# NFPA® 1910

# Standard for the Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels

## 2024 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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ISBN: 978-145593029-6 (Print)

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**NFPA® 1910**

**Standard for the**

# Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels

**2024 Edition**

This edition of NFPA 1910, *Standard for the Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels*, was prepared by the Technical Committees on Fire Department Apparatus, Marine Firefighting Vessels, and Emergency Vehicle Technicians Professional Qualifications, released by the Correlating Committee on Professional Qualifications. It was issued by the Standards Council on October 7, 2022, with an effective date of October 27, 2022.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition of NFPA 1910 was approved as an American National Standard on October 27, 2022.

## Origin and Development of NFPA 1910

This first edition of NFPA 1910, *Standard for the Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels*, is the result of the consolidation of legacy standards NFPA 1071, NFPA 1911, NPFA 1912, and NFPA 1925. The consolidation plan, which affects all documents in the Emergency Response and Responder Safety (ERRS) project, was approved during the April 2019 Standards Council meeting.

Many of the changes that have been made for this edition are related to the consolidation of the legacy standards NFPA 414, NFPA 1901, NFPA 1906, and NFPA 1917 into NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances*. Those changes include renumbering throughout the entire document and updating of the cross references. For the text in NFPA 1071 and NFPA 1925, few additional edits have been made because the last editions of those legacy standards were issued just prior to the consolidation plan being put into place.

Many of the changes made to the NFPA 1911 and NFPA 1912 content are based on the changes that were made to NFPA 1900. The fire department apparatus technical committee made a significant number of changes for the first edition of NFPA 1900, many of which needed to carry over into the content for which the technical committee is responsible in NFPA 1910 because the NFPA 1911 and NFPA 1912 content is derived from NFPA 1900 and consistency between the documents needs to be maintained.

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

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**Committee Scope:** This Committee shall have primary responsibility for documents on professional qualifications required of personnel engaged in the diagnosis, maintenance, and repair of systems and components that are unique to emergency response vehicles.

## Contents

**NFPA 1910**

**Standard for the**

# Inspection, Maintenance, Refurbishment, Testing, and Retirement of In-Service Emergency Vehicles and Marine Firefighting Vessels

**2024 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. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

## Chapter 1 Administration

### 1.1 Scope.

**1.1.1** This standard defines the minimum requirements for establishing an inspection, maintenance, refurbishment, retirement, and testing program for in-service emergency vehicles and marine firefighting vessels.

**1.1.2** This standard shall provide minimum requirements for marine firefighting vessels.

**1.1.3** This standard identifies the minimum job performance requirements (JPRs) for emergency vehicle technicians.

### 1.2 Purpose.

**1.2.1** The purpose of this standard is to provide requirements for an inspection, maintenance, refurbishment, retirement, and testing program that will ensure that in-service emergency vehicles and marine firefighting vessels are serviced and maintained to keep them in safe operating condition and ready for response at all times.

**1.2.2** The purpose of this standard shall be to provide the minimum requirements for the construction of new marine firefighting vessels or for the conversion of existing vessels to become marine firefighting vessels.

**1.2.3** The purpose of this standard is to specify the minimum JPRs for service as an emergency vehicle technician.

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

(1) Chapters 1 through 3, Chapters 4 through 28, Annexes A through D, and Annex L constitute NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles.*
(2) Chapters 1 through 3, Chapters 29 through 31, and Annexes A, E, F, and L constitute NFPA 1912, *Standard for Fire Apparatus Refurbishing.*
(3) Chapters 1 through 3, Chapters 32 through 48, and Annexes A, G, and L constitute NFPA 1925, *Standard on Marine Fire-Fighting Vessels.*
(4) Chapters 1 through 3, Chapters 49 through 51, and Annexes A, H, I, J, K, and L constitute NFPA 1071, *Standard for Emergency Vehicle Technician Professional Qualifications.*

## Chapter 2 Referenced Publications

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

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

NFPA 10, *Standard for Portable Fire Extinguishers,* 2022 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2021 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2022 edition.

*NFPA 72®, National Fire Alarm and Signaling Code®,* 2022 edition.

NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft,* 2020 edition.

NFPA 303, *Fire Protection Standard for Marinas and Boatyards,* 2021 edition.

NFPA 460, *Standard for Aircraft Rescue and Firefighting Services at Airports, Recurring Proficiency of Airport Fire Fighters, and Evaluating Aircraft Rescue and Firefighting Foam Equipment,* 2024 edition.

NFPA 1002, *Standard for Fire Apparatus Driver/Operator Professional Qualifications,* 2017 edition.

NFPA 1005, *Standard for Professional Qualifications for Marine Fire Fighting for Land-Based Fire Fighters,* 2019 edition.

NFPA 1500™, *Standard on Fire Department Occupational Safety, Health, and Wellness Program,* 2021 edition.

NFPA 1581, *Standard on Fire Department Infection Control Program,* 2022 edition.

NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances,* 2024 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.

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

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

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances,* 2018 edition.

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

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

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

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

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2022 edition.

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

**2.3 Other Publications.**

**2.3.1 ABS Publications.** American Bureau of Shipping, 16855 Northchase Drive, Houston, TX 77060.

*ABS Guidance Notes on Fire-Fighting Systems*, 2005, updated 2015.

*ABS Rules for Conditions of Classification — High Speed Craft*, 2024.

*ABS Rules for Building and Classing Steel Vessels*, 2024.

*ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*, 2024.

*ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*, 2024.

**2.3.2 ABYC Publications.** American Boat and Yacht Council, 613 Third Street, Suite 10, Annapolis, MD 21403.

ABYC A-4, *Fire Fighting Equipment*, 2018.

ABYC A-24, *Carbon Monoxide Detection Systems*, 2020.

ABYC A-27, *Alternating Current (AC) Generator Sets*, 2016.

ABYC A-28, *Galvanic Isolators*, 2019.

ABYC A-31, *Battery Chargers and Inverters,* 2020.

ABYC E-2, *Cathodic Protection*, 2019.

ABYC E-10, *Storage Batteries*, 2016.

ABYC E-11, *AC and DC Electrical Systems on Boats*, 2018.

ABYC H-2, *Ventilation of Boats Using Gasoline*, 2013.

ABYC H-3, *Exterior Windows, Windshields, Hatches, Doors, Portlights, and Glazing Materials*, 2019.

ABYC H-24, *Gasoline Fuel Systems*, 2017.

ABYC H-25, *Portable Marine Gasoline Fuel Systems*, 2016.

ABYC H-26, *Powering of Boats*, 2016.

ABYC H-32, *Ventilation of Boats Using Diesel Fuel*, 2018.

ABYC H-33, *Diesel Fuel Systems*, 2016.

ABYC H-40, *Anchoring, Mooring, and Strong Points*, 2019.

ABYC P-1, *Installation of Exhaust Systems for Propulsion and Auxiliary Engines,* 2019.

ABYC P-4, *Marine Inboard Engines and Transmissions*, 2019.

ABYC P-6, *Propeller Shafting Systems*, 2021.

ABYC P-14, *Mechanical Propulsion Control Systems*, 2020.

ABYC P-17, *Mechanical Steering Systems*, 2018.

ABYC P-18, *Cable Over Pulley Steering Systems for Outboard Engines*, 2018.

ABYC P-21, *Manual Hydraulic Steering Systems*, 2017.

ABYC P-22, *Steering Wheels*, 2018.

ABYC P-23, *Mechanical Steering and Propulsion Controls for Jet Boats*, 2017.

ABYC P-24, *Electric/Electronic Propulsion Control Systems*, 2013.

ABYC S-30, *Outboard Engine and Related Equipment Weights*, 2017.

*ABYC Standards and Technical Information Reports for Small Craft*, 2021.

ABYC TH-12, *Outboard Engine Mounting Guide*, 2017.

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

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

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

ANSI/NEMA Z535.4, *Product Safety Signs and Labels*, 2011, reaffirmed 2017.

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

ASME B1.20.1, *Pipe Threads, General Purpose, Inch*, 2013, reaffirmed 2018.

ASME B30.5, *Mobile and Locomotive Cranes*, 2018.

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

**2.3.5 ASNT Publications.** American Society for Nondestructive Testing, Inc., P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.

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

**2.3.6 ASTM Publications.** ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM B647, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage*, 2010, reapproved 2016.

ASTM B648, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor*, 2010, reapproved 2015e1.

ASTM E6, *Standard Terminology Relating to Methods of Mechanical Testing*, 2021.

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

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

ASTM E92, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*, 2017.

ASTM E114, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing*, 2021.

ASTM E165/E165M, *Standard Practice for Liquid Penetrant Testing for General Industry*, 2019.

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

ASTM E650/E650M, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*, 2017.

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

ASTM E797/E797M, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*, 2021.

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

ASTM E1220, *Standard Practice for Visible Penetrant Testing Using Solvent-Removable Process*, 2021.

ASTM E1316, *Standard Terminology for Nondestructive Examinations*, 2021.

ASTM E1418, *Standard Practice for Visible Penetrant Testing Using the Water-Washable Process*, 2021.

ASTM F683, *Standard Practice for Selection and Application of Thermal Insulation for Piping and Machinery*, 2021.

**2.3.7 AWS Publications.** American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672.

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

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, 2014.

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

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

**2.3.8 CGA Publications.** Compressed Gas Association, 8484 Westpark Drive, Suite 220, McLean, VA 22102.

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

**2.3.9 FAMA Publications.** Fire Apparatus Manufacturers' Association, P.O. Box 3065, Ocala, FL 34478.

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

*Fire Apparatus Safety Guide*, 2016.

**2.3.10 IMO Publications.** International Maritime Organization, 4 Albert Embankment, London, SE1 7SR, United Kingdom.

IMO A 18, Resolution 749, *Code on Intact Stability for All Types of Ships Covered by IMO Instruments*, 1993 edition.

**2.3.11 ISO Publications.** International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 9244, *Earth-moving machinery — Machine safety labels — General principles*, 2008, reconfirmed, amendment 1, 2016.

ISO 12217-1, *Small craft — Stability and buoyancy assessment and categorization — Part 1: Non-sailing boats of hull length greater than or equal to 6 m*, 2021.

ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection*, 2012, reconfirmed 2017.

ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, process and services*, 2012, reconfirmed 2018.

**2.3.12 US Government Publications.** US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 33, Code of Federal Regulations, Parts 1–124, "Navigation Rules."

Title 46, Code of Federal Regulations, Subchapter C, "Uninspected Vessels."

Title 46, Code of Federal Regulations, Subchapter F, "Marine Engineering."

Title 46, Code of Federal Regulations, Part 56, "Piping Systems and Appurtenances."

Title 46, Code of Federal Regulations, Part 111, "Electric Systems — General Requirements."

Title 46, Code of Federal Regulations, Part 112, "Emergency Lighting and Power Systems."

Title 46, Code of Federal Regulations, Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)."

Title 46, Code of Federal Regulations, Part 197, "Marine Occupational Safety and Health Standards — General."

Title 49, Code of Federal Regulations, Part 399.211, Appendix G, "Minimum Periodic Inspection Standards."

Title 33, United States Code, Parts 1251–1387, "Federal Water Pollution Control Act."

Navigation and Vessel Inspection Circular (NVIC) No. 9-97, Change 1, *Guide to Structural Fire Protection*, US Coast Guard, July 2010.

**2.3.13 Other Publications.**

*Merriam-Webster's Collegiate Dictionary,* 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

**2.4 References for Extracts in Mandatory Sections.**

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2021 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2022 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2020 edition.

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

NFPA 99, *Health Care Facilities Code,* 2021 edition.

NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft,* 2020 edition.

NFPA 1000, *Standard for Fire Service Professional Qualifications Accreditation and Certification Systems,* 2022 edition.

NFPA 1002, *Standard for Fire Apparatus Driver/Operator Professional Qualifications,* 2017 edition.

NFPA 1030, *Standard for Professional Qualifications for Fire Prevention Program Positions,* 2024 edition.

NFPA 1404, *Standard for Fire Service Respiratory Protection Training,* 2018 edition.

NFPA 1405, *Guide for Land-Based Fire Departments That Respond to Marine Vessel Fires,* 2020 edition.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program,* 2018 edition.

NFPA 1900, *Standard for Aircraft Rescue and Firefighting Vehicles, Automotive Fire Apparatus, Wildland Fire Apparatus, and Automotive Ambulances,* 2024 edition.

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

## Chapter 3 Definitions

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

**3.2 NFPA Official Definitions.**

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

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

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

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

**3.2.5 Shall.** Indicates a mandatory requirement.

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

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

**3.3 General Definitions.**

**3.3.1 Acceptance.** An agreement between the purchasing authority and the contractor that the terms and conditions of the contract have been met. [**1900,** 2024]

**3.3.2 Acceptance Tests.** Tests performed on behalf of or by the purchaser at the time of delivery to determine compliance with the specifications for the fire apparatus. [**1900,** 2024]

**3.3.3 Accessible.** Capable of being reached for inspection, maintenance, or removal without disturbing the permanent structure.

**3.3.3.1** ***Readily Accessible.*** Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, and so forth. [**70:**100]

**3.3.4 Accommodation Spaces.** Spaces designed for human occupancy as living spaces for persons aboard a vessel.

**3.3.5 Acoustic Emission Inspection.** A method of nondestructive testing (NDT) that utilizes acoustic or sound waves.

**3.3.6 Adjust.** To maintain or regulate, within prescribed limits, by setting the operating characteristics to specified parameters.

**3.3.7 Aerial Device.** An aerial ladder, elevating platform, or water tower that is designed to position personnel, handle materials, provide continuous egress, or discharge water. [**1900,** 2024]

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

**3.3.9 Aerial Ladder.** A self-supporting, turntable-mounted, power-operated ladder of two or more sections permanently attached to a self-propelled automotive fire apparatus and designed to provide a continuous egress route from an elevated position to the ground. [**1900,** 2024]

**3.3.10 Aerial Ladder Sections.** The structural members of the aerial ladder consisting of the base and fly sections.

**3.3.11 Aircraft Rescue and Firefighting (ARFF) Vehicle.** A vehicle designed to assist in preventing, controlling, or extinguishing fire involving or adjacent to an aircraft for the purpose of maintaining maximum escape routes for occupants using normal and emergency routes for egress.

**3.3.12 Alignment.** To adjust components to bring about optimum or desired performance.

**3.3.13 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. [**1900,** 2024]

**3.3.14 American Society for Nondestructive Testing (ASNT).** A professional organization that is devoted to promoting knowledge of nondestructive testing.

**3.3.15 American Welding Society (AWS).** An association that provides codes, guidelines, and standards utilized to evaluate welded structures and components in welded structures.

**3.3.16 Anchor.** A device designed to engage the bottom of a waterway and, through its resistance to drag, maintain a vessel within a given radius.

**3.3.17 Anchor Rode.** The line connecting an anchor with a vessel.

**3.3.18 Ancillary Boom Ladder.** A ladder or ladders affixed to a telescoping or articulating boom section.

**3.3.19 Angle of Approach.** The smallest angle made between the road surface and a line drawn from the front point of ground contact of the front tire to any projection of the apparatus in front of the front axle. [**1900,** 2024]

**3.3.20 Angle of Departure.** The smallest angle made between the road surface and a line drawn from the rear point of ground contact of the rear tire to any projection of the apparatus behind the rear axle. [**1900,** 2024]

**3.3.21* Anode.** A metal that in an electrolyte assumes a more electronegative charge than the one to which it is coupled.

**3.3.22 Articulating Boom.** An aerial device consisting of two or more folding boom sections whose extension and retraction modes are accomplished by adjusting the angle of the knuckle joints. [**1900,** 2024]

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

**3.3.24 Auxiliary Hydraulic Power.** A small gasoline engine, diesel engine, or electric motor–driven hydraulic pump used to operate an aerial device in an emergency or in lieu of the main hydraulic system. [**1900,** 2024]

**3.3.25* Auxiliary Pump.** A water pump mounted on the fire apparatus in addition to a fire pump and used for firefighting either in conjunction with or independent of the fire pump. [**1900,** 2024]

**3.3.26 Base Rail.** The lower chord (rail) of an aerial ladder to which rungs and reinforcements are attached. [**1900,** 2024]

**3.3.27 Base Section.** The first or bottom section of an aerial device. [**1900,** 2024]

**3.3.28 Bilge.** The lowest inner part of a ship's hull. [**1405,** 2020]

**3.3.29 Bitt.** Any of the deck posts, often found in pairs, around which ropes or cables are wound and held fast.

**3.3.30* Bitter End.** That end of a rope or cable that is wound around a bitt.

**3.3.31 Boarding Ladder.** A device used for boarding a vessel from the water, including handles, rails, ladders, steps, or platforms.

**3.3.32* Boom.** The structural member of an apparatus, other than an aerial ladder, which can be elevated, rotated, or extended. [**1900,** 2024]

**3.3.33 Boom Boost Cylinders.** The hydraulic cylinders located on the upper boom of an articulating boom aerial device that help lift the upper boom from the lower boom.

**3.3.34 Boom Support.** A structural component that is attached to the chassis frame and that is used to support the aerial device when it is in the cradled position.

**3.3.35 Bow.** The distance that the end of an aerial ladder or boom deviates from a straight line extension of the base section.

**3.3.36 Breathing-Air System.** The complete assembly of equipment such as compressors, a purification system, pressure regulators, safety devices, manifolds, air tanks or receivers, and interconnected piping required to deliver breathing air. [**1900,** 2024]

**3.3.37* Bridge.** The vessel's command and control area, usually enclosed, containing the principal helm, navigation systems, communications systems, and monitoring equipment for the vessel's operating systems.

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

**3.3.39 Cable Separation Guide.** The mechanism that aligns and separates the cable when it is wound on the drum of an aerial ladder's extension winch.

**3.3.40 Calibrate.** To correlate the reading of an instrument or system of measurement with a standard.

**3.3.41 Category A Machinery Space.** Spaces and trunks to such spaces that contain either internal combustion machinery used for main propulsion, internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or any oil-fired boiler, oil fuel unit, or oil-fired equipment other than boilers, such as inert gas generators, incinerators, and so forth.

**3.3.42 Center of Gravity.** The point at which the entire weight of the fire apparatus is considered to be concentrated so that, if supported at this point, the apparatus would remain in equilibrium in any position. [**1900,** 2024]

**3.3.43 Chassis.** The basic operating motor vehicle including the engine, frame, and other essential structural and mechanical parts, but exclusive of the body and all appurtenances for the accommodation of driver, property, passengers, appliances, or equipment related to other than control. Common usage might, but need not, include a cab (or cowl). [**1900,** 2024]

**3.3.44 Class A or Class B Foams.** See 3.3.98, Foam.

**3.3.45 Cleat.** Fitting attached to the vessel used to secure an anchor rode or other line to the vessel.

**3.3.46 Close-Off Pressure.** The maximum pressure the pump is capable of developing at zero discharge flow.

**3.3.47 Collector Rings.** An assembly of slip rings for transferring electrical energy from a stationary to a rotating member. [**70:**675.2]

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

**3.3.49 Component.** A constituent part of a mechanical or electrical device.

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

**3.3.51 Continuous Egress.** A continuous exit or rescue path down an aerial device from an elevated position to the ground. [**1900,** 2024]

**3.3.52* Contractor.** The person or company responsible for fulfilling an agreed-upon contract. [**1900,** 2024]

**3.3.53 Crew (Vessel).** Anyone associated with the onboard operation of the vessel.

**3.3.54 Cylinder Links.** The mechanisms that can be used in connecting an articulating boom to the end of the upper elevating cylinders or to the lower and upper booms.

**3.3.55 dBA.** Decibel, "A" scale.

**3.3.56 Defect.** A discontinuity in a part or a failure to function that interferes with the service or reliability for which the part was intended. [**1900,** 2024]

**3.3.57 Deficiency(ies).** A discontinuity in a part or a failure to function that interferes with the service or reliability for which the part was intended.

**3.3.58 Deflection.** The deviation from a straight course or fixed direction.

**3.3.59 Deformation.** Abnormal wear, defects, cracks or fractures, warpage, and deviations from the original condition that would affect safe and correct operation.

**3.3.60 Diagnosis.** The determination of the cause of a problem.

**3.3.61 Diagnostic Check.** An in-depth operational analysis of a system or component to verify that it is operating correctly.

**3.3.62 Discharge Pressure.** The water pressure on the discharge manifold of the fire pump at the point of gauge attachment.

**3.3.63 Discontinuity.** A change in the normal, physical structure of a material that can affect its serviceability.

**3.3.64 Diverter Valve.** A valve that, when actuated, diverts hydraulic fluid from one function to another or from one hydraulic system to another; in aerial devices, it is the valve that diverts hydraulic fluid from the hydraulic system for the stabilizers to the hydraulic system for the aerial device when the aerial device is in use and from the hydraulic system for the aerial device to the hydraulic system for the stabilizers when they are being deployed or stowed.

**3.3.65 Documentation.** Any written or electronic data or information relative to the emergency vehicle, including information on its operational checks, diagnostic checks, inspection, maintenance, and performance testing.

**3.3.66 Draft.** The use of suction to move a liquid (such as water) from a vessel or source that is below the intake of a pump.

**3.3.67 Drift.** A time-dependent movement away from an established position.

**3.3.68 Drivetrain.** The parts of an emergency vehicle that transmit power from the engine to the wheels, including the transmission, split shaft power takeoff, midship pump transmission, drive shaft(s), clutch, differential(s), and axles.

**3.3.69 Duty.** A fire-related service, function, or task identified in the fire brigade organizational statement and assigned to a member to perform.

**3.3.70 Dynamic Suction Lift.** The sum of the vertical lift and the friction and entrance loss caused by the flow through the suction strainers, sea chest, and piping, expressed in feet (meters).

**3.3.71* Eductor.** A device that uses the Venturi principle to siphon a liquid in a water stream.

**3.3.72* Electrolyte.** A liquid in which an electric current is easily conducted.

**3.3.73* Electronic Battery Conductance Tester.** A type of battery tester that uses proprietary electronic circuitry to determine the condition, or state of health (SOH), of a vehicle battery and does not apply a resistive load during the test.

**3.3.74 Elevating Platform.** A self-supporting, turntable-mounted device consisting of a personnel-carrying platform attached to the uppermost boom of a series of power-operated booms that articulate, telescope, or both and that are sometimes arranged to provide the continuous egress capabilities of an aerial ladder. [**1900,** 2024]

**3.3.75 Elevation Cylinder.** The hydraulic components consisting of a cylinder barrel, cylinder rod, and related hardware that are used to vary the angle of the ladder or booms.

**3.3.76 Elevation Indicator.** An instrument on an aerial device that shows the angle of elevation of the aerial ladder or boom.

**3.3.77 Elevation Lock.** A manual- or positive-locking device (i.e., holding valve) that can be actuated to maintain indefinitely a desired angle or elevation without dependence upon engine power.

**3.3.78 Emergency Hand-Crank Control.** An auxiliary or supplemental control with which the operator can manually operate select functions of the aerial device.

**3.3.79 Emergency Response Vehicle.** A motorized vehicle designated by an organization or agency to respond to emergency incidents where provisions have been made to include warning systems and specialized components such as pumps, aerial devices, and rescue equipment and are capable of transporting emergency response personnel.

**3.3.80* Emergency Vehicle.** A motor vehicle used by public, governmental, military, and private organizations to provide rescue, fire suppression, emergency medical services, hazardous materials mitigation, special operations, or other emergency services.

**3.3.81 Emergency Vehicle Technician (EVT).**

**3.3.81.1** ***Emergency Vehicle Technician (EVT) I.*** An individual who performs inspection, maintenance, and operational checks on emergency response vehicles and who, by possession of a recognized certificate, professional standing, or skill, has acquired the knowledge, training, and experience and has demonstrated the ability to deal with issues related to the subject matter, the work, or the project.

**3.3.81.2** ***Emergency Vehicle Technician (EVT) II.*** An individual who performs inspection, maintenance, diagnosis, repair, and performance testing on emergency response vehicles and who, by possession of a recognized certificate, professional standing, or skill, has acquired the knowledge, training, and experience and has demonstrated the ability to deal with issues related to the subject matter, the work, or the project.

**3.3.81.3*** ***Emergency Vehicle Technician (EVT) III.*** An individual who is the first-level supervisor responsible for Emergency Vehicle Technician I and II personnel performance, scheduling, quality control of repairs and maintenance work, and the compiling and reviewing of initial documentation.

