automatic transmission is in park, the warning devices signaling the blockage of the right-of-way shall be energized. The system shall be permitted to have a method of modifying the two signaling modes. [**1901:**11.8.6]

B.10.7 The optical warning devices shall be constructed or arranged so as to avoid the projection of light, either directly or through mirrors, into any driving or crew compartment(s). [**1901:**11.8.7]

B.10.8 The front optical warning devices shall be placed so as to maintain the maximum possible separation from the headlights. [**1901:**11.8.8]

B.10.9 The optical sources on each level shall be of sufficient number and arranged so that failure of a single optical source does not create a measurement point, in any zone on the same level as the failed optical source, without a warning signal at a distance of 30 m (100 ft) from the geometric center of the apparatus. [**1901:**11.8.9]

B.11 Flash Rate. [**1901:**11.8.10]

B.11.1 The minimum flash rate of any optical source shall be 75 flashes per minute, and the minimum number of flashes at any measurement point shall be 150 flashes per minute. [**1901:**11.8.10.1]

Steady burning nonflashing optical sources shall be permitted to be used. The optical energy provided by these nonflashing optical sources shall not be included in the calculations of the zone's total optical power. [**1901:**11.8.10.1]

B.11.2 The flasher of any current-interrupted flashing device shall otherwise meet the requirements of SAE J1054, *Warning Lamp Alternating Flashers.* [**1901:**11.8.10.2]

B.11.3 Permissible colors or combinations of colors in each zone, within the constraints imposed by applicable laws and regulations, shall be as shown in Table B.11.3. All colors shall be as specified in SAE J578, *Color Specification*, for white, red, yellow, or blue. [**1901:**11.8.11]

Table B.11.3 Zone Colors [**1901:**11.8.11]

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

B.11.4 Requirements for Large Apparatus. If the apparatus has a bumper-to-bumper length of 6.7 m (22 ft) or more or has an optical center on any optical warning device greater than 2.4 m (8 ft) above level ground, the requirements of 11.8.12.1 through 11.8.12.5 of NFPA 1901 shall apply. [**1901:**11.8.12]

B.11.4.1 The upper-level optical warning devices shall be mounted as high and as close to the corner points of the apparatus as is practical in order to define the clearance lines of the apparatus. However, these optical warning devices shall not be mounted above the maximum height, specified by the device manufacturer, that gives an intensity value at 1.2 m (4 ft) above level ground and 30.5 m (100 ft) from the optical warning device of less than 50 percent of that required at the optical center. [**1901:**11.8.12.1]

B.11.4.2 In order to define the clearance lines of the apparatus, the optical center of the lower-level optical warning devices in the front of the vehicle shall be mounted forward of the front axle centerline and as close to the front corner points of the apparatus as is practical. The optical center of the lower-level optical warning devices at the rear of the vehicle shall be mounted behind the rear axle centerline and as close to the rear corners of the apparatus as is practical. The optical center of any lower-level device shall be between 457 mm and 1575 mm (18 in. and 62 in.) above level ground. [**1901:**11.8.12.2]

B.11.4.3 A midship optical warning device shall be mounted on both the right and left sides of the apparatus with the optical center of the device at a distance between 457 mm and 1575 mm (18 in. and 62 in.) above level ground if the distance between the front and rear lower-level optical devices exceeds 7.6 m (25 ft) at the optical center. Additional midship optical warning devices shall be required, where necessary, to maintain a horizontal distance between the centers of adjacent lower-level optical warning devices of 25 ft (7.6 m) or less. [**1901:**11.8.12.3]

B.11.4.4 For each operating mode, the combined optical power of all the optical sources shall meet or exceed the zone total optical power requirements shown in Table B.11.4.4. [**1901:**11.8.12.4]

B.11.4.5 No individual measurement point shall be less than that shown in Table A.2.4.1(b). [**1901:**11.8.12.5]