**3.3.82 EMS.** Emergency medical services.

**3.3.83 Estimated In-Service Weight.** The amount that the fire apparatus manufacturer estimates the apparatus will weigh when it is placed in service with all fixed and portable equipment installed, all tanks full, and all personnel seating positions occupied. [**1900,** 2024]

**3.3.84 Extension Cylinder.** The hydraulic components consisting of a cylinder barrel, cylinder rod, and related hardware that are used to vary the length of extension of a telescoping aerial device.

**3.3.85 Extension Indicator.** A device on an aerial ladder or extensible boom aerial device that indicates the number of feet (meters) that the device has been extended.

**3.3.86 Extension Sheave.** A pulley through which an extension cable operates.

**3.3.87 Failure.** A cessation of proper functioning or performance.

**3.3.88 Fastener.** A mechanical device, such as a rivet, bolt, screw, or pin, that is used to hold two or more components together securely.

**3.3.89 Ferromagnetic Materials.** Materials, such as iron, cobalt, and nickel, that have an abnormally high magnetic permeability.

**3.3.90 Final-Stage Manufacturer.** An entity that performs such manufacturing operations on an incomplete vehicle that it becomes a complete vehicle. [**1900,** 2024]

**3.3.91 Fire Apparatus.** A vehicle designed to be used under emergency conditions to transport personnel and equipment, and to support the suppression of fires and mitigation of other hazardous situations. [**1900,** 2024]

**3.3.92 Fire Department.** An organization providing rescue, fire suppression, and related activities, including any public, governmental, private, industrial, or military organization engaging in this type of activity. [**1002,** 2017]

**3.3.93 Fire Monitor.** See 3.3.157, Monitor.

**3.3.94 Fire Pump.** A water pump with a rated capacity of at least 250 gpm (1000 L/min) but less than 3000 gpm (12,000 L/min) at 150 psi (1000 kPa) net pump pressure, or a water pump with rated capacity of 3000 gpm (12,000 L/min) or greater at 100 psi (700 kPa) net pump pressure that is mounted on a fire apparatus and intended for firefighting. [**1900,** 2024]

**3.3.95 Firefighting Vessel.** Any vessel whose primary mission is firefighting and pumping operations, including emergency operations.

**3.3.96 Fly Locks.** See 3.3.137, Ladder Locks.

**3.3.97 Fly Section.** Any section of an aerial telescoping device beyond the base section. [**1900,** 2024]

**3.3.98* Foam.** A stable aggregation of bubbles of lower density than oil or water. [**11,** 2021]

**3.3.99 Fracture.** A type of defect found in welds that has a large length-to-width ratio and travels through or adjacent to the metal grain boundaries; usually, this type of defect is referred to as a crack.

**3.3.100 Frame.** The basic structural system that transfers the weight of the emergency vehicle to the suspension system.

**3.3.101 Freeboard.** The vertical distance between the sheer and the waterline.

**3.3.102 Gallon, US Standard.** 1 US gal = 0.833 Imperial gal = 231 $in.^3$ = 3.785 L. [**58,** 2020]

**3.3.103 Galvanic Corrosion.** The corrosion that occurs at the anode of a galvanic couple caused by the flow of ions between dissimilar metals in an electrolyte and electron flow within the dissimilar metals.

**3.3.104 Galvanic Isolator.** A device installed in series with the ac grounding (green, or green with yellow stripe) conductor of the shore power cable to block, in effect, the low voltage dc galvanic current flow, yet permit the passage of ac current normally associated with the ac grounding (green, or green with yellow stripe) conductor. [**302,** 2020]

**3.3.105 Galvanically Compatible.** Metals that are close to each other in the galvanic series.

**3.3.106 Gauge.** A visual device that indicates a measurement.

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

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

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

**3.3.110 gpm.** Gallons per minute.

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

**3.3.112 Ground.** The electrical potential of the earth's surface. The boat's ground is established by a conducting connection (intentional or accidental) with the earth, including any conductive part of the wetted surface of a hull. [**302,** 2020]

**3.3.113 Ground Tackle.** A general term for the anchor, anchor rodes, and fittings used for securing a vessel to anchor.

**3.3.114 Grounded Conductor.** In marine firefighting vessels, a current-carrying conductor connected to the side of the electrical source that is intentionally maintained at ground potential.

**3.3.115 Grounding Conductor.** In marine firefighting vessels, a normally non-current-carrying conductor provided to connect the exposed metallic enclosures of electrical equipment to ground for the purpose of minimizing shock hazard to personnel.

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

**3.3.118* Helm.** The position from which direction and water speed of the vessel are controlled.

**3.3.119 Hinge Pins.** Pins that are used at either the swivel or point of articulation of an aerial device.

**3.3.120 Holding Valve.** A valve that maintains hydraulic pressure in a hydraulic actuator (cylinder, motor, etc.) until it is activated to release.

**3.3.121 Hull Potential Monitor.** A dc meter that measures the potential of a metallic hull or metallic hull fittings as compared to a reference electrode.

**3.3.122* Impressed Current System.** A cathodic protection system that uses an external power source to induce a dc electric current through an electrode (anode) that suppresses galvanic corrosion of the craft's hull.

**3.3.123 Inclining Experiment.** See 3.3.215, Stability Test (Inclining Experiment).

**3.3.124 Initial Attack Apparatus.** Fire apparatus with a fire pump of at least 250 gpm (1000 L/min) capacity, water tank, and hose body whose primary purpose is to initiate a fire suppression attack on structural, vehicular, or vegetation fires, and to support associated fire department operations. [**1900,** 2024]

**3.3.125 In-Service Emergency Vehicles.** Any emergency vehicles, including reserve vehicles, that are available for use under emergency conditions to transport personnel and equipment and to support suppression of fires and mitigation of other hazardous conditions.

**3.3.126 Inspect(ion).** To determine the condition or operation of a component(s) by comparing its physical, mechanical, and/or electrical characteristics with established standards, recommendations, and requirements through examination by sight, sound, or feel.

**3.3.127* Instability.** A condition of a mobile unit in which the sum of the moments tending to overturn the unit exceeds the sum of the moments tending to resist overturning. [**1900,** 2024]

**3.3.128 Intake Pressure.** The pressure on the intake passageway of the pump at the point of gauge attachment.

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

**3.3.130 Ironing.** Damage in the form of wear or indentations caused to the bottom of the aerial device base rail material by misalignment or malfunction of the rollers or slides.

**3.3.131* Jet Drive.** A propulsion unit that generates thrust in reaction to a water stream.

**3.3.132 Job.** An organized segment of instruction designed to develop sensory motor skills or technical knowledge.

**3.3.133 Job Performance Requirement (JPR).** A written statement that describes a specific job task, lists the items necessary to complete the task, and defines measurable or observable outcomes and evaluation areas for the specific task. [**1000,** 2022]

**3.3.134 Knuckle.** A point of connection between upper and lower booms of an articulating device; the point at which lower and upper booms are hinged together. [**1900,** 2024]

**3.3.135 Label.** A visual indication whether in pictorial or word format that provides for the identification of a control, switch, indicator, or gauge, or the display of information useful to the operator. [**1900,** 2024]

**3.3.136 Ladder Cradle.** A structural component that supports an aerial ladder when it is bedded.

**3.3.137 Ladder Locks.** The mechanical locks or pawls that prevent movement of the sections of an aerial device when the power is shut off or in the event of loss of pressure in hydraulic circuits.

**3.3.138 Leak.** The escape of a gas or liquid from a hose, pipe, coupling, connection, or other confining structure at any point where the escape should not occur.

**3.3.139 Leakage.** The escape of a fluid from its intended containment, generally at a connection.

**3.3.139.1** ***Class 1 Liquid Leakage.*** Seepage of liquid, as indicated by wetness or discoloration, not great enough to form drops.

**3.3.139.2** ***Class 2 Liquid Leakage.*** Leakage of liquid great enough to form drops, but not enough to cause drops to fall from the item being inspected.

**3.3.139.3** ***Class 3 Liquid Leakage.*** Leakage of liquid great enough to cause drops to fall from the item being inspected.

**3.3.140 Leveling Linkages.** The components and controls for achieving a level position of the platform.

**3.3.141 Lift.** The vertical height that water must be raised during a drafting operation, measured from the surface of a static source of water to the centerline of the pump intake.

**3.3.142 Limber Holes.** Holes in hull framing members to permit draining of liquids.

**3.3.143 Line.** Rope, when in use. [**2500,** 2022]

**3.3.144 Line-Voltage Circuit, Equipment, or System.** An ac or dc electrical circuit, equipment, or system where the voltage to ground or from line to line is greater than 30 V rms (ac), 42.4 V peak (ac), or 60 V dc. [**1900,** 2024]

**3.3.145 Liquid Penetrant Inspection.** A nondestructive inspection method used to locate and determine the severity of surface discontinuities in materials, based on the ability of a liquid to penetrate into small openings, such as cracks.

**3.3.146 Load Limit Indicator.** A load indicator or an instruction plate, visible at the operator's position, that shows the recommended safe load at any condition of an aerial device's elevation and extension. [**1900,** 2024]

**3.3.147 Low-Voltage Circuit, Equipment, or System.** An electrical circuit, equipment, or system where the voltage does not exceed 30 V rms (ac), 42.4 V peak (ac), or 60 V dc; usually 12 V dc in vehicles. [**1900,** 2024]

**3.3.148 Magnetic Particle Inspection.** A nondestructive inspection method used to locate discontinuities in ferromagnetic materials by magnetizing the material and then applying an iron powder to mark and interpret the patterns that form.

**3.3.149 Maintenance.** The act of servicing an emergency vehicle or a component(s) in order to keep the vehicle and its components in the required operating condition.

**3.3.150 Major Conversion.** A change in service of the vessel from some other use to use as a marine firefighting vessel.

**3.3.151 Manufacturer.** The person(s) or entity responsible for turning raw materials or components into a finished product. [**1900,** 2024]

**3.3.152 Manufacturer's Recommendation (Specification).** Any requirement or suggestion an emergency vehicle builder or component producer makes in regard to care and maintenance of its product(s).

**3.3.153 Manufacturer's Specifications.** Any requirement or service bulletin an emergency response vehicle builder or component producer provides with regard to the use, care, and maintenance of its product(s).

**3.3.154 Mobile Foam Fire Apparatus.** Fire apparatus with a permanently mounted fire pump, foam proportioning system, and foam concentrate tank(s) whose primary purpose is the control and extinguishment of flammable and combustible liquid fires in storage tanks and spills. [**1900,** 2024]

**3.3.155 Mobile Water Supply Apparatus (Tanker, Tender).** A vehicle designed primarily for transporting (pickup, transporting, and delivering) water to fire emergency scenes to be applied by other vehicles or pumping equipment. [**1900,** 2024]

**3.3.156 Modification.** An alteration or adjustment to any component that is a deviation from the original specifications or design of the emergency vehicle.

**3.3.157 Monitor.** A fixed master stream device, manually or remotely controlled, or both, capable of discharging large volumes of water or foam.

**3.3.158 Monitor Panel.** A device that is located at a position remote from the system being monitored (usually at the bridge) and that indicates the condition of the system being monitored.

**3.3.159 Moorings.** Methods of securing a vessel within a given area.

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

**3.3.161 Negative Pressure.** Pressure less than atmospheric. [**99,** 2021]

**3.3.162 Net Positive Suction Head (NPSH) ($h_{sv}$).** The total suction head in meters (feet) of liquid absolute, determined at the suction nozzle, and referred to datum, less the vapor pressure of the liquid in meters (feet) absolute. [**20,** 2022]

**3.3.163* Net Pump Pressure.** The sum of the discharge pressure and the suction lift converted to psi or kPa when pumping at draft, or the difference between the discharge pressure and the intake pressure when pumping from a hydrant or other source of water under positive pressure. [**1900,** 2024]

**3.3.164 Neutral Position.** The position of operating controls when the controls are not engaged.

**3.3.165 Nondestructive Testing (NDT).** One of several methods used to inspect a structural component without physically altering or damaging the materials.

**3.3.166 Operational Check.** Observation of the operation of a component on an emergency vehicle to determine its operational readiness.

**3.3.167 Operator.** A person qualified to operate an emergency vehicle.

**3.3.168 Operator Alert Device.** Any device, whether visual, audible, or both, installed in the driving compartment or at an operator's panel, to alert the operator to either a pending failure, an occurring failure, or a situation that requires his or her immediate attention.

**3.3.169* Optical Source.** Any single, independently mounted, light-emitting component in a lighting system. [**1900,** 2024]

**3.3.170 Out of Service.** When an emergency vehicle or component is not usable due to an unsafe or inoperable condition.

**3.3.171 Overhaul (Rebuild).** To make extensive repairs in order to restore a component to like-new condition in accordance with the original manufacturer's specifications.

**3.3.172 Override.** A system or device used to neutralize a given action or motion. [**1900,** 2024]

**3.3.173 Performance Tests.** Tests made after an emergency vehicle has been put into service to determine whether its performance meets predetermined specifications or standards.

**3.3.174 Personal Flotation Device (PFD).** A displacement device worn to keep the wearer afloat in water.

**3.3.175 Platform.** An assembly consisting of the support structure, floor, railings, and operator's secondary controls that is attached to the tip of a boom or an aerial ladder for carrying personnel and equipment.

**3.3.176 Pneumatic Lines.** The lines that supply air, which is normally for a breathing air system or for pneumatic power tools, to a platform or to the tip of an aerial ladder.

**3.3.177 Power Source.** A device that produces line voltage electricity.

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

**3.3.179 Preventive Maintenance.** The act or work of keeping something in proper condition by performing necessary preventive actions in a routine manner to prevent failure or breakdown.

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

**3.3.181 psi.** Pounds per square inch. [**1900**, 2024]

**3.3.182 PTO.** Power takeoff. [**1900,** 2024]

**3.3.183 Pump Operator's Panel.** The area on a fire apparatus that contains the gauges, controls, and other instruments used for operating the pump. [**1900,** 2024]

**3.3.184 Pump Operator's Position.** The location from which the pump operator operates the pump. [**1900,** 2024]

**3.3.185 Pumper.** Fire apparatus with a permanently mounted fire pump of at least 750 gpm (3000 L/min) capacity, water tank, and hose body whose primary purpose is to combat structural and associated fires. [**1900,** 2024]

**3.3.186* Purchaser.** The authority having responsibility for the specification and acceptance of the apparatus. [**1900,** 2024]

**3.3.187 Purchasing Authority.** The agency that has the sole responsibility and authority for negotiating, placing, and, where necessary, modifying each and every solicitation, purchase order, or other award issued by a governing body. [**1900,** 2024]

**3.3.188 Qualified Person.** A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to the subject matter, the work, or the project. [**1451,** 2018]

**3.3.189* Quint.** Fire apparatus with a permanently mounted fire pump, a water tank, a hose storage area, an aerial ladder or elevating platform with a permanently mounted waterway, and a complement of ground ladders. [**1900,** 2024]

**3.3.190 Rated Capacity (Aerial Device).** The total weight of all personnel and equipment that can be supported at the outermost rung of an aerial ladder or on the platform of an elevating platform with the aerial device placed in the horizontal position at its maximum horizontal extension when the stabilizers are fully deployed.

**3.3.191 Rated Capacity (Water Pump).** The flow rate to which the pump manufacturer certifies compliance of the pump when it is new. [**1900,** 2024]

**3.3.192* Rated Vertical Height.** The vertical distance measured by a plumb line from the maximum elevation of the aerial device allowed by the manufacturer to the ground.

**3.3.193 Rebuild.** To make extensive repairs in order to restore a component to like-new condition in accordance with the original manufacturer's specifications.

**3.3.194 Refurbishing.**

**3.3.194.1* *Level I Refurbishing.*** The assembly of a new fire apparatus by the use of a new chassis frame, driving and crew compartment, front axle, steering and suspension components, and the use of either new components or components from an existing apparatus for the remainder of the apparatus.

**3.3.194.2* *Level II Refurbishing.*** The upgrade of major components or systems of a fire apparatus with components or systems that comply with the applicable standards in effect at the time the original apparatus was manufactured.

**3.3.195 Relief Valve.** A device that allows the bypass of fluids to limit the pressure in a system.

**3.3.196 Repair.** To restore to sound condition after failure or damage.

**3.3.197 Replace.** To remove an unserviceable item and install a serviceable counterpart in its place.

**3.3.198 Replacement.** The removal of an existing component or system and the installation of a similar component or system generally of the same model or the same capability (i.e., "like for like" replacement).

**3.3.199 Requisite Knowledge.** Fundamental knowledge one must have in order to perform a specific task. [**1030,** 2024]

**3.3.200 Requisite Skills.** The essential skills one must have in order to perform a specific task. [**1030,** 2024]

**3.3.201 Reserve Emergency Vehicle.** An emergency vehicle retained as a backup emergency vehicle and used to replace a primary emergency vehicle when the primary emergency vehicle is out of service.

**3.3.202 Retired Emergency Vehicle.** A vehicle that was previously an emergency vehicle but, due to age or condition, is no longer capable of supporting the suppression of fires, the mitigation of hazardous situations, or operations at emergency scenes.

**3.3.203 Rotation Gear.** The main gear of an aerial device that is used for the rotation of the turntable.

**3.3.204 Rotation Gear Reduction Box.** The mechanism of an aerial device that transfers hydraulic or electric power to the rotation gear, creating the torque necessary to rotate the turntable.

**3.3.205 Rotation Lock.** A strong friction or other positive-locking device (e.g., holding valve) that retains the turntable in any desired position.

**3.3.206 rpm.** Revolutions per minute.

**3.3.207 Rung Cap Casting.** A casting that can be riveted to the outside of the base rail over the ends of each rung on an aerial ladder.

**3.3.208 Sacrificial Anode System.** Galvanic corrosion protection that employs zinc, aluminum, or magnesium anodes connected to the vessel's hull that dissolve away over time.

**3.3.209 Safety Stop Mechanism.** A device that is located on the aerial device and prevents raising the elevating platform booms or sections beyond safe operating horizontal or vertical angles.

**3.3.210 Service Tests.** See 3.3.173, Performance Tests.

**3.3.211 Severe Service.** Those conditions that apply to the rigorous, harsh, and unique applications of emergency vehicles, including, but not limited to, local operating and driving conditions, frequency of use, and manufacturer's severe service (duty) parameters.

**3.3.212 Sheer.** Upper edge of hull exterior at the intersection with the deck.

**3.3.213 Slide Blocks.** Blocks made of a variety of materials (e.g., brass, nylatron) that act as spacing devices, wear strips, or wear pads.

**3.3.214* Special Services Fire Apparatus.** A multipurpose vehicle that primarily provides support services at emergency scenes. [**1900,** 2024]

**3.3.215 Stability Test (Inclining Experiment).** A test to determine the vessel displacement (light ship survey) and the position of the center of gravity both vertical and longitudinal.

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

**3.3.217 Stabilizer Pad.** A plate inserted beneath a stabilizer shoe to give greater surface bearing area. [**1900,** 2024]

**3.3.218 Stabilizer Shoe.** A permanently mounted shoe on a stabilizer to provide a ground surface area. [**1900,** 2024]

**3.3.219 Standard Operating Procedures (SOPs).** Written instructions that document and define the manner in which activities should be conducted. [**1404,** 2018]

**3.3.220 Steering Axle(s).** Any axle(s) designed such that the wheels have the ability to turn the vehicle.

**3.3.221 Stem.** The most forward portion of the hull.

**3.3.222 Stressed-Skin-Type Boom Section.** A boom framework that is fabricated by the welding of metal into full box sections with internal torsional members.

**3.3.223 Structural Integrity.** An unimpaired condition of any component.

**3.3.224 Suspension System.** The components utilized to attach the axle(s) to the frame assembly.

**3.3.225 Tanker.** See 3.3.155, Mobile Water Supply Apparatus (Tanker, Tender).

**3.3.226 Task.** A specific job behavior or activity. [**1002,** 2017]

**3.3.227 Telescopic.** Extended or retracted by sliding of the overlapping sections.

**3.3.228 Tender.** See 3.3.155, Mobile Water Supply Apparatus (Tanker, Tender).

**3.3.229 Test.** To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards.

**3.3.230 Thimble.** A grooved metal reinforcement fitted snugly into an eye splice of rope to reduce chafing and to spread the tensional loads.

**3.3.231 Thruster.** Controllable device used to assist in maneuvering and positioning the vessel.

**3.3.232 Tonnage.** A measurement of enclosed volume of a vessel inside of structural frames (1 ton = 100 $ft^3$).

**3.3.233 Top Rail.** The top chord (rail) of an aerial ladder to which reinforcements are attached. [**1900,** 2024]

**3.3.234 Torque Box.** A structural component placed between the turntable and the chassis or part of the chassis frame of an aerial device to absorb the stresses of operation.

**3.3.235 Torque Value.** A measure of tightness or the amount of stress that is put on a fastening device (i.e., bolt) to secure it properly.

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

**3.3.237 Transfer Pump.** A water pump mounted on the emergency vehicle that is used to transfer water to and from the emergency vehicle.

**3.3.238 Trussed-Lattice-Type Boom Section.** An open truss boom framework with vertical and diagonal braces that are fastened to horizontal beams of the frame.

**3.3.239 Turntable.** A structural component that connects the aerial device to the chassis and stabilization system through a rotating bearing that permits 360-degree continuous rotation of the aerial device. [**1900,** 2024]

**3.3.240 Twist.** The degree of rotational movement from a given position.

**3.3.241 Ultrasonic Inspection.** A nondestructive method of inspection in which high-frequency vibrations are injected through the surface of the test material and bounced back to their source from the opposite surface; if a flaw exists, signals return in a different pattern, revealing the location and extent of the flaw.

**3.3.242 Unequipped Fire Apparatus.** The completed fire apparatus excluding personnel, agent(s), and any equipment removable without the use of tools. [**1900,** 2024]

**3.3.243* Upgrade.** The substitution or addition of components or systems with new components or systems with improved performance or capability.

**3.3.244* Vacuum.** The reduction in atmospheric pressure inside a pump or suction hose.

**3.3.245* Ventilation.** The changing of air within a compartment by natural or mechanical means. [**302,** 2020]

**3.3.246 Visual Check.** Examination by the eye without recourse to any optical devices except eyeglasses.

**3.3.247 Water Tower.** An aerial device consisting of permanently mounted power-operated booms that articulate, telescope, or both, and a waterway designed to supply a large capacity mobile elevated water stream. [**1900,** 2024]

**3.3.248 Weather Deck.** Any deck that is exposed to the weather and normally accessible to personnel and that permits walking or moving around outboard of the superstructure.

**3.3.249 Weldment.** A structure that is formed by the welding together of several components.

**3.3.250 Wildland Fire Suppression Apparatus.** A fire apparatus designed for fighting wildland fires that is equipped with a pump, a water tank, limited hose and equipment, and pump-and-roll capability. [**1900,** 2024]

**3.3.251 Windlass.** A mechanical device utilized in the recovery of anchor and chain by vessels following anchoring operations.

## Chapter 4 General Requirements (NFPA 1911)

**4.1 Administration.**

**4.1.1 Scope.**

**4.1.1.1** Chapters 4 through 28 define the minimum requirements for establishing an inspection, maintenance, and testing program for in-service emergency vehicles.

**4.1.1.2** Chapters 4 through 28 include requirements for emergency vehicle refurbishment and retirement.

**4.1.1.3** Chapters 4 through 28 identify the systems and items on an emergency vehicle that are to be inspected and maintained, the frequency of such inspections and maintenance, and the requirements and procedures for conducting performance tests on components.

**4.1.1.4** Chapters 4 through 28 provide sample forms for collecting inspection and test data.

**4.1.2 Purpose.**

**4.1.2.1** The primary purpose of this standard is to provide requirements for an inspection, maintenance, and testing program that will ensure that in-service emergency vehicles are serviced and maintained to keep them in safe operating condition and ready for response at all times.

**4.1.2.2** The secondary purpose of Chapters 4 through 28 is to establish that safety is a primary concern for the continued in-service use of an emergency vehicle and the ultimate decision to refurbish or retire that emergency vehicle.

**4.1.2.3** It is not the intent of this standard to restrict any jurisdiction from exceeding the minimum requirements described in this document.

**4.1.3 Application.**

**4.1.3.1** Chapters 4 through 28 shall apply to public, governmental, military, and private organizations providing rescue, fire suppression, emergency medical services, hazardous materials mitigation, special operations, or other emergency services.

**4.1.3.2** Chapters 4 through 28 shall apply to all in-service emergency vehicles, regardless of the year of manufacture.

**4.1.3.3** Chapters 4 through 28 shall apply to permanently installed components on emergency vehicles.

**4.1.3.4** This standard shall not apply to portable equipment carried on emergency vehicles unless otherwise stated in specific requirements.

**4.1.3.5** The provisions of this standard shall not supersede any instructions, specifications, or practices defined or required by the emergency vehicle manufacturer, component manufacturer, equipment manufacturer, or authority having jurisdiction.

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

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

**4.1.4.2** The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

**4.1.5* Units and Formulas.**

**4.1.5.1** In this standard, values for measurement in inch-pound units are followed by an equivalent in metric units.

**4.1.5.2** Either set of values shall be permitted to be used, but the same set of values (either inch-pound units or metric units) shall be used consistently.

**4.2* General.** All fire emergency vehicles that could be placed in service for emergency response shall be inspected, maintained, tested, and retired as required by this standard.

**4.2.1 Chassis, Driving and Crew Compartment, and Body.**

**4.2.1.1** The chassis, driving and crew compartment, and body shall be inspected and maintained as required by Chapter 8.

**4.2.1.2** The chassis components shall be performance tested as required by Chapter 20.

**4.2.2 Electrical Systems.**

**4.2.2.1** The low-voltage electrical systems on the emergency vehicle shall be inspected and maintained as required by Chapter 9 and performance tested as required by Chapter 21.

**4.2.2.2** If the emergency vehicle is equipped with a line voltage electrical system, that system shall be inspected and maintained as required by Chapter 14 and performance tested as required by Chapter 26.

**4.2.3 Water Pumping System or Water Tank.**

**4.2.3.1** If the emergency vehicle is equipped with a water pumping system or a water tank, the water pumping system(s) or the water tank(s) shall be inspected and maintained as required by Chapter 10.

**4.2.3.2** If the emergency vehicle is equipped with a fire pump, wildland fire pump, or industrial supply pump, the applicable pump system shall be performance tested as required by Chapter 22.

**4.2.4 Aerial Device.** If the emergency vehicle is equipped with an aerial device, the aerial device shall be inspected and maintained as required by Chapter 11 and performance tested as required by Chapter 23.

**4.2.5 Foam Proportioning System.** If the emergency vehicle is equipped with a foam proportioning system, the system shall be inspected and maintained as required by Chapter 12 and performance tested as required by Chapter 24.

**4.2.6 Compressed Air Foam System (CAFS).** If the emergency vehicle is equipped with a compressed air–foam system, the

system shall be inspected and maintained as required by Chapter 13 and performance tested as required by Chapter 25.

**4.2.7 Compressed Air Systems.**

**4.2.7.1** If the emergency vehicle is equipped with a compressed air system, the system shall be inspected and maintained as required by Chapter 15.

**4.2.7.2** If the emergency vehicle is equipped with a breathing air system, the system shall be performance tested as required by Chapter 28.

**4.2.8 Winches and Davits.** If the emergency vehicle is equipped with a winch or davit, the winch or davit shall be inspected and maintained as required by Chapter 18.

**4.2.9 Other Components or Auxiliary Systems.** If there are other fixed components or auxiliary systems on the emergency vehicle, those components or auxiliary systems shall be inspected, maintained, and tested in accordance with the component manufacturer's recommendations and this standard to the extent that the requirements are applicable.

**4.2.10 Trailers.** Trailers shall be inspected and maintained as required by Chapter 16.

**4.2.11 Patient Compartment.** If the emergency vehicle is equipped with a patient compartment, the patient compartment shall be inspected and maintained as required by Chapter 17.

**4.3 Taking Emergency Vehicles Out of Service.** It shall be the responsibility of the authority having jurisdiction (AHJ) to enforce the criteria for when the emergency vehicle is to be taken out of service in accordance with the requirements in Chapter 6.

**4.4 Qualifications of Personnel.**

**4.4.1** Inspections, maintenance, and testing of emergency vehicles shall be performed by qualified personnel as required by 4.4.1.1 or 4.4.1.2.

**4.4.1.1*** Any person performing diagnostic checks, inspections, performance testing, or maintenance of the emergency vehicle shall meet the qualifications of Chapters 49 through 51 or equivalent.

**4.4.1.2** Pump tests and annual aerial tests shall be performed by personnel qualified in accordance with Chapters 49 through 51 or equivalent, or by an organization that is accredited for inspection and testing systems on fire apparatus in accordance with ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection.*

**4.4.2*** Personnel performing visual inspections and operational checks in accordance with Chapter 7 and NFPA 1002 shall be approved by the AHJ and have a minimum of training on heavy-duty or emergency vehicles that includes DOT and chassis inspections.

**4.5 Safety.**

**4.5.1*** Anyone performing operational checks, diagnostic checks, inspections, or maintenance on emergency vehicles shall consult the correct operator's, service, and maintenance manuals before starting any work on the emergency vehicle.

**4.5.2** All safety warnings and recommendations shall be read and followed.

**4.5.3*** All federal, state or provincial, and local laws and regulations governing workplace safety shall be followed when performing maintenance on emergency vehicles.

**4.5.4** All federal, state or provincial, and local laws shall be followed in the use and disposal of chemicals and hazardous materials.

**4.5.5** Remediation equipment and methods shall be used prior to and during preventive maintenance when dealing with possible contamination by, and exposure to, hazardous materials, medical and biological waste, and other hazards.

**4.5.6** Personal protection, including eye protection, hearing protection, and suitable respirators for breathing protection, shall be used when the maintenance operations require such protection.

**4.5.7** A system or method shall be utilized to remove exhaust emissions from an operating engine in a confined area.

**4.5.8** Required methods shall be utilized to lift, support, secure, and stabilize the emergency vehicle undergoing maintenance.

**4.5.9** Proper tools and equipment shall be selected for the task to be performed.

**4.6 Inspections and Maintenance.**

**4.6.1** The emergency vehicle shall meet all federal, state or provincial, and local laws for motor vehicle inspection.

**4.6.2*** All inspections and maintenance shall be conducted in accordance with the manufacturer's recommended procedures.

**4.6.3*** It shall be the responsibility of the AHJ to develop and implement a schedule for the operational checking, inspection, diagnostic checking, and maintenance of the emergency vehicle and its systems and components in accordance with this document, the manufacturer's recommendations, local experience, and operating conditions.

**4.6.4** The visual and operational checks shall be done within 24 hours of a run or weekly if no runs are done during the week.

**4.6.4.1** Defined systems of the emergency vehicle shall be checked, including the fire pump, aerial device, warning lights, audible warning devices, patient compartment, cab and pump panel instrumentation, seat belts, tires, engine, transmission, drivetrain, and brake system.

**4.6.4.2** A check sheet shall be utilized to record the results of the visual and operational checks. *(See Annex C.)*

**4.6.5*** A complete inspection and diagnostic check of the emergency vehicles in accordance with Chapters 9 through 18 shall be conducted at least as frequently as recommended by the emergency vehicle manufacturer or once per year, whichever comes first.

**4.6.5.1** A complete inspection and diagnostic check of the emergency vehicles in accordance with Chapter 8 shall be conducted at least as frequently as recommended by the emergency vehicle manufacturer or twice a year, whichever comes first.

**4.6.6** Component inspections shall be performed at least as frequently as recommended by the manufacturer and when the emergency vehicle or any component is suspected or reported to have defects or deficiencies.

**4.6.7** All deficiencies found during an inspection shall be repaired or corrected by a qualified person.

**4.7 Maintenance and Repairs.**

**4.7.1** Maintenance and repairs shall be made in accordance with the manufacturer's recommendations.

**4.7.2** Parts or components used to maintain or repair the emergency vehicle shall meet or exceed the original manufacturer's specifications.

**4.8* Documentation.**

**4.8.1** Records shall be maintained on the results of all apparatus inspections, maintenance requests, preventive maintenance, repairs, and testing.

**4.8.2** Separate files shall be established and maintained for each individual emergency vehicle.

**4.8.3** All records shall be kept for the life of the vehicle and delivered with the vehicle upon transfer or change of ownership.

## Chapter 5 Retirement of Emergency Vehicles (NFPA 1911)

**5.1* General.**

**5.1.1** The fire department shall consider safety as the primary concern in the retirement of emergency vehicles.

**5.1.2** Retired emergency vehicles shall not be used for emergency operations.

## Chapter 6 Out-of-Service Criteria (NFPA 1911)

**6.1 General.**

**6.1.1** It shall be the responsibility of the AHJ to take the emergency vehicle or the defective portion of the emergency vehicle out of service if any of the deficiencies defined in this chapter are encountered.

**6.1.2** Where a technician conducts an evaluation of the emergency vehicle to determine if the emergency vehicle or a component is to be taken out of service, the technician shall report the findings to the AHJ in writing with one of the following recommendations:

(1) The emergency vehicle is to be taken out of service.
(2) The emergency vehicle is to be retained in service with specified limitations.
(3) The emergency vehicle is to be retained in service without limitations.

**6.1.3** In addition to the defects defined in this chapter, the AHJ shall include out-of-service criteria based on state, provincial, and local regulations; specific manufacturer's recommendations; and requirements established by the fire department.

**6.1.4** The emergency vehicle shall be returned to service only after the defects and deficiencies that caused the emergency vehicle to be taken out of service have been corrected and the defective component retested to satisfy the component manufacturer's specification and the requirements of this document.

**6.1.5** The AHJ shall establish a means to immediately identify that the emergency vehicle is out of service for any operator who might have reason to use the emergency vehicle.

**6.1.5.1** Out-of-service emergency vehicles shall be identified by one of the following means:

(1) Sign on the outside of the driver's door near the door handle
(2) Special bag that covers the steering wheel
(3) Large sign on the driver's window
(4) Highly visible mechanism at the driver's position on the emergency vehicle that all members of the department recognize as an out-of-service indicator

**6.1.5.2** A technician working on an emergency vehicle shall identify that an emergency vehicle is out of service or indicate that the apparatus is being serviced using one of the means specified in 6.1.5.1.

**6.1.6*** If a component or system on the fire apparatus is out of service, but the apparatus is still in service, a means shall be provided on the fire apparatus to immediately identify for the driver/operator which component or system is out of service.

**6.1.6.1** Out-of-service components shall be identified using both of the following:

(1) Distinctive color sign located on the inside of the driver's door identifying which component is out of service
(2) Highly visible device provided at the component control(s) indicating that the device is out of service

**6.1.6.2** Any out-of-service component shall be noted on the daily/weekly check sheet.

**6.1.6.3** If the fire pump or the aerial device is out of service, the engagement device shall be disabled so as to prevent operation of the pump or the aerial device.

**6.2 Driving and Crew Areas, Emergency Vehicle Body, and Compartmentation.**

**6.2.1** The following deficiencies of the driving and crew areas, the emergency vehicle body, and the compartmentation shall cause the emergency vehicle to be taken out of service:

(1) Cracked or broken windshield that obstructs the driver's/operator's view
(2) Missing or broken rearview mirrors that obstruct the driver's/operator's view
(3) Missing or broken windshield wipers
(4) Missing or broken door latches
(5) Missing or broken foot throttle

**6.2.2** If a seat belt is torn or has melted webbing, missing or broken buckles, or loose mountings, the following shall apply:

(1) If it is at a seat other than the driver's seat, that seat is to be taken out of service.
(2) If it is at the driver's seat, the entire emergency vehicle is to taken out of service.

**6.2.3*** If there are deficiencies with the following system or components, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ:

(1) Body mounting

(2) Cab mounting
(3) Steering wheel
(4) Required cab instrumentation
(5) Defrosters

**6.3 Chassis, Axles, Steering and Suspension Systems, Driveline, Wheels, and Tires.**

**6.3.1** The following deficiencies of the chassis, axles, steering and suspension systems, driveline, wheels, and tires shall cause the vehicle to be taken out of service:

(1) The gross axle weight rating (GAWR) shown on the vehicle weight rating label is greater than the tire manufacturer's load rating.
(2) When weighed in accordance with Section 20.2, the weight on the front axle, the weight on the rear axle, or the total gross weight of the emergency vehicle exceeds the values shown on the vehicle weight rating label.
(3) Tires have cuts in the sidewall that penetrate to the cord.
(4)* Tires have a tread depth of less than $\frac{4}{32}$ in. (3.2 mm) on any steering axle or $\frac{2}{32}$ in. (1.6 mm) on any nonsteering axle at any two adjacent major tread grooves anywhere on the tire.
(5) Tire speed rating is less than the governed vehicle speed rating of the vehicle.
(6) Suspension components are loose, broken, or missing.
(7) Wheels or rims have the following deficiencies:
    (a) Bent, broken, cracked, improperly seated, sprung, or mismatched lock or side ring(s)
    (b) Cracked, broken, or elongated bolt holes
    (c) Loose, missing, broken, cracked, stripped, or damaged fasteners
    (d) Weld deficiencies, as follows:
        i. Cracks in welds attaching disc wheel disc to rim
        ii. Cracks in welds attaching tubeless demountable rim to adapter
        iii. Welded repair on aluminum wheel(s) on a steering axle
        iv. Welded repair, other than disc to rim attachment, on steel disc wheel(s) mounted on the steering axle
(8) Axle flanges have Class 3 leakage.
(9) An axle has Class 3 leakage.
(10) Steering components do not meet the requirements of 49 CFR 399.211, Appendix G, "Minimum Periodic Inspection Standards."
(11) A steering component has Class 3 leakage.
(12) Driveline components do not meet the requirements of 49 CFR 399.211, Appendix G.

**6.3.2** A qualified technician shall conduct an out-of-service evaluation of the following tire deficiencies and make a written report, including recommendations to the AHJ:

(1) Punctures
(2) Cuts to the cord
(3) Bulges other than bumps or repairs; repair bulges greater than $\frac{3}{8}$ in. (10 mm), or bulges or knots associated with tread
(4) Sidewall separation

**6.4 Engine Systems.**

**6.4.1*** The following defects and deficiencies of the engine system shall cause the emergency vehicle to be taken out of service:

(1) Engine that will not crank or start
(2) Engine system that has Class 3 leakage of oil
(3) Engine that is overheating
(4) Fuel system component that has Class 2 leakage of fuel
(5) Stop-engine light that fails to turn off after engine is started

**6.4.2** If there are deficiencies of the following systems or components, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ concerning the following:

(1) Air filter restriction
(2) Fuel tank, mountings, or straps
(3) Exhaust leak into crew compartment
(4) Oil that contains coolant
(5) Oil that is diluted with fuel

**6.5 Engine Cooling System.**

**6.5.1** The following deficiencies of the engine cooling system shall cause the apparatus to be taken out of service:

(1) Cooling system component that has Class 3 leakage
(2) Coolant that contains oil
(3) Cooling system that exceeds maximum operating temperature

**6.5.2** If there are deficiencies with the following systems or components, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ:

(1) Radiator
(2) Water pump bearing
(3) Cooling fan
(4) Coolant system components

**6.6 Transmission and Clutch.**

**6.6.1** The following defects and deficiencies of the transmission and clutch shall cause the emergency vehicle to be taken out of service:

(1) Automatic transmission that overheats in any range
(2) Automatic transmission that has a "do not shift" light on
(3) Transmission components that have Class 3 leakage of transmission oil
(4) Transmission oil contaminated with coolant

**6.6.2** If there are deficiencies of the following systems or components, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ:

(1) Clutch components
(2) Transmission components
(3) Shift linkages

**6.7 Low-Voltage and Line Voltage Electrical Systems.**

**6.7.1** The following defects and deficiencies of the low-voltage electrical system and the line voltage electrical system shall cause the emergency vehicle to be taken out of service:

(1) Legally required lighting (DOT lighting) or horn that is not operational

(2) Ignition system that is not operational
(3) Charging system that is not operational
(4)* Any failure of the warning light system that creates any position around the vehicle from which no warning light is visible

**6.7.2** If there are deficiencies in the grounding and bonding system, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.7.3** If any of the following conditions exist, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ on the following:

(1)* Inoperative siren
(2) Overheating of power source and systems
(3) Tripping of circuit breakers [ground fault circuit interrupter (GFCI), if applicable]
(4) Line voltage power source producing high or low voltage or frequency
(5) Damaged receptacles or observed electrical shock hazard
(6) Any failure of the line voltage system that could affect patient care

**6.8 Braking Systems.**

**6.8.1 Air Brake Systems.**

**6.8.1.1*** Any one of the following deficiencies of the air brake system shall cause the emergency vehicle to be taken out of service:

(1) Service brakes that have an air pressure drop of more than 2 psi (13.8 kPa) in 1 minute for straight chassis or more than 3 psi (20.7 kPa) in 1 minute for combination chassis, with the engine stopped and the service brakes released
(2) Leak-down rate (time) of the applied side of the air brake that is more than 3 psi (20.7 kPa) in 1 minute for straight chassis or more than 4 psi (27.6 kPa) in 1 minute for combination chassis, with the engine stopped and the service brakes applied
(3) Brakes that are out of adjustment
(4) Braking system components that are not operational
(5) Service brake that does not meet test or DOT requirements
(6) Parking (spring) brake operation that does not meet parking brake tests or standards
(7) Air compressor that fails to build air pressure from 85 psi to 100 psi (586 kPa to 690 kPa) in 45 seconds, with engine at full rpm
(8) Air compressor that fails to maintain 80 psi to 90 psi (552 kPa to 621 kPa) pressure in the system, with the service brakes applied and the engine at idle, or air compressor that fails to fill the air system to the air compressor governor cutout pressure with the service and parking brakes released
(9) Friction surfaces, brake shoes, or disc brake pads that have grease or oil on them
(10) Brake linings or pads that are worn beyond the brake system manufacturer's minimum specifications
(11) Rotors and drums that are worn beyond the brake system manufacturer's minimum specifications
(12) Air gauge or audio low-air warning device that has failed

**6.8.1.2** If the antilock braking system (ABS) warning indicator indicates a problem, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.8.2 Hydraulic Brake Systems.**

**6.8.2.1*** Any one of the following deficiencies of the hydraulic brake system shall cause the emergency vehicle to be taken out of service:

(1) Brake system components that have Class 2 leakage of brake fluid
(2) Friction surfaces, brake shoes, or disc brake pads that have grease or oil on them
(3) Braking system components that are not operational
(4) Braking operation that does not meet braking tests or standards
(5) Parking (service) brake operation that does not meet parking brake tests or standards
(6) Brake warning light that is activated or brake pedal that falls away or drifts toward the floor when brake pressure is applied
(7) Brake linings or pads that are worn beyond the brake system manufacturer's minimum specifications
(8) Rotors and drums that are worn beyond the brake system manufacturer's minimum specifications

**6.8.2.2** If the ABS warning indicator indicates a problem, a qualified technician shall conduct an out-of-service evaluation and make a written report including recommendations to the AHJ.

**6.8.3 Air-Over-Hydraulic Brake Systems.** The requirements of 6.8.1 and 6.8.2 shall apply to the applicable portion of an air-over-hydraulic brake system.

**6.8.4 Wheel Chocks.** If the emergency vehicle is not equipped with two wheel chocks, mounted in readily accessible locations, the emergency vehicle shall be taken out of service.

**6.9 Fire Pump System.**

**6.9.1** The following deficiencies of the fire pump system shall cause the pumping system to be taken out of service:

(1) Pump that will not engage
(2) Pump shift indicators in cab and on operator's panel that do not function properly
(3) Pressure control system that is not operational
(4) Pump transmission components that have Class 3 leakage of fluid
(5) Pump operator's panel throttle that is not operational
(6)* Pump operator's engine speed advancement interlock that is not operational

**6.9.2** If there are deficiencies of the following systems or components, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ:

(1) Pump transmission lubricant
(2) Valves
(3) Valve controls
(4) Pump piping
(5) Pressure-indicating devices
(6) Water tank
(7) Water level indicator

**6.9.3** If pump shaft seals leak beyond the manufacturer's specifications, a qualified technician shall conduct an out-of-service evaluation of the problem and make a written report, including recommendations to the AHJ.

**6.9.4** If the pump test indicates a deficiency, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.10 Aerial Device Systems.**

**6.10.1** The following deficiencies of the aerial device and its systems shall cause the aerial device to be taken out of service:

(1) Power takeoff (PTO) that will not engage
(2) Stabilizer system that is not operational
(3) Aerial device that is not operational
(4) Hydraulic system components that are not operational
(5) Cable sheaves that are not operational
(6) Cables that are frayed
(7) Base and section rails that show ironing beyond the manufacturer's recommendations
(8) Aerial device that is structurally deformed
(9) Torque box fasteners that are broken or missing
(10) Turntable fasteners that are broken or missing

**6.10.2** If there are deficiencies of the following systems or components, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ:

(1) Hydraulic relief valve
(2) Hydraulic system components
(3) Emergency hydraulic system
(4) Visual and audible alarm systems
(5) Aerial lighting system
(6) Labels or warning signs
(7) Aerial water delivery system
(8) Class 3 hydraulic leak

**6.10.3** A qualified technician shall conduct an out-of-service evaluation of the following problems and make a written report, including recommendations to the AHJ:

(1) Rollers and slides that are worn beyond manufacturer's recommendations
(2) Rotation bearing that has clearances beyond the manufacturer's recommendations

**6.11 Trailers.**

**6.11.1** The following deficiencies of a trailer and its system shall cause the trailer to be taken out of service:

(1) Cracked trailer frame
(2) Damaged or inoperative hitch
(3) Damaged or missing safety chain or chain latch
(4) The gross axle weight rating (GAWR) shown on the trailer information label is greater than the tires manufacturer's load rating
(5) When weighed in accordance with Section 16.2, the weight on the axles of the trailer exceeds the values shown on the trailer information label
(6) Tires have cuts in the sidewall that penetrate to the cord
(7)* Tires that have a tread depth of less than $\frac{2}{32}$ in. (1.6 mm) or at any two adjacent major tread grooves anywhere on the tire
(8) Suspension components that are loose, broken, or missing
(9) Wheels or rims having the following deficiencies:
    (a) Damaged or mismatched lock or side ring(s)
    (b) Cracked, broken, or elongated bolt holes
    (c) Loose, missing, broken, cracked, stripped, or damaged fasteners
    (d) Weld defects
(10) Braking system components that are not operational
(11) Friction surfaces, brake shoes, or disc brake pads that have grease or oil on them
(12) Brake linings or pads that are worn beyond the brake system manufacturer's minimum specifications
(13) Rotors and drums that are worn beyond the brake system manufacturer's minimum specifications
(14) Brake system components that have Class 2 leakage of brake fluid
(15) Inoperative or damaged breakaway brake system
(16) Inoperative stop, turn, or marker lighting
(17) Damaged or missing trailer cord or plug

**6.11.2** A qualified technician shall conduct an out-of-service evaluation of the following tire deficiencies and make a written report, including recommendations to the AHJ, on:

(1) Tire punctures
(2) Tire cuts to the cord
(3) Tire bulges other than bumps or repairs; repair bulges greater than $\frac{3}{8}$ in. (10 mm), or bulges or knots associated with tread
(4) Tire sidewall separation

**6.12 Patient Compartment.** Any one of the following deficiencies of a patient compartment and its systems shall cause the patient compartment to be taken out of service:

(1) Patient compartment entry doors that do not latch properly
(2) Cot retention mechanism that does not hold the cot
(3) HVAC system that does not cool or heat properly
(4) Inoperative patient compartment illumination system
(5) Damaged or inoperative primary patient care seat or seat belt
(6) An inoperative medical gas system

**6.13 Aircraft Rescue and Firefighting (ARFF) Vehicles.**

**6.13.1 Driving and Crew Areas, Apparatus Body, and Compartmentation.** A vehicle shall be taken out of service if the window deluge system is inoperative.

**6.13.2 Chassis, Axles, Steering, Suspension Systems, Driveline, Wheels, and Tires.**

**6.13.2.1** A vehicle shall be taken out of service if a planetary axle or wheel end has Class 3 leakage.

**6.13.2.2** If a vehicle driveline locking system does not operate as intended, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.2.3** A vehicle shall be taken out of service if the driveline locking system fails to disengage.