B.11.5 Requirements for Small Apparatus. If the apparatus has a bumper-to-bumper length of less than 6.7 m (22 ft) and has the optical center of all optical warning devices at 2.4 m (8 ft) or less above level ground, the requirements of 11.8.13.1 through 11.8.13.4 of NFPA 1901 shall apply. [**1901:**11.8.13]

B.11.5.1 The upper-level optical warning devices shall be mounted as high as practical, but not over 2.4 m (8 ft), at the optical center. They shall be permitted to be combined in one or more enclosures and shall be permitted to be mounted on the cab roof or any other convenient point. [**1901:**11.8.13.1]

B.11.5.2 One or more lower-level optical warning devices shall be mounted as close as practical to each front corner of the apparatus with the optical center of the device at a distance between 457 mm and 1220 mm (18 in. and 48 in.) above level ground. [**1901:**11.8.13.2]

B.11.5.3 For each operating mode, the combined optical power of all the optical sources mounted on both the upper and lower levels shall meet or exceed the zone's total optical power requirements shown in Table B.11.5.3. [**1901:**11.8.13.3]

No individual measurement point shall be less than that shown in Table B.11.5.3. [**1901:**11.8.13.4]

B.11.5.4 Tests of Optical Warning Devices. [**1901:**11.8.14]

B.11.5.4.1 Mechanical and Environmental Test. All optical warning devices, including those tested under SAE J595, *Flashing Warning Lamps for Authorized Emergency, Maintenance, and Service Vehicles*, and SAE J1318, *Gaseous Discharge Warning Lamp for Authorized Emergency, Maintenance, and Service Vehicles*, shall be tested in conformance with SAE J845, *360 Degree Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles.* All devices shall comply with the following performance requirements of that standard:

(1) Vibration
(2) Moisture
(3) Dust
(4) Corrosion
(5) High temperature
(6) Low temperature

Table B.11.4.4 Minimum Optical Power Requirements for Large Apparatus [**1901:**Table 11.8.12.4]

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

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

Table B.11.5.3 Minimum Optical Power Requirements for Small Apparatus [**1901:**Table 11.8.13.3]

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

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

(7) Durability
(8) Warpage

Exception: Optical devices and components designed for mounting only in weatherproof, interior spaces shall be required to comply only with the vibration test and the warpage test for plastic components.[**1901:**11.8.14.1]

B.11.5.4.2 Photometric Test Procedures for Optical Devices. Testing shall be performed by, or on behalf of, the device manufacturer to ensure compliance with the requirements of 11.8.14.2.1 through 11.8.14.2.4 of NFPA 1901. The results of the testing shall be used by the apparatus builder or purchaser to determine compliance with this standard. The goniometer, integrating photometer, and other equipment used to take the test measurements shall meet the requirements of SAE J1330, *Photometry Laboratory Accuracy Guidelines*. [**1901:**11.8.14.2]

B.11.5.4.2.1 The optical source shall be mounted in a goniometer and operated as it would be in a normal system application. The minimum distance between the light emitting surface of the source being tested and the front face of the photometer detector shall be 18 m (59 ft). The goniometer shall be oriented and the integrating photometer shall be set to integrate light pulses from the source for 20 seconds. [**1901:**11.8.14.2.1]

B.11.5.4.2.2 For all tests performed with the power applied, the lighting system, or component thereof, shall be operated at 12.8 volts ±0.1 volt for 12-volt rated equipment and 25.6 volts ±0.2 volt for 24-volt rated equipment measured at the point of entry into the component. If the equipment is rated for operation on both 12 volts and 24 volts, the tests shall be performed at both voltages. [**1901:**11.8.14.2.2]

B.11.5.4.2.3 The technique described in 11.8.14.2.1 of NFPA 1901 shall be performed along the horizontal plane that passes through the optical center beginning at the optical center and repeated at 5-degree intervals to the left and right of the optical center throughout the active horizontal angle of light emission of the optical source. [**1901:**11.8.14.2.3]