**6.13.2.4*** A vehicle shall be taken out of service if an original tire has been replaced with a tire that does not conform with the following specifications:

(1) The sum of the tire load ratings meets or exceeds the gross axle weight ratings (GAWR) listed on the vehicle's FMVSS certification label

(2) The speed rating of the tire meets or exceeds the allowable vehicle maximum speed

**6.13.3 Engine Systems.** If the vehicle cannot achieve the performance requirements for acceleration and top speeds specified in 4.5.1.2 and 4.5.1.2.1 of NFPA 1900, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.4 Power Dividers and Modulating Clutches.**

**6.13.4.1** A vehicle shall be taken out of service if a power divider has Class 3 leakage.

**6.13.4.2** If a power divider overheats, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.4.3** If a power divider has oil contamination, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.4.4** If the modulating clutch has any slippage when it is fully engaged in the normal driving mode, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.4.5** A vehicle shall be taken out of service if the vehicle cannot pump and roll.

**6.13.5 Braking Systems.** If the vehicle cannot achieve the performance standards for service brake stopping distance specified in 4.11.2.2, 4.11.2.3, and 4.11.2.4 of NFPA 1900, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.6 Fire Pump Systems.**

**6.13.6.1** A vehicle shall be taken out of service if a fire pump will not engage or disengage.

**6.13.6.2** If there are any deficiencies in the fire pump drive system, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.6.3** The vehicle shall be taken out of service if the pump cannot supply the primary turret to meet the performance specifications specified in 6.4.12 of NFPA 1900.

**6.13.6.4** The vehicle shall be taken out of service if any deficiency exists that inhibits the delivery and replenishment of water to the pump.

**6.13.6.5** The vehicle shall be taken out of service if the water pump cannot maintain system pressure based on the manufacturer's recommendations.

**6.13.7 Foam Systems.**

**6.13.7.1** The vehicle shall be taken out of service if the foam system has any defects or deficiencies that cause the primary turret concentration or delivery to not meet the specified concentration and condition specified in Sections 28.1 and 28.2 of NFPA 460.

**6.13.7.2** The vehicle shall be taken out of service if any conditions exist that inhibit the refilling of the foam tank.

**6.13.7.3** If any foam-capable discharge other than the primary turret is out of specification for the concentration and condition specified in Sections 28.1 and 28.2 of NFPA 460, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.8 Turrets.**

**6.13.8.1** The vehicle shall be taken out of service if the dual rate primary turrets cannot meet the specified flow rate in the high flow–rate mode.

**6.13.8.2** The vehicle shall be taken out of service if the primary turret cannot meet the requirements for turret operational capabilities in 4.20.5(1), 4.20.5(2), and 4.20.5(3) of NFPA 1900.

**6.13.8.3** If the primary turret does not operate as designed and as specified in 4.20.1, 4.20.2, 4.20.3, 4.20.4.1, 4.20.4.2, 4.20.5(4), and 4.20.5(5) of NFPA 1900, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.9 Extendable Turret.**

**6.13.9.1** The vehicle shall be taken out of service if the extendable turret cannot be stowed.

**6.13.9.2** If the following conditions exist, the extendable boom shall be taken out of service:

(1) PTO will not engage
(2) Hydraulic system components are not operational
(3) Cables are frayed
(4) Extendable boom device is structurally deformed
(5) Turntable fasteners are broken or missing, or there are damaged bearings
(6) Extendable boom mounting system is deformed, damaged, or has missing or cracked bolts
(7) Extendable boom functions will not raise, lower, extend, retract, or rotate with the use of the primary controls

**6.13.9.2.1** A qualified technician shall conduct an out-of-service evaluation on the extendable boom and make a written report, including recommendations to the AHJ.

**6.13.10 Complimentary Agents.** If any complimentary agent system does not function as intended, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

**6.13.11 Winterization Systems.** If there is any defect in the winterization system, a qualified technician shall conduct an out-of-service evaluation and make a written report, including recommendations to the AHJ.

## Chapter 7 Daily/Weekly Visual and Operational Checks (NFPA 1911)

**7.1* General.** A visual and operational check of the apparatus shall be performed within 24 hours of a run or at least weekly.

**7.1.1** The visual and operational checks shall be performed to the requirements in Sections 7.2 through 7.4.

**7.1.2** The check sheet in Annex C or an equivalent check sheet shall be used to record the daily/weekly visual and operational checks.

**7.1.3** Personnel conducting the visual and operational checks shall meet the requirements of 4.4.2.

**7.2 Visual Checks.** A visual check of components, fluid levels, fluid condition, leaks, and systems shall include, but not be limited to, the following (if applicable):

(1) Engine oil fluid level and condition
(2) Transmission fluid level and condition
(3) Coolant level
(4) Power steering fluid level and condition
(5) Fluid leaks on the floor
(6) Tire condition
(7) Tire air pressure
(8) Wheel and lug nuts
(9) Seat belt condition
(10) Windshield, mirrors, and door glass
(11) Steering linkage
(12) Cab doors, handles and steps
(13) Battery condition
(14) Body and compartment door condition
(15) Running boards, steps, ladders, and handles
(16) Ground ladder racks and mounting
(17) Hydraulic brake fluid level
(18) Placards and warning decals
(19) Front and rear springs
(20) Fuel tank level and mounting
(21) Fire pump mounting
(22) Fire pump discharges and suctions valves
(23) Fire pump controls and gauges
(24) Pump drains
(25) Water tank level, leaks, and condition
(26) Primer oil level
(27) Aerial hydraulic system
(28) Hydraulic fluid level and condition
(29) Outriggers and torque box
(30) Aerial device controls
(31) Ladder and basket
(32) Waterway and monitor
(33) Auxiliary equipment and racks

**7.3 Operational Check.** An operational check of the components and systems shall include, but not be limited to, the following (if applicable):

(1) Starting system
(2) Battery voltage
(3) Audible and visual alarms
(4) Engine
(5) Charging system
(6) Cab gauges
(7) Steering system
(8) Seat belts
(9) Seat belt warning system
(10) Brake air compressor
(11) Transmission
(12) Warning light system
(13) Fire pump
(14) Pump panel gauges and controls
(15) Relief valve
(16) Pressure governor operation
(17) Foam system
(18) Primer system
(19) Pump valves and reels
(20) Main drain and other drains
(21) Cooler valves
(22) Water tank level indicator
(23) DOT lighting
(24) Horns
(25) Brake system
(26) Parking or spring brakes
(27) Windshield wipers and washers
(28) Line voltage generating source
(29) Work lighting
(30) Cab door glass
(31) Power steps and access ladders
(32) Aerial hydraulic system
(33) Aerial outriggers
(34) Aerial interlocks
(35) Aerial device
(36) Auxiliary equipment and racks
(37) Drain moisture from air brake system reservoirs

**7.4 Documentation.**

**7.4.1** A record of the visual and operational check sheet shall be kept.

**7.4.2** The AHJ shall develop and implement a procedure for reporting defects found during the visual and operational checks.

**7.4.3** The AHJ shall have a procedure to remove the apparatus from service if an out-of-service criteria defect is found during the visual and operational checks.

## Chapter 8 Inspection and Maintenance of the Chassis, Driving and Crew Compartment, and Body (NFPA 1911)

**8.1 General.** All components and systems commonly found on or in the chassis, driving compartment, crew compartment, and body shall be inspected and maintained in accordance with the manufacturer's instructions and this chapter.

**8.2 Frame and Suspension.**

**8.2.1** All frame rails and members shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**8.2.2** All suspension components including, but not limited to, the following shall be inspected for defects, missing or loose parts, and functional operation and be lubricated:

(1) Springs and spring hangers
(2) Air springs (bags), mounting brackets, and attaching hardware
(3) Equalizer beams and torque arms
(4) Shock absorbers

**8.2.3** The frame and suspension shall be inspected for proper alignment.

**8.3 Axles, Tires, and Wheels.**

**8.3.1** All axle components including, but not limited to, the following shall be inspected for security of mounting, structural integrity, deformation, abnormal wear, and leakage; be functionally operated; and be lubricated:

(1) Ball joints
(2) King pins
(3) Spindles and bushings
(4) Attaching hardware
(5) Axle beams and housings
(6) Axle shafts
(7) Axle power dividers
(8) Differentials and controls
(9) Two-speed axle shift units
(10) Upper and lower control arms

**8.3.2** Wheel bearings and seals shall be cleaned; inspected for deformation, wear, cracks, and leakage; and lubricated.

**8.3.3*** Tires shall be inspected for damage and inflated to the tire manufacturer's recommended pressure for the weight on the tire.

**8.3.4*** The tire load rating shall be checked to verify that it meets or exceeds the GAWR.

**8.3.5** The tire speed rating shall be checked to verify that it meets or exceeds the maximum top speed of the apparatus.

**8.3.6*** Tires shall be replaced at least every 7 years or more frequently when the tread wear exceeds state or federal standards as determined by measuring with a tread depth gauge. *[See 6.3.1(4).]*

**8.3.7*** Wheel-attaching nuts shall be torqued to the wheel manufacturer's recommendation.

**8.3.8** Wheels and rims shall be inspected for cracks, deformation, structural integrity, and corrosion.

**8.4 Engine.**

**8.4.1** The engine oil shall be inspected for contamination and maintained at the level specified by the engine manufacturer.

**8.4.2** The engine shall be inspected for security of mounting and fluid leaks.

**8.4.3** Engine oil and filters shall be serviced in accordance with the engine manufacturer's severe service recommendation.

**8.4.3.1** If no severe service recommendation exists, the shortest interval recommended by the engine manufacturer, based on time or mileage, shall be followed.

**8.4.4** The diagnostic codes for electronically controlled engines shall be reviewed for types and frequency of error codes that have been logged.

**8.4.5*** The engine performance shall be maintained in accordance with the engine manufacturer's recommendations.

**8.4.6** Engine braking systems shall be maintained in accordance with the manufacturer's recommendations.

**8.5 Engine Cooling System.**

**8.5.1** The engine coolant shall be inspected for contamination and maintained at the level specified by the manufacturer.

**8.5.2** The radiator assembly shall be inspected and cleaned of dirt, debris, and obstructions to airflow.

**8.5.3** All hoses and fittings shall be inspected for condition and leakage.

**8.5.4** The water pump(s) shall be inspected for condition and leakage.

**8.5.5** The cooling system shall be pressure tested for leakage.

**8.5.6** All belts shall be inspected for wear, deformation, and proper adjustment.

**8.5.7** The chemical components of the coolant shall be tested and maintained at the proper balance.

**8.5.8** Cooling system temperature indicators and gauges shall be diagnostically checked.

**8.5.9** Temperature control devices including, but not limited to, the following shall be diagnostically checked:

(1) Thermostats
(2) Clutch fans
(3) Radiator shutters
(4) Electric cooling fans

**8.5.10** Auxiliary heat exchangers installed in the engine cooling system shall be inspected for security of mounting, deformation, and leaks.

**8.6* Engine Fuel System.**

**8.6.1** Fuel filters and fuel-water separators shall be maintained in accordance with the manufacturer's recommendations.

**8.6.2** The fuel tank, lines, and all connections shall be inspected for security of mounting, deformation, and leakage.

**8.6.3** The carburetor or the injection pump and injectors shall be maintained in accordance with the engine manufacturer's recommendations.

**8.6.4** Gauges, indicators, and sending units shall be diagnostically checked.

**8.6.5*** All mechanical throttle linkage and stops shall be inspected for proper adjustment and diagnostically checked.

**8.6.6** All electronic throttle components and throttle position sensors (TPS) shall be inspected and diagnostically checked.

**8.7 Engine Air Intake System.**

**8.7.1** The engine air intake system shall include, but not be limited to, the following:

(1) Air cleaner element
(2) Piping
(3) Turbocharger
(4) Air after-cooler
(5) Intercooler
(6) Air-to-air cooler
(7) Blower
(8) Ember separator

**8.7.2** The engine air intake system shall be maintained in accordance with the manufacturer's severe service recommendation.

**8.7.2.1** If no severe service recommendation exists, the shortest service interval recommended by the engine manufacturer, based on time or mileage, shall be followed.

**8.7.3** Where engines are equipped with a charged air aftercooler, it shall be inspected visually for outward signs of damage or deformation.

**8.7.4** All hoses, tubes, and fittings shall be inspected for deformation and leakage.

**8.7.5** The airflow shall be monitored for restriction greater than that recommended by the engine manufacturer.

**8.8 Engine Exhaust System.**

**8.8.1** The engine exhaust system shall include, but not be limited to, the following:

(1) Exhaust manifold(s)
(2) Exhaust pipes
(3) Muffler(s)
(4) Tailpipe(s)
(5) Exhaust clamps, brackets, and mounting hardware
(6) Turbocharger
(7) Catalytic converter(s)
(8) Exhaust filtration system

**8.8.2** The exhaust system shall be inspected for security of mounting, deformation, and exhaust leaks and be maintained in accordance with the engine manufacturer's recommendations.

**8.9 Transmission.**

**8.9.1** The transmission shall be inspected for security of mounting, structural integrity, and leakage and be diagnostically checked.

**8.9.2** The clutch and linkage, if the emergency vehicle is so equipped, shall be inspected for condition and adjustment, diagnostically checked, and maintained in accordance with the manufacturer's recommendations.

**8.9.3** Transmission lubricants and filters shall be inspected for contamination.

**8.9.3.1** Lubricants shall be maintained at the level specified by the manufacturer.

**8.9.4** The lubricant and filters shall be serviced in accordance with the transmission manufacturer's severe service recommendation.

**8.9.4.1** If no severe service recommendation exists, the shortest interval recommended by the transmission manufacturer, based on time or mileage, shall be followed.

**8.9.5** The transmission controls and shift linkage shall be inspected for condition and maintained in accordance with the manufacturer's recommendations.

**8.9.6** All transmission indicators and gauges shall be tested for proper operation and accuracy.

**8.9.7** The diagnostic codes for all electronically controlled transmissions shall be reviewed for types and frequency of error codes that have been logged.

**8.9.8** Power takeoffs (PTOs) shall be inspected for security of mounting and leakage and be diagnostically checked.

**8.9.9** The lockup system for pumps and other accessories shall be inspected for leakage and diagnostically checked.

**8.9.10** Transmission braking systems shall be maintained in accordance with the manufacturer's recommendations.

**8.9.11** Auxiliary heat exchangers installed in the transmission cooling system shall be inspected for security of mounting, deformation, and leaks.

**8.10 Driveline.**

**8.10.1** All drive shafts, universal joints, carrier bearings, flanges, bearing cap bolts, and slip yokes shall be inspected for alignment, security of mounting, and wear and be lubricated.

**8.10.2** Driveline retarding systems shall be cleaned, inspected for security of mounting, diagnostically checked, and lubricated.

**8.11 Steering System.**

**8.11.1** The steering system shall include, but not be limited to, the following components:

(1) Power steering pump, filters, and reservoir
(2) Steering valve(s), cylinders, and hydraulic components
(3) Steering gear box(es)
(4) Steering gear mounting brackets
(5) Steering arms, drag links, pitman arms, tie rods, and tie rod ends
(6) Steering column assembly and steering wheel

**8.11.2** All steering system components shall be inspected for structural integrity, security of mounting, leakage, and condition; diagnostically checked; and lubricated.

**8.11.2.1** The surrounding vehicle components shall be inspected for indications that the wheels or tires have been rubbing during steering.

**8.11.2.2** Both the left and right steering axle stops shall be diagnostically checked to ensure the steering gear hydraulics relieve before contacting the steering stops.

**8.11.2.3 Steering Gear Mounting Bracket.**

**8.11.2.3.1** The steering gear mounting bracket shall be cleaned and inspected for cracks.

**8.11.2.3.2** All steering gear mounting bracket fasteners shall be inspected for proper installation, grade, and torque.

**8.11.2.4** The steering linkage assembly shall be inspected to ensure that the pinch bolts, cotter pins, and other retaining hardware are in place and properly secured.

**8.11.2.5** The steering wheel shall be rotated to check for steering backlash.

**8.11.3** The steering gear box(es) and power steering reservoir lubricant levels shall be maintained in accordance with the manufacturer's recommendations.

**8.11.4** The steering valve(s), steering arms, drag links, pitman arms, tie rod ends, and steering column assembly shall be lubricated.

**8.11.5** All steering pump belts, hoses, and lines shall be inspected for wear, adjustment, and deformation.

**8.11.6** Electronic steering controls and indicators shall be maintained in accordance with the manufacturer's recommendations.

**8.12 Braking System.**

**8.12.1*** The braking system shall be inspected and maintained in accordance with the manufacturer's severe service recommendation.

**8.12.1.1** If no severe service recommendation exists, the shortest interval recommended by the braking system manufacturer, based on time or mileage, shall be followed.

**8.12.2** The parking brake shall be inspected for structural integrity, security of mounting, missing or broken parts, and wear and be diagnostically checked.

**8.12.3** The parking brake controls and activating mechanism shall be inspected for structural integrity, security of mounting, and missing or broken parts; be diagnostically checked; and be lubricated.

**8.12.4** The brake linings shall be replaced in accordance with the brake manufacturer's severe service recommendation when they are contaminated, when the lining is worn to the minimum thickness for safe operation as defined by the brake manufacturer, or when the brake drum or rotor is replaced.

**8.12.5** The drums or rotors shall be inspected during scheduled maintenance, when there is a suspected problem, or at the time of brake lining replacement.

**8.12.5.1** The inspection required by 8.12.5.1 shall consist of, but not be limited to, the following:

(1) Evidence of extensive heat or heat cracking
(2) Out of round
(3) Wear beyond manufacturer's specifications
(4) Rust
(5) Taper
(6) Rotor parallelism
(7) Metal fatigue

**8.12.6** Machining of brake drums or rotors shall be done only in accordance with manufacturer's recommendations.

**8.12.7** All components of the braking system shall be inspected for damage and wear when performing a brake overhaul.

**8.12.8 Antilock Braking Systems.**

**8.12.8.1** Antilock braking systems (ABS), including the electronic control unit, cables, switches, relays, sensors, and valves, shall be inspected for any deficiencies and diagnostically checked.

**8.12.8.2** The ABS electronic control unit (ECU) diagnostic codes shall be reviewed for types and frequency of error codes that have been logged.

**8.12.9** If the emergency vehicle has a hydraulic brake system, the components to be inspected and maintained shall include, but not be limited to, the following:

(1) Pedal and linkage
(2) Brake switches
(3) Master cylinder
(4) Brake booster
(5) Hydraulic lines
(6) Valves
(7) Wheel cylinders or calipers
(8) Brake shoes or pads
(9) Brake drums or rotors
(10) Warning devices
(11) Mounting hardware
(12) Fluid level and contamination

**8.12.10** If the emergency vehicle has an air brake system, the components to be inspected and maintained shall include, but not be limited to, the following:

(1) Air compressor
(2) Pedal assembly
(3) All valves
(4) Hoses and lines
(5) Brake switches
(6) Brake air chambers
(7) Slack adjusters
(8) Cams and wedges
(9) Brake shoes or pads
(10) Brake drums or rotor
(11) Calipers
(12) Air dryers
(13) Drain valves
(14) Air tanks
(15) Warning devices
(16) Mounting hardware

**8.12.10.1** If air accessories are connected to the chassis air brake system, the requirements of 8.12.10.1.1 and 8.12.10.1.2 shall apply.

**8.12.10.1.1** The air brake system pressure protection valve(s) shall be diagnostically checked to the shutoff point.

**8.12.10.1.2** The pressure protection valve shall prevent the air accessories from drawing air from the air brake system when the air pressure drops below 80 psi (552 kPa) to ensure adequate air pressure for the braking system.

**8.12.10.2** Air reservoir tanks, air dryers, and drains shall be inspected for security of mounting, deformation, and leakage and be maintained in accordance with the manufacturer's recommendations.

**8.12.10.3** All valves, lines, cylinders, and chambers shall be inspected for security of mounting, deformation, and leakage and be diagnostically checked.

**8.12.10.4** The compressor and inlet filter system shall be inspected for security of mounting and be maintained in accordance with the manufacturer's recommendations.

**8.12.10.5** All chassis air system belts shall be inspected for wear and deformation and be maintained at the manufacturer's recommended adjustment.

**8.12.10.6** The cut-in and cut-out pressure settings of the air compressor governor shall be tested and maintained at the manufacturer's recommended settings.

**8.12.10.7** The low-air warning systems shall be tested to ensure that activation occurs at the manufacturer's recommended setting.

**8.12.10.8** Air pressure indicators shall be diagnostically checked.

**8.12.10.9** Leak-down rate (time) of the applied side of the air brake system shall be performance tested with the engine stopped and the service brakes applied.

**8.12.10.9.1** The air pressure shall not drop more than 3 psi (20.7 kPa) in 1 minute for a straight vehicle or more than 4 psi (27.6 kPa) in 1 minute for a combination vehicle when tested in accordance with 8.12.10.9.

**8.12.10.10** Leak-down rate (time) of the supply-side of the chassis air system shall be performance tested with the engine stopped and the service brakes released.

**8.12.10.10.1** The air pressure shall not drop more than 2 psi (13.8 kPa) in 1 minute for a straight vehicle or more than 3 psi (20.7 kPa) in 1 minute for a combination vehicle when tested in accordance with 8.12.10.10.

**8.13 Chassis Air-Powered Accessories.** All chassis air-powered accessories including, but not limited to, the following shall be diagnostically checked:

(1) Air horn
(2) Windshield wiper and washer
(3) Air-ride seats
(4) Air-powered steps and cab tilting systems
(5) Fire pump shift and valves

**8.14 Crew and Passenger Compartments.**

**8.14.1** All glass, windows, and mirrors shall be inspected for condition and be diagnostically checked.

**8.14.2** All seats shall be inspected for security of mounting and condition and be diagnostically checked.

**8.14.3** All seat belts shall be inspected for security of mounting and condition and be diagnostically checked.

**8.14.4** Doors, door hinges, latches, and door stops shall be inspected for security of mounting and condition, diagnostically checked, and lubricated.

**8.14.5** All components of the cab mounting system including, but not limited to, the following shall be inspected for security of mounting and deformation:

(1) Mounting brackets
(2) Cab base structure
(3) Resilient cushions
(4) Securing fasteners

**8.14.6*** All equipment mounting systems including, but not limited to, mounting systems for the following shall be inspected for security of mounting and deformation and be maintained free of corrosion:

(1) Radios, computers, and siren controls
(2) Self-contained breathing apparatus (SCBA)
(3) Portable lights
(4) Hand tools
(5) Emergency medical service (EMS) equipment
(6) Books, street directories, and maps

**8.14.7 Cab Tilting Systems.** If the emergency vehicle has a cab tilting system, it shall be inspected and maintained in accordance with 8.14.7.1 and 8.14.7.2.

**8.14.7.1*** All components of the cab tilting system including, but not limited to, the following shall be inspected for security of mounting and leaks and shall be diagnostically checked:

(1) Switches and remote controls
(2) Interlocks
(3) Motors and pumps
(4) Reservoirs
(5) Hoses and fittings
(6) Cylinders and lifting devices
(7) Cab support devices
(8) Split cab seals
(9) Pivot points
(10) Latches and hold-down devices

**8.14.7.2** Fluids shall be inspected for contamination and maintained to the levels recommended by the manufacturer.

**8.15 Body and Compartmentation.**

**8.15.1** All compartments and storage areas shall be inspected for structural integrity, deformation, and leaks.

**8.15.1.1** Hinges, latches, and seals shall be diagnostically checked and lubricated.

**8.15.1.2** Doors shall be diagnostically checked for correct operation and position.

**8.15.1.3** The hazard warning light and interlocks associated with, but not limited to, the following conditions shall be diagnostically checked:

(1) Open passenger or equipment compartment doors
(2) Ladder or equipment rack not in the stowed position
(3) Deployed stabilizer system
(4) Extended powered light tower

**8.15.2** All steps, platforms, handrails, and access ladders shall be inspected for security of mounting, structural integrity, and deformation.

**8.15.2.1** All slip-resistant surfaces shall be inspected for security of mounting and condition.

**8.15.2.2** All mechanical steps shall be diagnostically checked and lubricated.

**8.15.3** All equipment mounting racks and brackets shall be inspected for security of mounting and deformation, diagnostically checked, and lubricated.

**8.15.4*** All finishes and reflective striping shall be inspected for defects, corrosion, and damage.

**8.15.5*** Where required, all signs and labels shall be inspected for their presence and any defects, corrosion, and damage.

**8.16 Powered Equipment Racks.** If the emergency vehicle is equipped with powered equipment racks, the racks shall be inspected and maintained in accordance with 8.16.1 through 8.16.5.

**8.16.1** All locks used to hold equipment racks in the road travel position and all interlocks to prevent operation of equipment racks when the emergency vehicle is in motion shall be inspected for security of mounting and deformation.

**8.16.2** Racks and interlocks shall be diagnostically checked.

**8.16.3** All warning lights and visual signals for the equipment racks shall be diagnostically checked.

**8.16.4** Reflective striping or reflective paint shall be inspected for defects, corrosion, and damage.

**8.16.5** Equipment-holding devices shall be inspected for security of mounting and deformation, diagnostically checked, and lubricated.

## Chapter 9 Inspection and Maintenance of Low-Voltage Electrical Systems (NFPA 1911)

**9.1 General.** Low-voltage electrical systems shall be inspected and maintained in accordance with this chapter.

**9.1.1** All electrical equipment on the emergency vehicle shall be inspected and maintained, regardless of whether it is specified in Sections 9.2 through 9.13.

**9.1.2** All components of the low-voltage electrical system shall meet the following criteria:

(1) They are to be kept clean and free of accumulated dirt or corrosion.
(2) They are to be maintained in accordance with manufacturer's instructions and schedules.
(3) They are to be securely mounted.
(4) They are to be securely connected to their electrical supply and ground.

**9.2 Starting System.** All components of the starting system including, but not limited to, the following shall be inspected for security of mounting and deformation and be diagnostically checked:

(1) Batteries, cabling, and connections
(2) Cranking motor
(3) Solenoid, relays, and switches
(4) Interlock systems

**9.3 Wiring.** All wiring and wire looms shall be inspected for security of mounting, tight connections, proper routing, presence of grommets, condition, and cleanliness.

**9.4 Batteries.** The battery(ies) shall be tested for storage and performance capabilities in accordance with the manufacturer's recommendations.

**9.5 Charging System.**

**9.5.1** All components of the charging system including, but not limited to, the following shall be inspected for security of mounting, deformation, and alignment and be diagnostically checked:

(1) Alternator, regulator, and associated wiring and cables
(2) Isolators
(3) Alternator drive belts
(4) Solenoids, relays, switches, and instrumentation
(5) Interlock systems

**9.5.2*** The alternator shall be diagnostically checked.

**9.6 Ignition System.** All components of the ignition system including, but not limited to, the following shall be inspected for security of mounting and deformation and be diagnostically checked:

(1) Associated wiring and cables
(2) Solenoid, relays, switches, instrumentation, and lighting
(3) Primary and secondary systems
(4) Glow plugs

**9.7 Automatic Electrical Load Management System.**

**9.7.1** If so equipped, all components of the automatic electrical load management system including, but not limited to, the following shall be inspected for security of mounting and deformation:

(1) Electronic hardware
(2) Associated wiring and cables
(3) Relays, controls, and indicators
(4) Low-voltage warning devices

**9.7.2** The electrical load management system shall be checked for activation and operation of low-voltage warning devices in accordance with the manufacturer's recommendations.

**9.8 Miscellaneous Electrical Components.** Miscellaneous electrical components including, but not limited to, the following shall be inspected for security of mounting and deformation and be diagnostically checked:

(1) Battery conditioners and chargers
(2) Shoreline receptacles
(3) Radios and intercoms
(4) Converters and inverters
(5) Fast idle system
(6) Interlock system(s)
(7) Operator alert devices
(8) Other electrical components on the apparatus not otherwise specified in Section 9.8(1) through 9.8(7)

**9.9 Emergency Vehicle Lighting.** All emergency vehicle lighting including, but not limited to, the following shall be inspected for security of mounting and deformation and be diagnostically checked:

(1) Headlights
(2) Marker lights
(3) Clearance lights
(4) Turn signals and hazard lights
(5) Brake lights
(6) Backup lights
(7) Dash lights
(8) Other emergency vehicle lighting equipment on the vehicle not otherwise specified in Section 9.9(1) through 9.9(7)

**9.10 Work Lighting.** All work lighting including, but not limited to, the following shall be inspected for security of mounting and deformation and be diagnostically checked:

(1) Ground lights
(2) Step lights
(3) Flood, spot, and scene lights
(4) Cab interior lights
(5) Compartment lights
(6) Other work lighting on the emergency vehicle not otherwise specified in Section 9.10(1) through 9.10(5)

**9.11 Electrical Accessories.** All electrical accessories including, but not limited to, the following shall be diagnostically checked:

(1) Heater and defroster
(2) Air-conditioning system
(3) Windshield wipers and washers
(4) Instrumentation
(5) Traffic pre-emption
(6) Other electrical accessories on the emergency vehicle not otherwise specified in Section 9.11(1) through 9.11(5)

**9.12 Warning Devices.** All warning devices including, but not limited to, the following shall be inspected for security of mounting and deformation and be diagnostically checked:

(1) Emergency warning lights
(2) Electric and electronic sirens
(3) Automotive traffic horn
(4) Air horns
(5) Backup alarm
(6) Other warning devices on the emergency vehicle not otherwise specified in Section 9.12(1) through 9.12(5)

**9.13 Electric Trailer Brake Actuator.** If the emergency vehicle is equipped with an electric trailer brake actuator, the electric trailer brake actuator shall be inspected and diagnostically checked.

## Chapter 10 Inspection and Maintenance of Water Pumping Systems and Water Tanks (NFPA 1911)

**10.1 General.**

**10.1.1** If the fire apparatus is equipped with a fire pump, auxiliary pump, industrial pump, transfer pump, or wildland fire pump, the pump shall be inspected and maintained in accordance with Section 10.2 and the component manufacturer's recommendations.

**10.1.2** If the fire apparatus is equipped with a water tank, the tank shall be inspected and maintained in accordance with Section 10.3 and the component manufacturer's recommendations.

**10.2 Fire Pump, Auxiliary Pump, Industrial Pump, and Transfer Pump.**

**10.2.1* General.** All fire pumps, auxiliary pumps, industrial pumps, transfer pumps, and wildland fire pumps shall be inspected for security of mounting, structural integrity, and leakage and be diagnostically checked.

**10.2.2 Pump Shaft Packing or Mechanical Seals.** All pump shaft packing or mechanical seals shall be inspected and maintained in accordance with the manufacturer's recommendations.

**10.2.3 Renewable Anodes and Intake Strainers.** Renewable anodes, intake strainers, or any other means to prevent galvanic corrosion shall be inspected for condition and replaced if necessary.

**10.2.4 Pump Drive System.**

**10.2.4.1*** The pump drive system shall be inspected for security of mounting and leakage, diagnostically checked, and lubricated as required by the component manufacturer.

**10.2.4.2*** All pump shift controls, pump shift indicators located in the driving compartment and on the operator's panel, engine speed advancement interlocks, and any other interlocks of the pump drive system shall be inspected for security of mounting and leakage, diagnostically checked, and lubricated as required.

**10.2.4.3** All fluids in the pump drive system shall be inspected for contamination and maintained at the level and condition specified by the component manufacturer.

**10.2.5 Piping and Valves.** All pump piping, valves and valve controls, fire hose connections, caps, chains, and gaskets shall be inspected for security of mounting, structural integrity, proper valve operation, deformation, corrosion, and leakage and be lubricated as required by the component manufacturer.

**10.2.6 Instrumentation and Gauges.** All instrumentation, gauges, and lighting shall be inspected for security of mounting and condition and be diagnostically checked.

**10.2.7 Pump Test Label.** The pump test label shall be inspected to ensure that it is legible and attached to the vehicle.

**10.2.8 Pump Controls.** All pump control systems including, but not limited to, the following shall be diagnostically checked:

(1) Engine speed control and interlock
(2) Pressure control devices
(3) Transfer valve
(4) Transmission lockup system

**10.2.9 Pump Priming System.**

**10.2.9.1** The pump priming system shall be inspected for security of mounting and leakage and be diagnostically checked.

**10.2.9.2** The priming fluid, if required, shall be inspected for contamination and proper type and be maintained at the level recommended by the component manufacturer.

**10.2.10 Pump Drive Engine.** If the pump has a separate drive engine, that engine shall be inspected and maintained in accordance with Sections 8.4 through 8.8, as applicable, and in accordance with the manufacturer's recommendations.

**10.3 Water Tanks.** If the apparatus is equipped with a water tank, the tank shall be inspected for security of mounting, structural integrity, deformation, and leakage and be maintained in accordance with 10.3.1 and 10.3.2 and the component manufacturer's recommendations.

**10.3.1** The tank sumps, if equipped with a sump cleanout, shall be cleaned.

**10.3.2** Where so equipped, anodes and other means to prevent galvanic corrosion shall be inspected and maintained as recommended by the manufacturer.

## Chapter 11 Inspection and Maintenance of Aerial Devices (NFPA 1911)

**11.1 General.** If the fire apparatus is equipped with an aerial ladder, elevating platform, or water tower, the aerial device and its associated systems shall be inspected and maintained in accordance with this chapter.

**11.2 Inspection.** The aerial device shall be inspected in accordance with Chapter 23.

**11.3 Maintenance.** The aerial device and its associated systems shall be maintained in accordance with the aerial device manufacturer's recommendations.

**11.4 Air Storage Systems.**

**11.4.1** If the aerial device has an air storage system, the air storage tanks shall be inspected to verify that hydrostatic test

dates are within the periods specified by the manufacturers and the applicable governmental agencies.

**11.4.2** Test reports shall be reviewed to verify that the air has been tested and is in accordance with NFPA 1989.

## Chapter 12 Inspection and Maintenance of Foam Proportioning Systems (NFPA 1911)

**12.1* General.** If the fire apparatus is equipped with a foam proportioning system, the system shall be inspected and maintained in accordance with this chapter.

**12.2 System Components.**

**12.2.1** All components of the foam proportioning system shall be maintained in accordance with the recommendations of the foam system manufacturer.

**12.2.2** All components of the foam proportioning system shall be inspected for security of mounting, structural integrity, and leakage and be diagnostically checked.

**12.3* Cleaning.** The foam proportioning system components not designed to stay in continuous contact with foam concentrate shall be thoroughly flushed after each use to ensure that all piping and components are clear of all foam concentrate.

**12.4 Instrumentation and Controls.** All instrumentation, gauges, and controls shall be inspected for security of mounting and condition and be diagnostically checked.

**12.5 Strainer or Filter.** Where a foam concentrate strainer(s) or filter(s) is utilized, the strainer/filter assembly shall be serviced at routine scheduled intervals.

**12.6 Foam Concentrate Pump.**

**12.6.1** Where the foam proportioning system is equipped with a foam concentrate pump, it shall be maintained as recommended by the manufacturer.

**12.6.2** The oil for the pump lubrication system shall be inspected for possible water/foam contamination and be maintained at the level recommended by the manufacturer.

**12.7 Foam Concentrate or Foam Solution Tanks.**

**12.7.1** All foam concentrate or foam solution tanks shall be inspected for security of mounting, structural integrity, deformation, and leakage.

**12.7.2 Foam Concentrate Inspection.**

**12.7.2.1** At least annually, a visual inspection shall be made of the foam concentrate(s) in the apparatus storage tank(s) for evidence of sludging or deterioration.

**12.7.2.2** If evidence of sludging or deterioration is observed, the foam concentrate shall be replaced or tested to determine if it is suitable for continued use.

**12.7.2.3** Foam concentrates that have exceeded the shelf life specified by the concentrate manufacturer or that the test results determine are not suitable for continued use shall be replaced.

**12.8 Diagnostic Check.** The foam system shall be operated to demonstrate the ability of the system to discharge foam solution or equivalent.

## Chapter 13 Inspection and Maintenance of Compressed Air–Foam Systems (CAFS) (NFPA 1911)

**13.1 General.** If the fire apparatus is equipped with a compressed air–foam system (CAFS), the system shall be inspected and maintained in accordance with this chapter.

**13.2 System Components.**

**13.2.1** All components of the compressed air–foam system shall be maintained in accordance with the recommendations of the manufacturer.

**13.2.2** All components of the compressed air–foam system shall be inspected for security of mounting, structural integrity, and leakage and be diagnostically checked.

**13.2.3** The foam proportioning system shall be maintained, serviced, and flushed as required by Chapter 12.

**13.3 Compressed Air Source.**

**13.3.1 General.** The components of the compressed air source including, but not limited to, the following shall be inspected for security of mounting, deformation, cleanliness, and leaks and be diagnostically checked as recommended by the manufacturer:

(1) Filters
(2) Piping, clamps, tubing, and hose
(3) Moisture drains
(4) Air-pressure relief valves
(5) Brackets on the air intake system

**13.3.2 Diagnostic Check.** The air compressor shall be diagnostically checked as recommended by the manufacturer.

**13.3.3 Air-Cooled Engine-Driven Air Compressor.**

**13.3.3.1*** All components of an air-cooled engine-driven air compressor shall be inspected for security of mounting, deformation, cleanliness, and leaks.

**13.3.3.2** The engine shall be inspected and maintained in accordance with the following portions of this standard:

(1) Subsections 8.4.1 through 8.4.5
(2) Sections 8.6 through 8.8

**13.3.4 Water-Cooled Engine-Driven Air Compressor.**

**13.3.4.1** All components of a water-cooled engine-driven air compressor shall be inspected for security of mounting, deformation, cleanliness, and leaks.

**13.3.4.2** The air compressor shall be diagnostically checked as recommended by the manufacturer.

**13.3.4.3** The engine shall be inspected and maintained in accordance with the following portions of this standard:

(1) Subsections 8.4.1 through 8.4.5
(2) Subsections 8.5.1 through 8.5.9
(3) Sections 8.6 through 8.8

**13.3.5 Power Takeoff (PTO)–Driven Air Compressor.**

**13.3.5.1** All components of a PTO-driven air compressor including, but not limited to, the following shall be inspected for security of mounting, deformation, and leaks and be diagnostically checked as recommended by the manufacturer:

(1) PTO

(2) Drive shafts
(3) Transfer case
(4) Gear box
(5) Air compressor

**13.3.5.2** All fluids in the PTO system(s) shall be inspected for contamination and maintained at the level recommended by the manufacturer.

**13.3.6 Hydraulic-Driven Air Compressor.**

**13.3.6.1** All components of a hydraulic-driven air compressor including, but not limited to, the following shall be inspected for security of mounting, deformation, and leaks and be diagnostically checked as recommended by the manufacturer:

(1) Hydraulic pump
(2) Hydraulic motor
(3) Hydraulic fluid reservoir
(4) Hydraulic fluid cooler
(5) Control systems
(6) Hose, lines, and valves

**13.3.6.2** All fluids in the hydraulic system(s) shall be inspected for contamination and proper type and be maintained at the level recommended by the manufacturer.

## Chapter 14 Inspection and Maintenance of Line Voltage Electrical Systems (NFPA 1911)

**14.1 General.** If the emergency vehicle has a line voltage electrical system, it shall be inspected and maintained in accordance with this chapter.

**14.2 Power Source.**

**14.2.1** All components of the line voltage power source shall be maintained in accordance with the recommendations of the manufacturer.

**14.2.2** All power sources shall be inspected for security of mounting, condition, and fluid leakage.

**14.2.3** Power sources shall be diagnostically checked.

**14.2.4** Remote controls for power sources shall be inspected for condition and diagnostically checked.

**14.3 Wiring.** All wiring and wire looms shall be inspected for security of mounting, tight connections, proper routing, presence of grommets, condition, and cleanliness.

**14.4 Appliances and Controls.** All line voltage appliances and controls including, but not limited to, the following appliances and controls shall be inspected for security of mounting and condition:

(1) Cord reels
(2) Extension cords
(3) Scene lights
(4) Circuit breaker boxes
(5) Switches
(6) Relays
(7) Receptacles
(8) Inlet devices
(9) Light towers
(10) Other line voltage devices not otherwise specified in Section 14.4(1) through 14.4(9)

**14.5 Circuit Protection.**

**14.5.1** Circuit breakers and ground fault circuit interrupters (GFCIs) shall be inspected for condition and diagnostically checked.

**14.5.2** All circuit breakers and ground fault circuit interrupters (GFCIs) shall be cycled off and on.

**14.6 Instrumentation.** Instrumentation, including voltmeter(s), ammeter(s), and frequency meter(s); warning and indicator lights; and associated interlock systems, shall be inspected for condition and diagnostically checked.

**14.7 Engine-Driven Generators.**

**14.7.1 Air-Cooled Engine-Driven Line Voltage Generator.**

**14.7.1.1*** All components of an air-cooled engine-driven line voltage generator shall be inspected for security of mounting, deformation, cleanliness, and leaks.

**14.7.1.2** The engine shall be inspected and maintained in accordance with the following portions of this standard:

(1) Subsections 8.4.1 through 8.4.5
(2) Sections 8.6 through 8.8

**14.7.2 Water-Cooled Engine-Driven Line Voltage Generator.**

**14.7.2.1** All components of a water-cooled engine-driven line voltage generator shall be inspected for security of mounting, deformation, cleanliness, and leaks.

**14.7.2.2** The engine shall be inspected and maintained in accordance with the following portions of this standard:

(1) Subsections 8.4.1 through 8.4.5
(2) Subsections 8.5.1 through 8.5.9
(3) Sections 8.6 through 8.8

**14.8 Power Takeoff (PTO)–Driven Line Voltage Generators.**

**14.8.1** All components of PTO-driven line voltage generators including, but not limited to, the following shall be inspected for security of mounting, deformation, and leaks:

(1) PTO
(2) Drive shafts
(3) Transfer case
(4) Gear box
(5) Generator

**14.8.2** All fluids in the PTO system(s) shall be visually inspected for contamination and maintained at the level recommended by the manufacturer.

**14.9 Hydraulic-Driven Line Voltage Generators.**

**14.9.1** All components of hydraulic-driven line voltage generators including, but not limited to, the following shall be inspected for security of mounting, deformation, and leaks:

(1) Hydraulic pump and drive system
(2) Hydraulic motor and drive system
(3) Hydraulic fluid reservoir
(4) Hydraulic fluid cooler
(5) Control systems
(6) Hose, lines, and valves

**14.9.2** All fluids in the hydraulic system(s) shall be visually inspected for contamination and proper type and be maintained at the level recommended by the manufacturer.

**14.10 Belt-Driven Line Voltage Generators.** All components of belt-driven line voltage generators including, but not limited to, the following shall be inspected for security of mounting and deformation:

(1) Belts
(2) Pulleys
(3) Clutch and control system
(4) Electronics
(5) Generator
(6) Mounting hardware

## Chapter 15 Inspection and Maintenance of Utility Air and Breathing Air Systems (NFPA 1911)

**15.1 General.** Any compressed air system on a fire apparatus, whether for breathing or utility air, shall be inspected and maintained in accordance with this chapter.

**15.1.1** If the emergency vehicle has a breathing air compressor system, the compressor system shall be serviced annually by a manufacturer's authorized representative.

**15.1.2** If the emergency vehicle has a breathing air compressor system, the quality of air produced by the breathing air compressor system shall be tested in accordance with NFPA 1989 following completion of the annual servicing required by 15.1.1.

**15.2 System Components.**

**15.2.1** All components of the air system shall be maintained in accordance with the recommendations of the assembler or manufacturer.

**15.2.2** All thermal insulating material around air system components shall be inspected for security of mounting and condition.

**15.2.3** If the air system has drive belts, they shall be inspected for proper adjustment.

**15.2.4** Automatic shutdown systems shall be tested in accordance with the recommendations of the assembler or manufacturer.

**15.2.5** All system components shall be diagnostically checked for leaks, operation, and pressure settings.

**15.3 Labels.** All warning signs, function labels, and instruction plates shall be inspected for condition and legibility.

**15.4 Piping, Hose, Valves, and Instrumentation.**

**15.4.1** All rigid piping shall be inspected for security of mounting and deformation.

**15.4.2** All flexible hose shall be inspected for cuts, abrasions, or damage.

**15.4.3** All valves, quick couplers, and hose reels shall be inspected for security of mounting, proper operation, and leakage.

**15.4.4** All gauges, instruments, and regulators shall be inspected for security of mounting and condition.

**15.5 Air Compressors.**

**15.5.1** Compressors and boosters shall be inspected for security of mounting and diagnostically checked.

**15.5.2** Air-intake filters and screens shall be inspected for security of mounting and airflow obstruction or restriction.

**15.5.3** The compressor cooling system shall be inspected for cleanliness and diagnostically checked.

**15.6 Purification System.**

**15.6.1** The purification system shall be inspected for security of mounting and deformation, tested for leakage, and diagnostically checked.

**15.6.2** Filter elements and purifier cartridges shall be replaced when specified by the manufacturer.

**15.7 Air Storage Tanks.**

**15.7.1** Air storage tanks shall be inspected for security of mounting and be tested for leakage.

**15.7.2** Air storage tanks shall be inspected to verify that hydrostatic test dates are within the periods specified by the manufacturers and the applicable governmental agencies.

**15.8* Refill Stations.** Fragmentation tubes, guards, or any other safety devices associated with SCBA filling stations shall be inspected for security of mounting, deformation, and condition.

**15.9 Air Compressor.**

**15.9.1 Air-Cooled Engine-Driven Air Compressor.**

**15.9.1.1*** All components of an air-cooled engine-driven air compressor shall be inspected for security of mounting, deformation, cleanliness, and leaks.

**15.9.1.2** The air compressor shall be diagnostically checked as recommended by the manufacturer.

**15.9.1.3** The engine shall be inspected and maintained in accordance with the following portions of this standard:

(1) Subsections 8.4.1 through 8.4.5
(2) Sections 8.6 through 8.8

**15.9.2 Water-Cooled Engine-Driven Air Compressor.**

**15.9.2.1** All components of a water-cooled engine-driven air compressor shall be inspected for security of mounting, deformation, cleanliness, and leaks.

**15.9.2.2** The air compressor shall be diagnostically checked as recommended by the manufacturer.

**15.9.2.3** The engine shall be inspected and maintained in accordance with the following portions of this standard:

(1) Subsections 8.4.1 through 8.4.5
(2) Subsections 8.5.1 through 8.5.9
(3) Sections 8.6 through 8.8

**15.9.3 Power Takeoff (PTO)–Driven Air Compressor.**

**15.9.3.1** All components of a PTO-driven air compressor including, but not limited to, the following shall be inspected for security of mounting, deformation, and leaks and be diagnostically checked as recommended by the manufacturer:

(1) PTO
(2) Drive shafts
(3) Transfer case
(4) Gear box
(5) Air compressor

**15.9.3.2** All fluids in the PTO system(s) shall be inspected for contamination and maintained at the level recommended by the manufacturer.

**15.9.4 Hydraulic-Driven Air Compressor.**

**15.9.4.1** All components of a hydraulic-driven air compressor including, but not limited to, the following shall be inspected for security of mounting, deformation, and leaks and be diagnostically checked as recommended by the manufacturer:

(1) Hydraulic pump
(2) Hydraulic motor
(3) Hydraulic fluid reservoir
(4) Hydraulic fluid cooler
(5) Control systems
(6) Hose, lines, and valves

**15.9.4.2** All fluids in the hydraulic system(s) shall be inspected for contamination and proper type and be maintained at the level recommended by the manufacturer.

**15.10 Records.**

**15.10.1** Complete records shall be maintained of all inspections and maintenance performed on the compressed air system.

**15.10.2** If the system is a breathing air compressor system, records of air quality testing, as required by NFPA 1989, shall be examined to determine that the air is being tested at the proper intervals and that no indications of deteriorating air quality exist.

## Chapter 16 Inspection and Maintenance of Trailers (NFPA 1911)

**16.1 General.** Trailers shall be inspected and maintained in accordance with this chapter.

**16.2 Frame, Hitch, Axle, and Suspension.**

**16.2.1** All frame rails and members shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**16.2.2** All suspension components including, but not limited to, the following shall be inspected for defects, missing or loose parts, and functional operation and be lubricated:

(1) Springs and spring hangers
(2) Air springs (bags), mounting brackets, and attaching hardware
(3) Equalizer beams and torque arms
(4) Shock absorbers

**16.2.3** The safety chains and chain latches shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**16.2.4** The hitch mounting shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**16.2.4.1** The hitch operation and lock shall be diagnostically checked.

**16.2.5** The axle shall be inspected for alignment.

**16.2.6** All axle components including, but not limited to, the following shall be inspected for security of mounting, structural integrity, deformation, and abnormal wear; functionally operated; and lubricated:

(1) Spindles and bushings
(2) Attaching hardware
(3) Axle beams

**16.2.7** Wheel bearings and seals shall be cleaned; inspected for deformation, wear, cracks, and leakage; and lubricated.