B.11.5.4.2.4 Measurements shall be repeated at 5 degrees up and 5 degrees down from the horizontal plane that passes through the optical center beginning at a point on a line passing through the optical center and perpendicular to the horizontal plane and passing through the optical center. The measurements shall be repeated at 5-degree intervals to the left and right of this line throughout the active horizontal angle of light emission of the optical source. If the optical warning device contains more than one optical source, the test shall be repeated for each optical source. [**1901:**11.8.14.2.4]

B.11.5.5 Certification of Compliance. The apparatus manufacturer shall be permitted to demonstrate compliance of the warning system by one of the following methods:

(1) Certification that the system was installed within the geometric parameters specified by the manufacturer of the system and referencing the optical source test reports provided by the manufacturer of the system.
(2) Certification that a mathematical calculation performed by a qualified person demonstrates that the combination of individual devices as installed meets the requirements of this standard. This calculation shall be based on test reports for individual optical sources provided by the manufacturer of the device.
(3) Actual measurement of the lighting system after installation on the apparatus. [**1901:**11.8.15]

B.11.6 Audible Warning Devices. [**1901:**11.9]

B.11.6.1 Audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren shall be provided. The siren manufacturer shall certify the siren as meeting the requirements of SAE J1849, *Emergency Vehicle Sirens*. A means shall be provided to allow the activation of the siren within convenient reach of the driver. [**1901:**11.9.1]

B.11.6.2 Where furnished, air horns, electric siren(s), and electronic siren speaker(s) shall be mounted as low and as far forward on the apparatus as practical. Audible warning equipment shall not be mounted on the roof of the apparatus. [**1901:**11.9.2]

B.11.7 Work Lighting. [**1901:**11.10]

B.11.7.1 The work area immediately behind the vehicle shall be illuminated to a level of at least 33 lx (3 footcandles) within a 3 m × 3 m (10 ft × 10 ft) square to the rear of the vehicle. If a hose bed is provided, lighting on this hose bed shall be at a level of 33 lx (3 footcandles) or higher. Lateral hose beds (crosslays) that are permanently covered shall not be required to be illuminated. [**1901:**11.10.1]

B.11.7.2 The apparatus shall be equipped with lighting that is capable of providing illumination at a minimum level of 11 lx (1 footcandle) on ground areas within 762 mm (30 in.) of the edge of the apparatus in areas designed for personnel to climb onto the apparatus or descend from the apparatus to the ground level. Lighting designed to provide illumination on areas under the driver and crew riding area exits shall be activated automatically when the exit doors are opened. All other ground area lighting shall be switchable. [**1901:**11.10.2]

B.11.7.3 Apparatus shall have sufficient lighting to provide an average minimum level of 11 lx (1 footcandle) in the crew compartment(s); the engine compartment; the pump compartment; and each enclosed tool and equipment compartment greater than 0.11 m^3 (4 ft^3) in volume and having an opening greater than 92,900 mm^2 (144 $in.^2$); as well as on all work areas, steps, and walkways. [**1901:**11.10.3]

B.11.7.4 Switches for all work lighting shall be readily accessible. The lights shall be arranged to minimize accidental breakage. [**1901:**11.10.4]

B.11.8 Hazard Light. A red flashing or rotating light, located in the driving compartment, shall be illuminated automatically whenever the apparatus's parking brake is not fully engaged and any of the following conditions exist:

(1) Any passenger or equipment compartment door is open.
(2) Any ladder or equipment rack is not in the stowed position.
(3) Stabilizer system not in its stowed position.
(4) Powered light tower is extended.
(5) Any other device is opened, extended, or deployed that creates a hazard or is likely to cause damage to the apparatus if the apparatus is moved.