**16.2.8*** Tires shall be inspected for damage and inflated to the tire manufacturer's recommended pressure.

**16.2.9*** Tires shall be replaced at least every 7 years or more frequently when the tread wear exceeds federal, state, or provincial standards as determined by measuring with a tread depth gauge. *[See 6.3.1(4).]*

**16.2.10** The tire load rating times the number of tires on the axle shall be checked to verify that it meets or exceeds the GAWR.

**16.2.11** Wheel attaching nuts shall be torqued to the wheel manufacturer's specifications.

**16.2.12** Wheels and rims shall be inspected for cracks, deformation, structural integrity, and corrosion.

**16.3 Trailer Brake Systems.**

**16.3.1** The braking system shall be inspected and maintained in accordance with the manufacturer's recommendations.

**16.3.2** The brake linings shall be replaced in accordance with the brake manufacturer's recommendations when they are contaminated, when the lining is worn to the minimum thickness for safe operation as defined by the brake manufacturer, or when the brake drum or rotor is replaced.

**16.3.3** The drums or rotors shall be inspected during scheduled maintenance, when there is a suspected problem, or at the time of brake lining replacement.

**16.3.3.1** The inspection shall consist of, but not be limited to, inspecting for the following:

(1) Evidence of extensive heat or heat cracking
(2) Out of round drums/warped rotors
(3) Wear beyond manufacturer's specifications
(4) Rust pitting
(5) Tapered drums
(6) Rotor parallelism
(7) Metal fatigue

**16.3.4** If the trailer has an electric brake system, the following additional components shall be inspected and maintained:

(1) Wiring and ground connections

(2) Magnets and mounting
(3) Mounting hardware
(4) Electrical break away system and battery

**16.3.5** If the trailer has a hydraulic brake system, the following additional components shall be inspected and maintained:

(1) Actuator and linkage
(2) Hydraulic lines
(3) Master cylinder
(4) Valves
(5) Wheel cylinders or calipers
(6) Mounting hardware
(7) Fluid level and contamination
(8) Break away system

**16.3.6** If the trailer has an air brake system, the following additional components shall be inspected and maintained:

(1) All valves
(2) Hoses and lines
(3) Brake air chambers
(4) Slack adjusters
(5) Cams and wedges
(6) Calipers
(7) Air tanks
(8) Drain valves
(9) Mounting hardware
(10) Glad hands and hoses

**16.3.6.1** The air brake system pressure protection valve(s) shall be diagnostically checked to the shutoff point.

**16.3.6.2** Leak-down rate (time) of the applied side of the air brake system shall be diagnostically checked with the engine stopped and the service brakes applied.

**16.3.6.2.1** The air pressure shall not drop more than 4 psi (27.6 kPa) in 1 minute for a combination vehicle when tested in accordance with 16.3.6.2.

**16.3.7** All components of the braking system shall be inspected for damage and wear when performing a brake overhaul.

**16.4 Trailer Electrical and Lighting.** All trailer electrical systems and lighting shall be inspected and maintained to the applicable requirements of Chapter 9.

## Chapter 17 Inspection and Maintenance of Patient Compartment (NFPA 1911)

**17.1 General.** The patient compartment shall be inspected and maintained in accordance with this chapter.

**17.2 Patient Compartment Interior.**

**17.2.1** Seats and seat belts shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**17.2.2** Seats and seat belts operation shall be diagnostically checked and lubricated.

**17.2.3** The cot retention system shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**17.2.4** The cot retention system shall be diagnostically checked and lubricated.

**17.2.5** The HVAC system shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**17.2.6** The HVAC system shall be diagnostically checked.

**17.2.7** Action panel switches shall be inspected and diagnostically checked.

**17.2.8** The medical gas system and components shall be inspected for defects, structural integrity, leaks, and missing or loose parts.

**17.2.9** The medical gas system and components shall be diagnostically checked.

**17.2.10** Interior compartments, doors, locks and latches shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**17.2.11** Line voltage outlets shall be inspected and diagnostically checked.

**17.2.12** The line voltage power source shall be inspected and diagnostically checked.

**17.2.13** Low-voltage outlets shall be inspected and diagnostically checked.

**17.2.14** Fire extinguishers and mounts shall be inspected for defects, structural integrity, corrosion, charge, and missing or loose parts.

**17.2.15** Handrails and mounts shall be inspected for defects, structural integrity, corrosion, and missing or loose parts.

**17.2.16** The seat belt warning system shall be diagnostically checked.

**17.2.17** The air exhaust fan system shall be diagnostically checked.

**17.2.18** The automatic patient compartment illumination and scene light activation from patient compartment doors shall be diagnostically checked.

**17.2.19** The manual patient compartment illumination and scene light activation shall be diagnostically checked.

**17.2.20** The carbon monoxide detector shall be diagnostically checked.

**17.3 Auxiliary Equipment.**

**17.3.1** Medical gas tank mounts and lifts shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**17.3.2** Oxygen lifts shall be diagnostically checked.

**17.3.3** Medical equipment mounts shall be inspected for defects, structural integrity, corrosion, perforations, and missing or loose parts.

**17.3.4** Suction pumps and outlets shall be inspected for defects, structural integrity, leaks, and missing or loose parts.

**17.3.5** Suction pumps and outlets shall be diagnostically checked.

## Chapter 18 Inspection and Maintenance of Winch Systems (NFPA 1911)

**18.1 General.** Any winch or winch attachment point on a fire apparatus shall be inspected and maintained in accordance with this chapter.

**18.2 Winch Assembly.** The winch assembly shall be cleaned, inspected for security of mounting, diagnostically checked, and lubricated.

**18.3 Winch Wire or Synthetic Rope.**

**18.3.1** The winch wire or synthetic rope shall be unwound from the winch drum and checked for security of attachment to the drum, security of attachment at the clevis and hook, kinks in the wire or rope, and frayed strands.

**18.3.2** Wire rope shall be cleaned and lubricated in accordance with the manufacturer's instructions.

**18.3.3** All rollers and guides shall be inspected for proper lubrication, proper operation, and any signs of wear.

**18.4 Power Supply and Controls.**

**18.4.1** Power supply cables, remote control cables, and hydraulic hose shall be checked for wear, cracking, kinking, and abrasion.

**18.4.2** The controls shall be diagnostically checked to ensure that they allow forward, reverse, neutral, and free-spooling clutch operation.

**18.4.3** Hydraulic fluid and filters shall be maintained in accordance with the manufacturer's recommendations.

**18.4.4** If present, the "OK to operate winch" indicator and the interlock system to prevent advancement of the engine speed shall be diagnostically checked.

**18.5 Attachment Points.** Attachment points for removable electric winches shall be inspected for security of mounting and damage.

## Chapter 19 Inspection, Testing, and Maintenance of Aircraft Rescue and Firefighting (ARFF) Vehicles

**19.1 General.** Aircraft rescue and firefighting (ARFF) vehicle components and systems shall be annually inspected and maintained in accordance with the manufacturer's instructions and the requirements of this chapter.

**19.2 Crew and Passenger Compartments.**

**19.2.1** Deluge systems shall be inspected for leaks, spray pattern, security of mounting, deformation, and corrosion; diagnostically checked, including automatic wiper activation; and maintained.

**19.2.2** Driver's enhanced vision systems (DEVS) shall be inspected for security of mounting and deformation and diagnostically checked.

**19.2.3** Rollover alerts shall be inspected for security of mounting and deformation; diagnostically checked; and maintained.

**19.2.4** Monitoring and data acquisition systems (MADAS) shall be inspected for security of mounting and deformation and diagnostically checked.

**19.2.5** Imaging, video, and cameras shall be inspected for corrosion, security of mounting, and deformation and diagnostically checked.

**19.3 Axles, Tires, and Wheels.**

**19.3.1** Vehicle driveline locks shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.3.2** Planetary axles and wheel ends shall be inspected for leaks and deformation; diagnostically checked; and maintained.

**19.3.3** Central tire inflation systems shall be inspected for leaks and deformation; diagnostically checked; and maintained.

**19.4 Engine/Auxiliary Braking Systems.** Engine/auxiliary braking systems shall be diagnostically checked and maintained.

**19.5 Pumping Systems.**

**19.5.1** Driveline modulating clutches shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.5.2** Water pump clutches shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.5.3** Power dividers shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.5.4** Accessory power takeoffs (PTOs) shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.5.5** Torque boxes shall be inspected for security of mounting and deformation; diagnostically checked; and maintained.

**19.6 Foam Systems.**

**19.6.1** Foam transfer pumping systems shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.6.2** Foam tank vents shall be inspected for deformation and diagnostically checked.

**19.7 Complimentary Systems.**

**19.7.1** Mounting systems for propellant storage tanks shall be inspected for security of mounting and deformation and diagnostically checked.

**19.7.2** Mounting systems for agent tanks shall be inspected for security of mounting and deformation and diagnostically checked.

**19.7.3** Agent storage tanks shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.7.4** Lifting systems, supports, and straps shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.7.5** Pressure regulators shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.7.6** Controls, valves, actuators, and hoses shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.7.7** Pressure indicating devices shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.7.8** The quantity of the complimentary agents shall be inspected.

**19.7.9** Complimentary agent system components that are not designed to continuously contact the complimentary agent shall be thoroughly flushed after each use to ensure all piping and components are clear of agent.

**19.7.10** Complimentary propellant system pressurized cylinders shall be inspected for the current hydrostatic test date.

**19.8 Hose Reels, Handlines, and Preconnected Lines.**

**19.8.1** Hose reels, handlines, and preconnected lines shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.8.2** Controls, valves, actuators, and hoses shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.8.3** Rewind systems shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.8.4** Flow switches shall be inspected for leaks, security of mounting, and deformation and diagnostically checked.

**19.8.5** Hose reel brake systems shall be inspected for security of mounting and deformation, diagnostically checked, and maintained.

**19.8.6** Nozzle holders shall be inspected for security of mounting and deformation.

**19.8.7** Backup hand cranks shall be inspected for security of mounting, deformation, and presence.

**19.9 Winterization.** Winterization packages and kits shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained.

**19.10 Turrets.**

**19.10.1** Turret systems shall be inspected for leaks, security of mounting, deformation, and corrosion; diagnostically checked under operational pumping system pressure; and maintained.

**19.10.2** Turret system backup and manual controls shall be diagnostically checked.

**19.10.3** Complimentary agent hoses used in conjunction with turrets shall be inspected for leaks, security of mounting, and deformation.

**19.10.4** Nozzles shall be checked for damage, debris, or other obstructions that would impact the flow or discharge pattern.

**19.11 Extendable Turrets.**

**19.11.1** Extendable turrets shall be inspected, diagnostically checked, and maintained according to the manufacturer's specifications.

**19.11.2** Three-way valves shall be inspected for leaks, corrosion, security of mounting, and deformation and diagnostically checked.

**19.11.3** Piercing tips and clutches shall be inspected for security of mounting, deformation, and structural integrity and diagnostically checked.

**19.11.4** Emergency backup systems shall be inspected for leaks, security of mounting, and deformation; diagnostically checked; and maintained according to the manufacturer's specifications.

**19.11.5** Extendable turret piping and hoses shall be inspected for leaks, security of mounting, and deformation.

**19.11.6** Diagnostic codes for extendable turrets shall be reviewed for types and frequency of error codes that have been logged.

**19.11.7** Mounting hardware shall be checked and torqued to the manufacturer's recommendations.

**19.12 Under Truck Nozzles.** Under truck nozzles shall be inspected for security of mounting, deformation, and corrosion and diagnostically checked.

**19.13 Electrical.** Low-voltage electrical systems shall be diagnostically checked for an excessive parasitic drain.

## Chapter 20 Road Tests and Annual Weight Verification (NFPA 1911)

**20.1 General.** The chassis components shall be tested annually as required by this chapter.

**20.2 Emergency Vehicle Axle Weight Test.**

**20.2.1** The fully loaded emergency vehicle shall be weighed following the procedure specified in 20.2.2 through 20.2.5 to ensure that the weight on the front and rear axles and the gross vehicle weight do not exceed the gross axle weight ratings (GAWRs) and the gross vehicle weight rating (GVWR) or gross combination weight rating (GCWR) shown on the emergency vehicle's rating label.

**20.2.2** The emergency vehicle shall be prepared to be weighed as follows:

(1) Load the emergency vehicle with all items that are onboard while it is in service.
(2) Fill all fluid tanks, including the following:
    (a) Fuel tank
    (b) Foam tank(s)
    (c) Water tank
    (d) Drinking water coolers
    (e) Ice chests
    (f) Portable equipment fuel containers
(3) Remove all personnel from the driving and crew compartments.

**20.2.3*** The emergency vehicle shall be weighed using a certified truck scale as follows:

(1) Weigh the front axle.
(2) Weigh the rear axle, whether single or tandem.
(3) Weigh the entire apparatus.

**20.2.4** The emergency vehicle weight form shown in Figure 20.2.4 shall be completed as follows to determine if the emergency vehicle is overloaded:

(1) Record the axle weight ratings shown on the emergency vehicle's rating label on line A.
(2) Record the weight data obtained when the emergency vehicle is weighed, as required by 20.2.3, on line B.
(3)* Determine the personnel allowance by multiplying the number of riding positions in the driving and crew compartment by 200 lb (90 kg) and record that value on line C.
(4)* Determine other weight that might be added, including any items found on the emergency vehicle when it is in service but missing during the weighing, such as personal clothing, and additional equipment that might be carried during response to certain incidents, and enter those values on line D.
(5) Add lines B, C, and D for each column and record the value on line E.
(6) Subtract line E from line A and record the value on line F.

**20.2.5** If any of the reserve capacity values (line F of Figure 20.2.4) are not positive, equipment on the vehicle shall be removed or redistributed as necessary and the vehicle reweighed until all reserve values are positive.

**20.3 Braking System.**

**20.3.1** Testing of the braking system, including antilock brake systems and auxiliary brake systems, shall be conducted at least annually and whenever adjustments, repairs, or modifications have been performed on any component that can affect the proper operation of the braking system or systems.

**20.3.2** All testing shall be conducted at a location and in a manner that does not violate local, state, provincial, or federal traffic laws.

**20.3.3*** The braking system test procedure shall be as follows:

(1) Lay out a course that is 12 ft (3.7 m) wide with a start and stop line, with the stop line showing the stopping distance for the type of vehicle. *(See Table 20.3.3.)*
(2) Approach the start line with the vehicle being tested centered in the course and traveling at a speed of 20 mph (32 km/hr).

**Table 20.3.3 Stopping Distances**

| Gross Vehicle Weight Rating | ft | m |
|---|---|---|
| 10,000 lb (4,540 kg) or less | 25 | 7.5 |
| Single-unit vehicles over 10,000 lb (4,540 kg), except truck tractor | 35 | 10.5 |
| Combination vehicles and truck tractors over 10,000 lb (4,540 kg) | 40 | 12.0 |

(3) Apply the service brake firmly as the vehicle's front bumper crosses the start line.
(4) Observe whether the vehicle comes to a smooth stop within the prescribed distance without pulling to the right or left beyond limits.

**20.3.4 Stopping Distance.**

**20.3.4.1** The vehicle stopping distance shall be not greater than that given in Table 20.3.3.

**20.3.4.2** During braking, the vehicle shall not pull to the left or right across the sides of the course boundaries.

**20.4 Parking Brake System.**

**20.4.1*** The parking brake system shall be tested at least annually.

**20.4.2*** The parking brake system shall hold the fully loaded emergency vehicle on a grade of 20 percent or the steepest grade in the department's jurisdiction if a grade of 20 percent is not available.

**20.4.3** The parking brake shall be tested with the vehicle stopped while facing uphill and again while facing downhill on the same grade.

**20.5 Road Test.**

**20.5.1** A road test of the emergency vehicle shall be conducted at least annually, after each scheduled maintenance interval, and after repair, adjustment, or modification of the engine, transmission, drivetrain, suspension, brakes, or steering.

| | Front Axle | Rear Axle | Tiller Axle | Total Vehicle |
|---|---|---|---|---|
| A. GAWR | | | | |
| B. Recorded weight | | | | |
| C. Personnel allowance | | | | |
| D. Other adjustments | | | | |
| E. Total of rows B, C, and D | | | | |
| F. Reserve capacity (row A minus row E) | | | | |

**FIGURE 20.2.4 Emergency Vehicle Weight Form.**

**20.5.2** The test shall be conducted on dry, level, paved roads that are in good condition.

**20.5.3** The engine shall not be operated in excess of the maximum governed speed.

**20.5.4** The test shall consist of the following:

(1) Attaining a minimum top speed of not less than 50 mph (80 km/hr)
(2) Observing and recording the following while driving at least 1 mile at a safe speed for the conditions and making turns of 90 degrees to both the left and right:
    (a) Improper transmission shifting
    (b) Driveline and vehicle vibrations
    (c) Drifting and pulling during acceleration or braking
    (d) Abnormal noise
    (e) Resistance to steering recovery after a 90-degree turn

## Chapter 21 Performance Testing of Low-Voltage Electrical Systems (NFPA 1911)

**21.1 General.** The major components of the low-voltage electrical systems shall be tested as required by this chapter.

**21.2* Frequency.** Performance tests shall be conducted at least annually and whenever major repairs or modifications to the low-voltage electrical system or any component of the system have been made.

**21.3 Battery Test.**

**21.3.1 Inspection.** Before testing, the batteries shall be carefully inspected.

**21.3.1.1** The batteries shall be cleaned of any accumulated dirt or corrosion.

**21.3.1.1.1** The battery connections shall be checked to ensure that they are clean and tight.

**21.3.1.2** The batteries shall be inspected for cracks, swelling, deformation, or other physical defects.

**21.3.1.3** Batteries that are not sealed shall be checked to verify that the cells have the proper electrolyte level.

**21.3.1.3.1** Distilled water shall be added to the battery cells, if necessary.

**21.3.1.4** Batteries that are sealed shall be inspected to verify that any electrolyte level indicator indicates sufficient electrolyte.

**21.3.2 Battery Test Procedure.** Each battery shall be individually tested using either the procedure specified in 21.3.2.1 or the procedure specified in 21.3.2.2.

**21.3.2.1* Conductivity Testing.** The following procedure shall be used to test the batteries if an electronic battery conductance tester is used:

(1) If the battery terminal voltage is below 12.4 volts for a 12-volt battery, or 6.2 volts for a 6-volt battery, fully charge the battery before proceeding.
(2) Turn off the fire emergency vehicle and remove any charger.
(3) Disconnect all battery cables from the battery to be tested.
(4) Connect the tester to the battery to be tested, making the connection to the lead pad of the battery post or terminal and not to a battery cable.
(5) Perform the test in accordance with the instructions provided by the tester manufacturer.
(6) Record the cold cranking amperage (CCA) value reported in the vehicles maintenance records for trend analysis.
(7) If the measured CCA of the battery is less than 80 percent of the original CCA rating of the battery, the battery has failed.

**21.3.2.2 Load Testing.**

**21.3.2.2.1 General.** The following procedure shall be used to test the batteries if a battery load tester is used instead of an electronic battery conductance tester:

(1) If the battery terminal voltage is below 12.6 volts for a 12-volt battery or 6.3 volts for a 6-volt battery, fully charge the battery before proceeding.
(2) Turn off the fire emergency vehicle and remove any charger.
(3) Disconnect all battery cables from the battery to be tested.
(4) Connect a load tester to the battery to be tested.
(5) Connect a digital voltmeter that has a ±0.5 percent dc voltage accuracy or better if the load tester has no dc voltage meter.
(6) Adjust the current load of the load tester to one-half the CCA rating for the battery being tested.
(7) Measure and record the temperature of the battery.
(8) Apply the load for 15 seconds.
(9) Record the battery terminal voltage at the end of 15 seconds.
(10) Discontinue the load test.
(11) If the voltage is below the value shown in Table 21.3.2.2.1, the battery has failed.

**21.3.2.2.2 Battery Failure.**

**21.3.2.2.2.1** If the battery fails, the load shall be removed and the terminal voltage observed for 15 minutes.

**21.3.2.2.2.2** If the voltage fails to reach 12.45 volts for a 12-volt battery or 6.23 volts for a 6-volt battery, the battery shall be fully recharged and the test repeated once.

**21.3.2.2.2.3** If the voltage does reach 12.45 volts for a 12-volt battery or 6.23 volts for a 6-volt battery, the battery shall be considered as failing the test.

**Table 21.3.2.2.1 Voltage for Battery to Pass Load Test**

| Battery Temperature | | Voltage (V) | |
|---|---|---|---|
| °F | °C | 12-Volt Battery | 6-Volt Battery |
| 80 | 27 | 9.70 | 4.85 |
| 70 | 21 | 9.60 | 4.80 |
| 60 | 16 | 9.50 | 4.75 |
| 50 | 10 | 9.40 | 4.70 |
| 40 | 4 | 9.30 | 4.65 |
| 30 | –1 | 9.10 | 4.55 |
| 20 | –6 | 8.90 | 4.45 |
| 10 | –12 | 8.70 | 4.35 |
| 0 | –18 | 8.50 | 4.25 |

**21.4* Starter Wiring Test.**

**21.4.1** The wiring from the battery to the starter shall be inspected for corrosion, loose connections, worn insulation, or potential chafing points.

**21.4.2** The maximum voltage drop between the points defined in 21.4.2.1 and 21.4.2.2 shall be measured while the engine is cranking.

**21.4.2.1** The voltage drop in the positive (+) starter wiring shall be measured between the positive (+) input post on the starter solenoid (not the wire or connector) and the positive (+) battery terminal (not the wire or connector).

**21.4.2.2** The voltage drop in the ground (−) starter wiring shall be measured between the case of the starter (not the engine block or frame) and the negative (−) battery terminal (not the wire or connector).

**21.4.3** The voltage drop in the positive or negative circuits shall not exceed 0.1 volts per 100 amps of draw for a 12-volt nominal system or 0.2 volts per 100 amps of draw for a 24-volt nominal system.

**21.5* Alternator Test.**

**21.5.1** One or more digital voltmeters with a ±0.5 percent or better dc voltage accuracy and an ammeter capable of measuring the full output of the alternator with a ±3 percent or better dc current accuracy shall be used for the alternator test.

**21.5.2** Alternator output shall be measured between the alternator output post and the battery as specified in 21.5.2.1 and 21.5.2.2.

**21.5.2.1** The alternator's positive (+) lead voltage drop shall be measured from the positive (+) output post of the alternator (not the wire or connector) to the positive (+) battery terminal (not the wire or connector).

**21.5.2.2** The alternator's negative (−) lead voltage drop shall be measured from the alternator case or the negative (−) output post of the alternator (not the wire or connector) to the negative (−) battery terminal (not the wire or connector).

**21.5.3** The meters shall be permitted to be connected before or after starting the engine.

**21.5.4** The measurement point shall be selected such that any current to loads from the alternator, but not from the battery, are included in the measurement.

**21.5.5*** The alternator shall be tested as follows:

(1) Start the test with the engine temperature below 100°F (38°C).
(2) Increase the engine speed to 75 percent of maximum (governed) engine speed.
(3) Turn on enough electrical loads on the emergency vehicle for the total draw to exceed the alternator output, adding load at the battery, if necessary.
(4) Record the maximum alternator current and the voltage drop in the positive (+) and negative (−) alternator leads.
(5) Stop the test and turn off loads.
(6) If the alternator output current does not reach at least 80 percent of its nameplate rated output current, the test has failed.
(7)* If the voltage drop exceeds 0.2 volts for a 12-volt nominal system or 0.4 volts for a 24-volt nominal system in either alternator lead, the test has failed.

**21.6 Regulator Test.**

**21.6.1** The regulator test shall be performed with the battery fully charged.

**21.6.2** The voltage shall be measured at the battery terminals.

**21.6.3** The temperature of the regulator shall be measured and recorded.

**21.6.4** The alternator output shall be measured at a point between the alternator output post and the battery, with the measurement point selected such that any current to loads from the alternator, but not from the battery, is included in the measurement.

**21.6.5** The regulator shall be tested twice.

**21.6.5.1** The first test shall be run with all loads that can be turned off and the engine at idle speed.

**21.6.5.2** The second test shall be run with sufficient loads turned on that the alternator is producing a minimum of one-half of its rated output and the engine running at one-half of maximum (governed) speed.

**21.6.6*** The test shall be considered failed if the voltage at the battery is not within the range listed in Table 21.6.6.