The light shall be marked with a sign that reads: "Do Not Move Apparatus When Light Is On." [**1901:**11.11]

B.11.9 Backup Alarm. An electric or electronic backup alarm shall be provided that meets the Type D (87 dBA) requirements of SAE J994, *Alarm — Backup — Electric, Laboratory Performance Testing*. [**1901:**11.12]

B.11.10 Stop, Tail, and Directional Lights. The apparatus shall be equipped with all stop, tail, and directional lights required by the Federal Motor Vehicle Safety Standard (FMVSS) No. 108, "Lamps, reflective devices, and associated equipment." Equipment shall be mounted so that it will not obscure the rear stop, tail, and directional lights. Directional lights shall be visible from the front, sides, and rear of the apparatus. On apparatus 10 m (30 ft) or longer in length, a turn signal shall be mounted approximately midway along the apparatus at approximately running board height. [**1901:**11.13]

B.11.11 Electrical System Performance Tests. [**1901:**11.14]

B.11.11.1 The apparatus low-voltage electrical system shall be tested and certified. The certification shall be delivered to the purchaser with the apparatus. [**1901:**11.14.1]

B.11.11.2 Tests shall be performed when the air temperature is between 0°F and 110°F (–18°C and 43°C). [**1901:**11.14.2]

B.11.11.3 Test Sequence. The following three tests shall be performed in the order indicated below. Before each test, the batteries shall be fully charged until the voltage stabilizes at the voltage regulator set point and the lowest charge current is maintained for 10 minutes. Failure of any of these tests shall require a repeat of the sequence. [**1901:**11.14.3]

B.11.11.3.1 Reserve Capacity Test. The engine shall be started and kept running until the engine and engine compartment temperatures are stabilized at normal operating temperatures and the battery system is fully charged. The engine shall be shut off and the minimum continuous electrical load shall be activated for 10 minutes. All electrical loads shall be turned off prior to attempting to restart the engine. The battery system shall then be capable of restarting the engine. Failure to restart the engine shall be considered a test failure. [**1901:**11.14.3.1]

B.11.11.3.2 Alternator Performance Test at Idle. The minimum continuous electrical load shall be activated with the engine running at idle speed. The engine temperature shall be stabilized at normal operating temperature. The battery system shall be tested to detect the presence of battery discharge current. The detection of battery discharge current shall be considered a test failure. [**1901:**11.14.3.2]

B.11.11.3.3 Alternator Performance Test at Full Load. The total continuous electrical load shall be activated with the engine running up to the engine manufacturer's governed speed. The test duration shall be a minimum of 2 hours. Activation of the load management system shall be permitted during this test. However, an alarm sounded by excessive battery discharge, as detected by the system required in 11.3.3 of NFPA 1901, or a system voltage of less than 11.7 volts dc for a 12-volt nominal system or 23.4 volts dc for a 24-volt nominal system, for more than 120 seconds, shall be considered a test failure. [**1901:**11.14.3.3]

B.11.11.4 Low-Voltage Alarm Test. [**1901:**11.14.4]

B.11.11.4.1 Following the completion of the above tests, the engine shall be shut off. The total continuous electrical load shall be activated and shall continue to be applied until the excessive battery discharge alarm activates. [**1901:**11.14.4.1]

B.11.11.4.2 The battery voltage shall be measured at the battery terminals. With the load still applied, a reading of less than 11.7 volts dc for a 12-volt nominal system or 23.4 volts dc for a 24-volt nominal system shall be considered a test failure. [**1901:**11.14.4.2]

B.11.11.4.3 The battery system shall then be able to restart the engine. Failure to restart the engine shall be considered a test failure. [**1901:**11.14.4.3]

B.11.12 Documentation. At the time of delivery, the manufacturer shall provide the following:

(1) Documentation of the electrical system performance tests
(2) A written load analysis, including the following:
    (a) The nameplate rating of the alternator
    (b) The alternator rating under the conditions specified in 11.3.1 of NFPA 1901
    (c) Each component load specified in 11.3.2 of NFPA 1901 comprising the minimum continuous load
    (d) Additional loads that, when added to the minimum continuous load, determine the total connected load
    (e) Each individual intermittent load [**1901:**11.15]

B.11.13 Where specified, auxiliary generators shall be installed in accordance with NFPA 1901, *Standard for Automotive Fire Apparatus*, Chapter 21. The following material is extracted verbatim from the 1999 edition of NFPA 1901 and is included here as a convenience for users of this standard.