**21.7 Battery Charger or Conditioner Test.**

**21.7.1** If the emergency vehicle is equipped with a battery charger or conditioner, the battery charger or conditioner shall be tested as follows:

(1) Before starting the test, turn off the engine.
(2) Before starting the test, fully charge batteries to at least 12.66 volts for a 12-volt nominal system, at least 25.32 volts for a 24-volt nominal system, or at least 37.98 volts for a 42-volt nominal system.
(3) Connect shoreline power to the charger or conditioner.
(4) Record battery voltage at the beginning of the test.
(5) Apply a load of at least 80 percent of the nominal charger output for 1 hour.
(6) Verify the load with an ammeter.
(7) At the end of the test, remove the load and record the battery voltage.

**Table 21.6.6 Voltage Range for Battery to Pass Regulator Test**

| Regulator Temperature | | Voltage (V) | | |
|---|---|---|---|---|
| °F | °C | 12-Volt Nominal System | 24-Volt Nominal System | 42-Volt Nominal System |
| 200 | 93 | 13.6–14.2 | 27.2–28.4 | 40.8–42.6 |
| 150 | 66 | 13.7–14.3 | 27.4–28.6 | 41.1–42.9 |
| 100 | 38 | 13.8–14.4 | 27.6–28.8 | 41.4–43.2 |
| 50 | 10 | 14.0–14.9 | 28.0–29.8 | 42.0–44.7 |
| 0 | −18 | 14.2–15.5 | 28.4–31.0 | 42.6–46.5 |

**21.7.2** The test shall be considered a failure if the system does not maintain a battery voltage of at least 12.54 volts for a 12-volt nominal system, at least 25.08 volts for a 24-volt nominal system, or at least 37.62 volts for a 42-volt nominal system.

**21.8* Total Continuous Electrical Load Test.**

**21.8.1** The total continuous electrical load test shall be permitted to be conducted simultaneously with other electrical or pumping tests.

**21.8.2** The voltage measurements for this test shall be made with a voltmeter with a resolution of 0.01 volts or better.

**21.8.3** The following test procedure shall be used:

(1) Begin the test with the battery terminal voltage of at least 12.66 volts.
(2) Advance the engine speed to at least 50 percent of the governed speed of the engine.
(3)* Turn on all loads that comprise the total continuous electrical load, except loads associated with the following:
    (a) Aerial hydraulic pump
    (b) Foam pump
    (c) Hydraulic-driven equipment
    (d) Winch
    (e) Windshield wipers
    (f) Four-way hazard flashers
    (g) Compressed air foam system (CAFS) compressor
(4) Measure the battery voltage at the battery terminals.
(5) Operate the emergency vehicle under the conditions specified in 21.8.3(2) through 21.8.3(4) continuously for at least 20 minutes, with load shedding permitted by the system if the vehicle is equipped with an automatic electrical load management system.
(6) Measure the battery voltage at the battery terminals.
(7) Turn off electrical loads and reduce engine speed, unless required for other simultaneous testing.

**21.8.4*** If the battery terminal voltage is less than 12.54 volts, the test shall be considered a failure.

**21.9 Solenoid and Relay Test.**

**21.9.1** The solenoid and relay test shall be performed on all relays and solenoids that control the power to motors, or total loads of 50 amperes or more, including the following:

(1) Starter motor
(2) Primer motor
(3) Aerial emergency power source
(4) Cab tilt hydraulic pump
(5) Hydraulic or electric ladder or equipment racks
(6) Battery or master load disconnects
(7) Mechanical siren

**21.9.2** The solenoid or relay shall be tested as follows:

(1) Attach a voltmeter from the input power stud to the point between the contacts and the motor or load.
(2) Activate the load.
(3) Measure the voltage across the power connections.
(4) Restore any insulation disturbed by the performance of the test.

**21.9.3*** The test shall be considered failed if the voltage drop exceeds 0.3 volts.

**21.10 Low-Voltage Alarm Test.**

**21.10.1** The following test shall be started with the engine off and the battery voltage at or above 12 volts for a 12 volt nominal system, 24 volts for a 24 volt nominal system, or 36 volts for a 42 volt nominal system.

**21.10.2** With the engine shut off, the total continuous electrical load shall be activated and continuously applied until the excessive battery discharge alarm activates.

**21.10.3** The battery voltage shall be measured at the battery terminals.

**21.10.4** The test shall be considered a failure if the alarm does not sound in less than 140 seconds after the voltage drops to 11.70 volts for a 12-volt nominal system, 23.4 volts for a 24-volt nominal system, or 35.1 volt for a 42-volt nominal system.

## Chapter 22 Performance Testing of Fire Pumps, Wildland Fire Pumps, Ultra-High-Pressure Pumps, and Industrial Supply Pumps (NFPA 1911)

**22.1* General.** If the fire apparatus is equipped with a fire pump or an industrial supply pump, the pump shall be inspected and tested as required by this chapter.

**22.2* Frequency.** Performance tests shall be conducted at least annually; whenever repairs, as listed below, are done; and whenever modifications are made to the pump or to any components of the emergency vehicle that are used in pump operations. Repairs requiring a performance test include, but are not limited to, the following:

(1) Removal of the pump transmission
(2) Removal of fire, wildland, ultra-high-pressure, or industrial pumps
(3) Removal of chassis transmission, pump PTO, or pump hydraulic drive
(4) Engine overhaul or removal
(5) Engine injector or injection pump replacement or repair
(6) Engine or transmission electronic control module (ECM) replacement or reprogramming
(7) Engine turbo charger replacement
(8) Radiator removal

**22.3 Test Site.**

**22.3.1* Test Site from Draft.** The test site shall be adjacent to a supply of clear water, with the water level such that the lift from the surface of the water to the center of the pump intake connection is not greater than the maximum lift shown in 22.5.1.1 and is close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water.

**22.3.2* Test Site from Hydrant.** The site shall provide an area for stationing the apparatus, a hydrant(s) capable of flowing the rated capacity of the pump, and an adjacent area where the water can be discharged.

**22.4* Environmental Conditions.** Tests shall be performed when the conditions are as follows:

(1) Air temperature: 0°F to 110°F (–18°C to 43°C)
(2) Water temperature: 35°F to 90°F (2°C to 32°C)
(3) Barometric pressure: 29 in. Hg (98.2 kPa) minimum (corrected to sea level)

**22.5 Equipment.**

**22.5.1 Suction or Intake Hose.**

**22.5.1.1* Suction Hose and Strainer from Draft.** When a pump is tested from draft at elevations up to 2000 ft (610 m), the suction hose arrangement shall be as specified in NFPA 1900 for the particular pump capacity rating and type.

**22.5.1.2* Intake Hose from Hydrant.**

**22.5.1.2.1** When testing a pump from a hydrant, the intake hose shall be of a size and length that will allow the necessary amount of water to reach the pump with a minimum intake gauge pressure of 20 psi (140 kPa) while flowing at rated capacity.

**22.5.1.2.2** Only the strainer at the pump intake connection shall be required.

**22.5.2 Discharge Hose.**

**22.5.2.1*** The fire hose arrangement shall allow discharge of the rated capacity of the pump to the nozzles or other flow-measuring equipment.

**22.5.2.2** All fire hose shall meet the requirements of NFPA 1961 and be current with NFPA 1962.

**22.5.2.3** To ascertain if the hose and coupling are starting to separate, the hose shall be marked immediately behind each coupling.

**22.5.2.4** If the hose assembly shows any sign of coupling slippage, the test shall be stopped and that section of hose replaced.

**22.5.3 Flow-Measuring Equipment.**

**22.5.3.1** Any flow-measuring equipment that is used shall be capable of measuring the flow rate to within ±5 percent accuracy.

**22.5.3.2*** Where nozzles are used for flow measurements, they shall be used in accordance with 22.5.3.2.1 through 22.5.3.2.3.

**22.5.3.2.1** The nozzle(s) shall be smoothbore.

**22.5.3.2.2*** Pitot tubes shall be used to measure the flow.

**22.5.3.2.3** A monitor or other device shall be used to prevent movement of the nozzle.

**22.5.3.3*** A square-edged round orifice and pressure gauge or other equipment, such as flowmeters, volumetric tanks, or weigh tanks, shall be used to measure flow.

**22.5.4 Pressure-Measuring Equipment.**

**22.5.4.1*** All test gauges shall meet the requirements for Grade A gauges as specified in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

**22.5.4.2** The pump intake test gauge shall be at least size 3½ in accordance with Paragraph 3.1 of ASME B40.100 and have a range of 30 in. Hg (100 kPa) vacuum to zero for a vacuum gauge, or 30 in. Hg (100 kPa) vacuum to 150 psi (1000 kPa) for a compound gauge.

**22.5.4.3** The discharge pressure test gauge shall be at least size 3½ in accordance with Paragraph 3.1 of ASME B40.100 and have a range of 0 to 400 psi (0 to 2800 kPa).

**22.5.4.4** Pitot gauges shall be at least a size 2½ in accordance with Paragraph 3.1 of ASME B40.100 and have a range of at least 0 psi to 160 psi (0 kPa to 1100 kPa).

**22.5.4.5** All test gauge connections to the pump shall include "snubbing" means, such as a needle valve, that can be used to damp out rapid gauge needle movements, unless the gauges are liquid-filled.

**22.5.5 Test Gauge Calibration.**

**22.5.5.1** All test gauges shall be calibrated at least annually, or if damaged or accuracy is in question, in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments*.

**22.5.5.2** Calibrating equipment shall consist of a dead-weight gauge tester or a master gauge meeting the requirements for Grade 3A or Grade 4A gauges, as specified in ASME B40.100, that has been calibrated within the preceding year.

**22.5.6* Engine Speed–Measuring Equipment.** The engine speed–measuring equipment shall consist of a nonadjustable tachometer supplied from the engine or transmission electronics, a revolution counter on a checking shaft outlet and a stop watch, or other engine speed–measuring means that is accurate to within ±50 rpm of actual speed.

**22.6* Conditions for Test.**

**22.6.1 General.** Performance tests shall be conducted at a site meeting the conditions outlined in Section 22.3 and at a time when the environmental conditions are as specified in Section 22.4.

**22.6.2* Engine-Driven Accessories.**

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

**22.6.2.2** If the chassis engine drives the pump, the total continuous electrical loads, excluding those loads associated with the equipment defined in 22.6.2.2.2, shall be applied for the entire pumping portion of the test.

**22.6.2.2.1*** If the fire apparatus was built to the 1996 through 2016 editions of NFPA 1901 or to NFPA 1900 and the apparatus is equipped with a fixed power source driven by the same engine that drives the fire pump, the power source shall be running at a minimum of 50 percent of its rated capacity throughout the pumping portion of the pump test.

**22.6.2.2.2** The following devices shall be permitted to be turned off or not operating during the pump test:

(1) Aerial hydraulic pump
(2) Foam pump
(3) Hydraulic-driven equipment (other than hydraulic-driven line voltage generator)
(4) Winch
(5) Windshield wipers
(6) Four-way hazard flashers
(7) CAFS compressor

**22.6.2.2.3** If any electrical loads are connected through an automatic electrical load management system, the system shall be permitted to automatically disconnect the loads during the course of the test.

**22.6.3 Carbon Monoxide Monitoring.**

**22.6.3.1** Where tests are performed inside a structure or anywhere having limited air circulation, carbon monoxide–monitoring equipment shall be used.

**22.6.3.2** Carbon monoxide–monitoring equipment shall be checked and calibrated in accordance with the manufacturer's recommendations.

**22.6.3.3** Carbon monoxide–monitoring equipment shall include a warning device.

**22.7 Procedure.** *(See Annex B.)*

**22.7.1* General.** The ambient air temperature, water temperature, lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to, and immediately following, the pump test.

**22.7.2 List of Required Tests.** The following tests, as applicable, shall be conducted as part of the performance testing of fire pumps, wildland fire pumps, industrial supply pumps, and ultra-high-pressure pumps:

(1) Engine speed test
(2) Pump shift indicator test
(3) Pump engine control interlock test
(4) Priming system test
(5) Vacuum test
(6) Pumping system test
(7) Pressure control system test
(8) Intake relief valve system test
(9) Gauge test
(10) Flowmeter test
(11) Tank-to-pump flow rate test

**22.7.3 Engine Speed Test.**

**22.7.3.1** A test of the governed engine speed shall be made.

**22.7.3.2** The engine speed shall be within ±50 rpm of the governed engine speed as recorded on the pump test label.

**22.7.3.3 Discrepancies.**

**22.7.3.3.1** The reason for any discrepancy shall be determined prior to testing.

**22.7.3.3.2** Testing shall begin only if the discrepancy will not have an adverse effect on the outcome of the test.

**22.7.4* Pump Shift Indicator Test.** A test of the pump shift indicators shall be conducted to verify that the pump shift indicators in the cab and on the operator's panel indicate correct pump status when the pump is shifted.

**22.7.5* Pump Engine Control Interlock Test.** For apparatus where the chassis engine drives the pump and where electric or electronic engine throttle controls are provided, a test of the interlock that controls the advancement of the engine speed at the pump operator's panel shall be made.

**22.7.5.1** If the apparatus is equipped with a pump driven through a split shaft PTO, the test shall verify that for each of the conditions specified in the first four columns of Table 22.7.5.1, the indicators and engine speed controls operate as specified in the last four columns. [**1900:**24.13.8.1]

**22.7.5.2** If the apparatus is equipped with a pump driven through a transmission-mounted PTO, front-of-engine crankshaft PTO, or engine flywheel PTO that is designed for stationary pumping only, the test shall verify that for each of the conditions specified in the first four columns of Table 22.7.5.2, the indicators and engine speed controls operate as specified in the last four columns. [**1900:**24.13.8.2]

**22.7.5.3** If the apparatus is equipped with a pump driven by the chassis engine designed for both stationary pumping and pump-and-roll, the test shall verify that for each of the conditions specified in the first four columns of Table 22.7.5.3, the indicators and engine speed controls operate as specified in the last four columns. [**1900:**24.13.8.3]

**22.7.5.4** Testing shall be performed with a qualified person positioned in the driving compartment and a qualified person verifying engine speed control status at the pump operator's panel.

**22.7.5.5** Shifting of the pump transmission/PTO shall be done in accordance with the manufacturer's instructions.

**22.7.5.6** For wildland and fire apparatus compliant with the 2016 edition of NFPA 1906, the 2016 edition of NFPA 1901, or NFPA 1900 where the pump is driven by the chassis engine and automatic transmission through a split shaft PTO, it shall be verified that an interlock system prevents the pump drive system from being shifted out of the "Pump Engaged" mode of operation when the chassis transmission is in pump gear.

**22.7.6 Priming System Tests.**

**22.7.6.1** If the pump is tested from draft, a priming system test shall be conducted.

**22.7.6.2** The test shall be permitted to be performed in connection with priming the pump for the pumping test.

**22.7.6.3** With the apparatus set up for the pumping test, the primer shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water.

**22.7.6.4** The interval from the time the primer is started until the time the pump is discharging water shall be noted.

**22.7.6.5** The time required to prime the pump shall not exceed 30 seconds if the rated capacity is 1250 gpm (4732 L/min) or less.

**22.7.6.6** The time required to prime the pump shall not exceed 45 seconds if the rated capacity is 1500 gpm (5678 L/min) or more but less than 3000 gpm (12,000 L/min).

**22.7.6.7** The time required to prime the pump shall not exceed 90 seconds if the rated capacity is 3000 gpm (12,000 L/min) or more.

**22.7.6.8** An additional 15 seconds shall be permitted to meet the requirements of 22.7.6.5, 22.7.6.6, or 22.7.6.7 where the pump system includes an auxiliary 4 in. (100 mm) or larger intake pipe having a volume of 1 $ft^3$ (0.0283 $m^3$) or more.

**Table 22.7.5.1 Pump Driven Through Split Shaft PTO**

| Test Conditions | | | | Verifications | | | |
|---|---|---|---|---|---|---|---|
| **Transmission Type** | **Chassis Transmission Gear Selected** | **Parking Brake Status** | **Pump Shift Control Action Status (Driving Compartment)[a]** | **Pump Indicator Status (Driving Compartment)** | **Pump Indicator Status (Pump Operator's Panel)** | **Engine Speed Control in Cab** | **Engine Speed Control at Pump Operator's Panel** |
| Either | Neutral[b] | On | Road | None | None[c] | Yes | No[c] |
| Either | Neutral[b] | On | Road | None | "Throttle Ready"[c] | Yes or No[d] | Yes[c] |
| Either | Neutral[b] | Off | Road | None | None | Yes | No |
| Automatic | Neutral | On | Engaged | "Pump Engaged"[e] | None[c] | Yes | No[c] |
| Automatic | Neutral | On | Engaged | "Pump Engaged"[e] | "Throttle Ready"[c] | Yes or No[d] | Yes[c] |
| Automatic | Neutral | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Automatic | Pump gear[f] | On | Engaged | "Pump Engaged" and "OK to Pump" | "Throttle Ready" and "OK to Pump" | Yes or No[d] | Yes |
| Automatic | Pump gear[f] | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Automatic | Pump gear[f] | On | Road | None | None | Yes | No |
| Automatic | Pump gear[f] | Off | Road | None | None | Yes | No |
| Automatic | Any gear other than neutral and pump gear[g] | On | Road | None | None | Yes | No |
| Automatic | Any gear other than neutral and pump gear[g] | Off | Road | None | None | Yes | No |
| Automatic | Any gear other than neutral and pump gear[g] | On | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Automatic | Any gear other than neutral and pump gear[g] | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Manual | Any gear or neutral | On | Engaged | "Pump Engaged" and "OK to Pump" | "Throttle Ready" and "OK to Pump" | Yes or No[d] | Yes |
| Manual | Any gear or neutral | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |

[a]Refers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.
[b]A manual transmission can be in any gear or neutral.
[c]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.
[d]Some apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.
[e]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.
[f]The chassis transmission shift selector is placed in position for pumping as indicated on the label provided in the driving compartment.
[g]The chassis transmission shift selector is placed in some position other than neutral or the position for pumping as indicated on the label provided in the driving compartment.
[**1900:**Table 24.13.8.1]

**Table 22.7.5.2 Pump Driven Through Transmission-Mounted PTO, Front-of-Engine Crankshaft PTO, or Engine Flywheel PTO Designed for Stationary Pumping Only**

| Test Conditions | | | | Verifications | | | |
|---|---|---|---|---|---|---|---|
| Transmission Type | Chassis Transmission Gear Selected | Parking Brake Status | Pump Shift Control Action Status (Driving Compartment)[a] | Indicator Status (Driving Compartment) | Indicator Status (Pump Operator's Panel) | Engine Speed Control in Cab | Engine Speed Control at Pump Operator's Panel |
| Either | Neutral[b] | On | Disengaged | None | None[c] | Yes | No[c] |
| Either | Neutral[b] | On | Disengaged | None | "Throttle Ready"[c] | Yes or No[d] | Yes[c] |
| Either | Neutral[b] | Off | Disengaged | None | None | Yes | No |
| Automatic | Neutral | On | Engaged | "Pump Engaged" and "OK to Pump" | "Throttle Ready" and "OK to Pump" | Yes or No[d] | Yes |
| Automatic | Neutral | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Automatic | Any gear other than neutral | On | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Automatic | Any gear other than neutral | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |
| Automatic | Any gear other than neutral | On | Disengaged | None | None | Yes | No |
| Automatic | Any gear other than neutral | Off | Disengaged | None | None | Yes | No |
| Manual | Any gear or neutral | On | Engaged | "Pump Engaged" and "OK to Pump" | "Throttle Ready" and "OK to Pump" | Yes or No[d] | Yes |
| Manual | Any gear or neutral | Off | Engaged | "Pump Engaged"[e] | None | Yes | No |

[a]Refers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.
[b]A manual transmission can be in any gear or neutral.
[c]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.
[d]Some apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.
[e]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.
[**1900:**Table 24.13.8.2]

**22.7.7* Vacuum Tests.** The interior of the pump shall be subjected to a vacuum test as follows:

(1) Open all intake valves, cap or plug all intakes, and remove all discharge caps.
(2) Operate the primer in accordance with the manufacturer's instructions.
(3) Attain a maximum vacuum of at least 22 in. Hg (75 kPa) unless the altitude is above 2000 ft (610 m), in which case the vacuum attained is permitted to be less than 22 in. Hg (75 kPa) by 1 in. Hg (3.4 kPa) for each 1000 ft (305 m) of altitude above 2000 ft (610 m).
(4) Do not drop vacuum more than 10 in. Hg (34 kPa) in 5 minutes.
(5) Do not use the primer after the 5-minute test period has begun.
(6) Do not operate the engine at any speed greater than the governed speed during the test.
(7)* Close all intake valves, remove the cap or plug from each valved intake, and repeat test steps in 22.7.7(2) through 22.7.7(6).

**22.7.8 Pumping System Tests.**

**22.7.8.1 Wildland and Ultra-High-Pressure Fire Pumps.**

**22.7.8.1.1** Wildland fire pumps and ultra-high-pressure fire pumps shall be subjected to a 30-minute pumping test consisting of continuous pumping at rated capacity at rated net pump pressure.

**22.7.8.1.2** The flow, discharge pressure, intake pressure, and engine speed shall be recorded at least every 15 minutes but not fewer than three times for each test sequence.

**Table 22.7.5.3 Stationary Pumping and Pump-and-Roll**

| Test Conditions | | | | Verifications | | | |
|---|---|---|---|---|---|---|---|
| **Transmission Type** | **Chassis Transmission Gear Selected** | **Parking Brake Status** | **Pump Shift Control Action Status (Driving Compartment)[a]** | **Indicator Status (Driving Compartment)[b]** | **Indicator Status (Pump Operator's Panel)** | **Engine Speed Control in Cab** | **Engine Speed Control at Pump Operator's Panel** |
| Either | Neutral[c] | On | Disengaged | None | None[d] | Yes | No[d] |
| Either | Neutral[c] | On | Disengaged | None | "Throttle Ready"[d] | Yes or No[e] | Yes[d] |
| Either | Neutral[c] | Off | Disengaged | None | None | Yes | No |
| Automatic | Neutral | On | Engaged | "Pump Engaged" and "OK to Pump" | "Throttle Ready" and "OK to Pump" | Yes or No[e] | Yes |
| Automatic | Neutral | Off | Engaged | "Pump Engaged" and "OK to Pump-and-Roll"[f] | None | Yes | No |
| Automatic | Any gear other than neutral | On | Engaged | "Pump Engaged"[b] | None | Yes | No |
| Automatic | Any gear other than neutral | Off | Engaged | "Pump Engaged" and "OK to Pump-and-Roll" | None | Yes | No |
| Automatic | Any gear other than neutral | On | Disengaged | None | None | Yes | No |
| Automatic | Any gear other than neutral | Off | Disengaged | None | None | Yes | No |
| Manual | Any gear or neutral | On | Engaged | "Pump Engaged" and "OK to Pump" | "Throttle Ready" and "OK to Pump" | Yes or No[e] | Yes |
| Manual | Any gear or neutral | Off | Engaged | "Pump Engaged" and "OK to Pump-and-Roll" | None | Yes | No |

[a]Refers to the physical position of the pump shift control, or status of an electrical control action, in the driving compartment. The indicators associated with a particular pump shift control position might or might not provide indication of a particular status.
[b]Some apparatus can be designed with additional interlocks that prevent pump engagement and the "Pump Engaged" indicator, or disengage the pump when additional interlock conditions are not met.
[c]A manual transmission can be in any gear or neutral.
[d]Engine speed control at the pump operator's panel is permitted for those apparatus that have "Throttle Ready" indication on the pump operator's panel when the chassis transmission is in neutral and the parking brake is engaged. If there is no "Throttle Ready" indication, there is no engine speed control at the pump operator's panel.
[e]Some apparatus can be designed such that the throttle in the cab is disabled when the throttle control on the pump panel is enabled. The preferred arrangement is that the throttle in the cab not be disabled when the throttle control on the pump operator's panel is enabled.
[f]"OK to Pump-and-Roll" stays on in neutral to allow shifting to neutral when temporarily stopped with the foot brake applied. This allows additional throttle to be applied for greater pump speed. Do not shift to neutral while the vehicle is moving; this is a prohibited operation in at least 17 states. [**1900:**Table 24.13.8.3]

**22.7.8.2 Fire Pumps and Industrial Supply Pumps.**

**22.7.8.2.1** If the fire pump has a rated capacity of 250 gpm (1000 L/min) or greater but less than 3000 gpm (12,000 L/min), the pump shall be subjected to the pumping test consisting of the following:

(1) At least 20 minutes of pumping at 100 percent of rated capacity at 150 psi (1000 kPa) net pump pressure
(2) If the fire pump has a rated capacity of 750 gpm (3000 L/min) or greater but less than 3000 gpm (12,000 L/min), an overload test as follows:
    (a) The overload test is to consist of pumping rated capacity at 165 psi (1100 kPa) net pump pressure for at least 5 minutes.
    (b) The overload test is to immediately follow the pumping test at rated capacity at 150 psi (1100 kPa) net pump pressure.
(3) At least 10 minutes of pumping at 70 percent of rated capacity at 200 psi (1400 kPa) net pump pressure
(4) At least 10 minutes of pumping at 50 percent of rated capacity at 250 psi (1700 kPa) net pump pressure

**22.7.8.2.2** If the fire pump or industrial supply pump has a rated capacity of 3000 gpm (12,000 L/min) or greater, the pump shall be subjected to the pumping test consisting of the following:

(1) At least 20 minutes of pumping at 100 percent of rated capacity at 100 psi (700 kPa) net pump pressure

(2) At least 10 minutes of pumping at 70 percent of rated capacity at 150 psi (1000 kPa) net pump pressure
(3) At least 10 minutes of pumping 50 percent of rated capacity at 200 psi (1400 kPa) net pump pressure

**22.7.8.2.3*** If the fire pump or industrial supply pump is a two-stage, parallel/series-type pump, the following criteria shall apply:

(1) The test at 100 percent of capacity is to be run with the pump in parallel mode.
(2) The test at 70 percent of capacity is permitted to be run with the pump in either series or parallel mode.
(3) The test at 50 percent of capacity is to be run with the pump in series mode.