B.11.13.1 Application. Where any part of a line voltage electrical system is provided as a fixed installation, the applicable requirements of this chapter shall apply. [**1901:**21.1]

B.11.13.2 General Requirements. [**1901:**21.2]

B.11.13.2.1 The maximum voltage between any conductor and any other conductor or an earth ground shall not exceed 250 volts ±10 percent. [**1901:**21.2.1]

B.11.13.2.2 Any fixed line voltage power source producing alternating current (ac) line voltage shall produce electric power at 60 cycles ±5 cycles. [**1901:**21.2.2]

B.11.13.2.3 Except where superseded by the requirements of this chapter, all components, equipment, and installation procedures shall conform to NFPA 70, *National Electrical Code*® (herein referred to as the *NEC*®). Where the requirements of this chapter differ from those in the NEC, the requirements in this chapter shall apply. [**1901:**21.2.3]

B.11.13.2.4 When available, line voltage electrical system equipment and materials included on the apparatus shall be listed and used only in the manner for which they have been listed. All equipment and materials shall be installed in accordance with the manufacturer's instructions. [**1901:**21.2.4]

B.11.13.2.5 Location Ratings. [**1901:**21.2.5]

B.11.13.2.5.1 Any equipment used in a dry location shall be listed for dry locations. [**1901:**21.2.5.1]

B.11.13.2.5.2 Any equipment used in a wet location shall be listed for wet locations. [**1901:**21.2.5.2]

B.11.13.2.5.3 Any equipment used in an under-body or under-chassis location that is subject to road spray shall be either listed as Type 4 or mounted in an enclosure that is listed as Type 4. [**1901:**21.2.5.3]

B.11.13.3 Grounding and Bonding. [**1901:**21.3]

B.11.13.3.1 Grounding. Grounding shall be in accordance with Section 250.6, Portable and Vehicle-Mounted Generators, of the *NEC.* Ungrounded systems shall not be used. Only stranded or braided copper conductors shall be used for grounding and bonding. [**1901:**21.3.1]

B.11.13.3.1.1 An equipment grounding means shall be provided in accordance with Section 250.91, Material, of the *NEC.* [**1901:**21.3.1.1]

B.11.13.3.1.2 The grounded current-carrying conductor (neutral) shall be insulated from the equipment grounding conductors and from the equipment enclosures and other grounded parts. The neutral conductor shall be colored white or gray in accordance with Section 200.6, Means of Identifying Grounded Conductors, of the *NEC.* [**1901:**21.3.1.2]

B.11.13.3.1.3 Any bonding screws, straps, or buses in the distribution panelboard or in other system components between the neutral and equipment grounding conductor shall be removed and discarded. [**1901:**21.3.1.3]

B.11.13.3.2 Bonding. [**1901:**21.3.2]

B.11.13.3.2.1 The neutral conductor of the power source shall be bonded to the vehicle frame. The neutral bonding connection shall only occur at the power source. [**1901:**21.3.2.1]

B.11.13.3.2.2 In addition to the bonding required for the low-voltage return current, each body and each driving or crew compartment enclosure shall be bonded to the vehicle frame by a copper conductor. This conductor shall have a minimum amperage rating of 115 percent of the nameplate current rating of the power source specification label as defined in Section 310.15, Ampacities, of the *NEC.* A single conductor that is sized to meet the low-voltage and line voltage requirements shall be permitted to be used. [**1901:**21.3.2.2]