**22.7.8.2.4** A complete set of readings shall be taken and recorded a minimum of five times during the 20-minute test for 100 percent rated capacity, a minimum of twice during the overload test if performed, and a minimum of three times during each of the 10-minute tests for 70 percent capacity and 50 percent capacity.

**22.7.8.3** The prescribed duration of the pumping tests shall not be started until the pump pressure and the discharge quantity are stabilized at the prescribed values.

**22.7.8.4** The engine shall not be throttled down, except when the hose, a nozzle, or the position of a transfer valve is being changed.

**22.7.8.5** If the flow rate or pressure readings vary by more than 5 percent during a particular test, the reason for the fluctuation shall be determined, the cause corrected, and the test continued or repeated.

**22.7.9* Pressure Control System Tests.**

**22.7.9.1 Wildland Fire Pumps.** If a pressure control system is supplied on a wildland fire pump, it shall be tested as follows:

(1) Operate the wildland fire pump to deliver rated capacity at rated net pump pressure.
(2) Set the pressure control system in accordance with the manufacturer's instructions to maintain the discharge at rated net pump pressure ±5 percent.
(3) Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(4) Do not exceed a rise in discharge pressure of 60 psi (400 kPa).
(5) Record the rise in discharge pressure.

**22.7.9.2 Fire Pumps Less than 3000 gpm (12,000 L/min).** If the fire pump has a rated capacity of less than 3000 gpm (12,000 L/min), the pressure control device shall be tested as specified in 22.7.9.2.1 through 22.7.9.2.3.

**22.7.9.2.1** The pressure control device shall be tested at 150 psi (1000 kPa) net pump pressure as follows:

(1) Deliver rated capacity at 150 psi (1000 kPa) net pump pressure.
(2) Set the pressure control device in accordance with the manufacturer's instructions to maintain the discharge at 150 psi (1000 kPa) net pump pressure.
(3)* Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(4) Do not exceed a rise in discharge pressure of 30 psi (200 kPa).
(5) Record the rise in discharge pressure.

**22.7.9.2.2** The pressure control device shall be tested at 90 psi (620 kPa) net pump pressure as follows:

(1) Reestablish the conditions of pumping rated capacity at 150 psi (1000 kPa) net pump pressure.
(2) Reduce the discharge pressure to 90 psi (620 kPa) net pump pressure by throttling the engine fuel supply with no change to the discharge valve setting, hose, or nozzles.
(3) Set the pressure control device in accordance with the manufacturer's instructions to maintain the discharge at 90 psi (620 kPa) net pump pressure.
(4) Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(5) Do not exceed a rise in discharge pressure of 30 psi (200 kPa).
(6) Record the rise in discharge pressure.

**22.7.9.2.3** The pressure control device shall be tested at 50 percent of rated capacity at 250 psi (1700 kPa) net pump pressure as follows:

(1) Deliver 50 percent of rated capacity at 250 psi (1700 kPa) net pump pressure.
(2) Set the pressure control device in accordance with the manufacturer's instructions to maintain the discharge at 250 psi (1700 kPa) net pump pressure.
(3) Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(4) Do not exceed a rise in discharge pressure of 30 psi (200 kPa).
(5) Record the rise in discharge pressure.

**22.7.9.3 Pumps 3000 gpm (12,000 L/min) or Greater.** If the fire pump or industrial supply pump has a rated capacity of 3000 gpm (12,000 L/min) or greater, the pressure control device shall be tested as specified in 22.7.9.3.1 through 22.7.9.3.3.

**22.7.9.3.1** The pressure control device shall be tested at rated pump capacity at 100 psi (700 kPa) net pump pressure as follows:

(1) Deliver rated capacity at 100 psi (700 kPa) net pump pressure.
(2) Set the pressure control device in accordance with the manufacturer's instructions to maintain the discharge at 100 psi (700 kPa) net pump pressure.
(3)* Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(4) Do not exceed a rise in discharge pressure of 30 psi (200 kPa).
(5) Record the rise in discharge pressure.

**22.7.9.3.2** The pressure control device shall be tested at 90 psi (620 kPa) net pump pressure as follows:

(1) Reestablish the original conditions of pumping rated capacity at 100 psi (700 kPa) net pump pressure.
(2) Reduce the discharge pressure to 90 psi (620 kPa) net pump pressure by throttling the engine fuel supply with no change to the discharge valve setting, hose, or nozzles.
(3) Set the pressure control device in accordance with the manufacturer's instructions to maintain the discharge at 90 psi (620 kPa) net pump pressure.
(4) Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(5) Do not exceed a rise in discharge pressure of 30 psi (200 kPa).
(6) Record the rise in discharge pressure.

**22.7.9.3.3** The pressure control device shall be tested at 50 percent of rated pump capacity at 200 psi (1400 kPa) net pump pressure as follows:

(1) Deliver 50 percent of rated capacity at 200 psi (1400 kPa) net pump pressure.
(2) Set the pressure control device in accordance with the manufacturer's instructions to maintain the discharge at 200 psi (1400 kPa) net pump pressure.
(3) Close all discharge valves in no fewer than 3 seconds and no more than 10 seconds.
(4) Do not exceed a rise in discharge pressure of 30 psi (200 kPa).
(5) Record the rise in discharge pressure.

**22.7.9.4* Ultra-High-Pressure Fire Pumps.** The pressure control system of an ultra-high-pressure fire pump shall be tested as follows:

(1) Operate the ultra-high-pressure fire pump to deliver rated capacity at rated discharge gauge pressure.
(2) Set the pressure control device in accordance with the manufacturer's instructions.
(3) Close all discharge valves.
(4) Do not exceed a rise in discharge pressure of 40 percent of the rated pump pressure.
(5) Operate the pump with the discharge lines closed for 3 minutes without the temperature of the pump exceeding 140°F (60°C).
(6) Record the final discharge pressure, any rise in discharge pressure, and the final pump temperature.

**22.7.10* Intake Relief Valve System Test.** If the apparatus is equipped with an intake relief valve system or a combination intake/discharge system, a test to ensure the system is operating in accordance with the manufacturer's specifications shall be conducted.

**22.7.11 Gauge Test.**

**22.7.11.1*** Each water pressure gauge shall be checked for accuracy at a minimum of three points, including 150 psi (1000 kPa), 200 psi (1400 kPa), and 250 psi (1700 kPa).

**22.7.11.2** Any gauge that is off by more than 10 psi (70 kPa) shall be recalibrated, repaired, or replaced.

**22.7.12 Flowmeter Test.**

**22.7.12.1*** Each flowmeter shall be checked for accuracy at the test flows shown in Table 22.7.12.1.

**Table 22.7.12.1 Flow-Measuring Points for Flowmeters**

| Pipe Size | | Test Flow | |
|---|---|---|---|
| in. | mm | gpm | L/min |
| 1 | 25 | 40 | 150 |
| 1½ | 40 | 90 | 340 |
| 2 | 50 | 160 | 600 |
| 2½ | 60 | 250 | 950 |
| 3 | 80 | 375 | 1400 |
| 4 | 100 | 625 | 2400 |
| 5 | 125 | 1000 | 4000 |
| 6 | 250 | 1440 | 5500 |

**22.7.12.2** Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced.

**22.7.13 Tank-to-Pump Flow Rate Test.** If the apparatus is equipped with a water tank, the tank-to-pump flow rate also shall be checked using the following procedure:

(1) Fill the water tank until it overflows.
(2) Close all intakes to the pump.
(3) Close the tank fill line and bypass cooling line.
(4) Connect hose lines and nozzles for discharging water at the anticipated flow rate to one or more of the discharge outlets.
(5) Fully open the tank to the pump valve(s) and the discharge valves leading to the hose lines and nozzles.
(6) Adjust the engine throttle until the maximum consistent pressure reading on the discharge pressure gauge is obtained.
(7) Close the discharge valve(s) and refill the water tank. The bypass line is permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits.
(8) Fully reopen the discharge valves and take a pitot reading or other flow measurement while the water is being discharged, with the engine throttle adjusted to maintain the discharge pressure noted in 22.7.13(6), if necessary.
(9)* Record the flow rate and compare it with the rate designated by the manufacturer when the apparatus was new or with the rate established in previous testing.

**22.8* Test Results.**

**22.8.1*** The pumping system (that is, engine, pump, transmission) shall not overheat, lose power, or exhibit other defects during the entire test.

**22.8.2** The flow rate, discharge pressure, intake pressure, and engine speed recorded for each test shall be the average of the readings taken during that test.

**22.8.3*** The results of all tests of the pump system shall be recorded and compared with the results of previous tests.

**22.8.4** If the engine speed required to meet any of the test points during the pumping test exceeds 110 percent of the engine speed listed on the test label attached to the apparatus, the pumping system shall be repaired.

**22.8.5** Indications of decreasing pump or component performance shall be reported to the AHJ.

**22.8.6** Data that are submitted at the time of the delivery test and all results of service tests shall be maintained in a permanent file and compared year to year to identify changing conditions that could indicate developing problems with the engine or pump.

**22.8.7*** If the AHJ wishes to rerate the pump, the pump shall be tested to the complete pumping test as specified in NFPA 1900, including having the test witnessed and certified by an accredited third-party testing organization.

## Chapter 23 Performance Testing of Aerial Devices (NFPA 1911)

**23.1 General.** If the fire apparatus is equipped with an aerial device, the aerial device shall be inspected and tested as required by this chapter.

**23.1.1** All inspections and tests specified in this standard, except those specifically designated as nondestructive tests (NDT), shall be conducted at the following times:

(1) At least annually
(2) After major repairs or overhaul
(3) Following the use of the aerial device when the aerial device could have been subjected to unusual operating conditions of stress or load
(4) When there is reason to believe that usage has exceeded the manufacturer's recommended aerial device operating procedures

**23.1.2*** The inspections and tests specified in this chapter as NDT shall be conducted as follows:

(1) At least every 5 years
(2) Whenever visual inspection or load testing indicates a potential structural or safety problem
(3) When there is a desire to further confirm continued operational safety

**23.1.3** If the aerial device is involved in a situation that produces any structural damage, or if the inspections and tests that are required in this standard reveal any problems that affect the structural integrity of the aerial device, the aerial device shall be placed out of service.

**23.1.3.1*** The aerial device shall be repaired to an acceptance level in accordance with the manufacturer's standard.

**23.1.3.2** If the manufacturer is no longer in business and therefore cannot be consulted with regard to repair of the aerial device, the repairs shall be performed by a repair facility that is acceptable to the AHJ.

**23.1.3.3** The aerial device shall be tested to the full operational load and NDT of this standard before it is placed back in service.

**23.1.4*** The inspections and tests specified herein shall be the minimum performance test requirements for all aerial devices.

**23.1.4.1** Since each manufacturer's unit will be somewhat different, specific attention shall be given to the manufacturer's instructions concerning periodic maintenance and inspection checks.

**23.1.4.2** The testing personnel shall have written documentation identifying the aerial device manufacturer's operating procedures, component performance specifications, and tolerances.

**23.1.5*** Only qualified persons, acceptable to the AHJ, shall be permitted to operate the apparatus during testing procedures.

**23.2 Inspection Personnel.**

**23.2.1** The inspections and tests outlined in this standard shall be performed by qualified persons, a third-party testing company, or the manufacturer, as determined acceptable by the AHJ.

**23.2.2** The person actually performing the nondestructive test work shall be certified as at least a Level II NDT technician in the test method used, as specified in ASNT CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel*.

**23.2.3** Trainees and personnel certified to Level I NDT in the test method used shall be permitted to conduct the nondestructive tests so long as they work under the direct and immediate supervision of either a Level II or an ASNT Level III NDT technician holding current certification in the same test method.

**23.3 Third-Party Test Companies.** If a third-party test company is employed to perform NDT, that company shall be accredited to the requirements of ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection*.

**23.4 Visual Inspection.** A visual inspection shall be performed in accordance with the requirements of Sections 23.8, 23.9, or 23.10, depending on the aerial device.

**23.4.1** The visual inspection shall be conducted prior to any operational or load testing and carried out in a systematic sequence.

**23.4.2** The visual inspection shall be to detect any visible defects, damage, or improperly secured parts.

**23.5 Weld Inspection.**

**23.5.1** When the inspections required by 23.1.1 are performed, all accessible structural welds shall be visually inspected for fractures.

**23.5.2** When the NDT required by 23.1.2 is performed, all accessible structural welds shall be inspected by technicians who meet the criteria of Section 23.2 for the test methods used.

**23.5.3 Welds on Steel.**

**23.5.3.1** All accessible structural welds on steel shall be inspected in accordance with the applicable provisions of AWS D1.1/D1.1M, *Structural Welding Code — Steel*.

**23.5.3.2** All structural welds shall comply with weld quality as specified in the visual inspection acceptance criteria of AWS D1.1/D1.1M.

**23.5.4 Welds on Aluminum.**

**23.5.4.1** All accessible structural welds on aluminum shall be inspected in accordance with the applicable provisions of AWS D1.2/D1.2M, *Structural Welding Code — Aluminum*.

**23.5.4.2** All structural welds shall comply with weld quality as specified in the visual inspection acceptance criteria of AWS D1.2/D1.2M.

**23.5.5** The application of a particular NDT weld inspection technique shall be as recommended by AWS B1.10/B1.10M, *Guide for the Nondestructive Examination of Welds*.

**23.6 Bolt and Pin Inspection.** Bolts and pins that are subjected to ultrasonic testing shall contain no ultrasonic magnetic acoustic transducer indications on a visual display that can be interpreted as cracks or elongated material.

**23.7 Nondestructive Testing Procedures.**

**23.7.1** All test procedures shall be consistent with ASTM E1316, *Standard Terminology for Nondestructive Examinations*.

**23.7.2** All ultrasonic inspections shall be conducted in accordance with the following standards:

(1) ASTM E114, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing*
(2) ASTM E797/E797M, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*

**23.7.3** All magnetic particle inspections shall be conducted in accordance with ASTM E709, *Standard Guide for Magnetic Particle Testing*.

**23.7.4** All liquid penetrant inspections shall be conducted in accordance with the following standards:

(1) ASTM E165/E165M, *Standard Practice for Liquid Penetrant Testing for General Industry*
(2) ASTM E1220, *Standard Practice for Visible Penetrant Testing Using Solvent-Removable Process*
(3) ASTM E1418, *Standard Practice for Visible Penetrant Testing Using the Water-Washable Process*

**23.7.5** All hardness readings shall be conducted in accordance with the following standards:

(1) ASTM B647, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage*
(2) ASTM B648, *Standard Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor*
(3) ASTM E6, *Standard Terminology Relating to Methods of Mechanical Testing*
(4) ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*
(5) ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*
(6) ASTM E92, *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*

**23.7.6** All acoustic emission inspections shall be conducted in accordance with the following standards:

(1) ASTM E569/E569M, *Standard Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation*
(2) ASTM E650/E650M, *Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors*

**23.7.7** All eddy current inspections shall be conducted in accordance with ASTM E1004, *Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy Current) Method*.

**23.8 Inspecting and Testing Aerial Ladders.**

**23.8.1 General.**

**23.8.1.1** The tests specified in Section 23.8 shall apply only to metal aerial ladders.

**23.8.1.2** In addition to the manufacturer's recommendations for annual inspections and tests, the inspections and tests detailed in 23.8.2 through 23.8.11 shall be performed.

**23.8.1.3** An inspection procedure preceded by a plus sign (+) indicates that an appropriate NDT shall be conducted as required by 23.1.2.

**23.8.2 Service Records.** The aerial ladder's service records shall be checked for any reports that indicate defective conditions.

**23.8.3 Hydraulic Components.** Hydraulic components shall show no signs of hydraulic fluid leakage.

**23.8.3.1** A component shall be considered leaking if hydraulic fluid (oil) droplets are forming on the component.

**23.8.3.2** A film of hydraulic fluid on the component shall not be considered severe enough to categorize the component as leaking.

**23.8.4 Turntable, Torque Box, Suspension, and Tractor-Drawn Components Inspection and Test.** The turntable, torque box, suspension components, and tractor-drawn components, where applicable, shall be inspected on all aerial ladders in accordance with 23.8.4.1 through 23.8.4.29.

**23.8.4.1 Rotation-Bearing Mounting Bolts.** The rotation-bearing mounting bolts shall be inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the bolt torque on all accessible bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all accessible bolts for internal flaws.

**23.8.4.2 Torque Box Mounting to Frame.**

**23.8.4.2.1** If the torque box is bolted to the frame, the torque box mounting to the frame shall be inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the torque on all accessible bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all bolts for internal flaws.

**23.8.4.2.2** If the torque box is welded to the frame, the torque box mounting to the frame shall be inspected as follows:

(1) Visually inspect all accessible attaching welds for fractures.
(2) (+) Inspect all accessible attaching welds.

**23.8.4.3 Tractor-Drawn Components Mounting to Frame.**

**23.8.4.3.1** If tractor-drawn components are bolted to the frame, the mounting of the tractor-drawn components to the frame shall be inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the torque on all accessible bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all bolts for internal flaws.

**23.8.4.3.2** If tractor-drawn components are welded to the frame, the mounting of the tractor-drawn components to the frame shall be inspected as follows:

(1) Visually inspect all accessible attaching welds for fractures.
(2) (+) Inspect all accessible attaching welds.

**23.8.4.4 Suspension System.**

**23.8.4.4.1** If the suspension system components are bolted to the frame, the mounting of the suspension system components to the frame shall be inspected as follows:

(1) Inspect all accessible bolts for proper installation.
(2) (+) Inspect all accessible bolts for internal flaws.

**23.8.4.4.2** If the suspension system components are welded to the frame, all accessible attaching welds shall be visually inspected for fractures.

**23.8.4.5 Rotation Gear and Bearing.** The rotation gear and bearing shall be inspected as follows:

(1) Inspect the rotation gear for missing or damaged teeth, pinion-to-gear alignment, proper lubrication, and backlash.
(2) Inspect the bearing clearance.

**23.8.4.6 Rotation Gear Reduction Box Mounting.**

**23.8.4.6.1** If the rotation gear reduction box is bolted to the turntable, the rotation gear reduction box mounting shall be inspected as follows:

(1) Inspect all bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a calibrated torque wrench, verify that the torque on all bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all bolts for internal flaws.

**23.8.4.6.2** If the rotation gear reduction box is welded to the turntable, the rotation gear reduction box mounting shall be inspected as follows:

(1) Visually inspect all of the accessible weldments for defects and all of the welds for fractures.
(2) (+) Inspect all reduction box attaching welds.

**23.8.4.7 Structural Components.** The structural components shall be inspected as follows:

(1) Visually inspect all of the accessible structural weldments for defects and all of the welds for fractures.
(2) (+) Inspect all accessible structural component welds.

**23.8.4.8 Rotation Hydraulic Swivel.** The rotation hydraulic swivel shall be inspected for external hydraulic fluid leakage and the security of the swivel attachment to the structure.

**23.8.4.9 Hydraulic Lines and Hose.** All hydraulic lines and hose shall be inspected for kinks, cuts and abrasions, and hydraulic fluid leakage at connectors and fittings.

**23.8.4.10 Elevation, Extension, and Rotation Lock(s).** The elevation, extension, and rotation lock(s) shall be inspected as follows:

(1) Inspect the manual valve on the elevation, extension, and rotation lock(s) for external hydraulic fluid leakage.
(2) Verify by visual inspection that the manual elevation lock operates properly by engaging the lock and then attempting to raise and lower the ladder while the main hydraulic system is operating.
(3) Verify by visual inspection that the manual extension lock operates properly by engaging the lock and then attempting to extend or retract the ladder while the main hydraulic system is operating.
(4) Verify by visual inspection that the manual rotation lock operates properly by engaging the lock and attempting to rotate the turntable clockwise and counterclockwise while the main hydraulic system is operating.
(5) If provided, verify that the rotation interlock system operates properly.
(6) If provided, verify that the system provided to avoid collisions between the aerial device and the apparatus cab/body operates properly.
(7) For aerial devices that have computer-controlled or electronically controlled limitations to the range of aerial movement, perform a test to validate the proper operation of the control system as defined by the manufacturer.

**23.8.4.11 Power Takeoff (PTO).** The PTO shall be inspected as follows:

(1) Inspect the PTO for external hydraulic fluid leakage.
(2) Verify that the PTO engages and disengages properly.

**23.8.4.12 Hydraulic Pump.** The hydraulic pump shall be inspected for external hydraulic fluid leakage.

**23.8.4.13 Collector Rings.** The collector rings shall be inspected as follows:

(1) If the collector rings are accessible, inspect them for foreign material buildup.
(2) If the collector ring terminals are accessible, inspect them for damage.
(3) Conduct tests to ensure the proper operation of the collector rings by rotating the aerial device while electric-powered devices are in operation.
(4) If applicable, check for indications of moisture in the electrical chamber by visually inspecting the desiccant moisture indicators.

**23.8.4.14 Elevation Cylinder Anchor Ears and Plates.**

**23.8.4.14.1** The elevation cylinder anchor ears and plates shall be inspected as follows:

(1) Visually inspect the elevation cylinder anchor ears and plates for defects and the attaching welds for fractures.
(2) (+) Inspect the elevation cylinder anchor ears and plate-attaching welds.

**23.8.4.14.2** If the elevation cylinder anchor is bolted, it shall be further inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the bolt torque on all accessible bolts meets the manufacturer's specification.
(3) (+) Inspect all accessible bolts for internal flaws.

**23.8.4.15 Elevation Cylinder Pins.** The elevation cylinder pins shall be inspected as follows:

(1) Inspect the cylinder pins for proper installation, alignment, lubrication, operation, and retention.
(2) (+) Inspect cylinder pins for internal flaws.

**23.8.4.16 Elevation Cylinders.**

**23.8.4.16.1** The elevation cylinders shall be inspected as follows:

(1) Inspect the cylinder rods for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seal and the end gland seal for external hydraulic fluid leakage that exceeds the manufacturer's specifications.

**23.8.4.16.2*** The elevation cylinders shall be subjected to a drift test as follows:

(1) With the hydraulic fluid at ambient temperature, place the aerial device at 60 degrees elevation at full extension.
(2) Mark the cylinder position.

(3) Close the manually operated locking valves, and allow the device to stand for 1 hour with the engine off.
(4) Measure the drift and verify that the results do not exceed the manufacturer's specifications for allowable cylinder drift.

**23.8.4.17 Holding Valves on Elevation Cylinders.** The holding valves on the elevation cylinders shall be inspected for external hydraulic fluid leakage.

**23.8.4.18 Operating Controls.** The operating controls shall be inspected as follows:

(1) Inspect the operating controls to ensure control handles are not damaged or missing, functions are identified, operating instructions and warnings are posted, and no hydraulic fluid leakage has occurred.
(2) Verify that the controls operate smoothly, return to neutral position when released, and do not bind during operation.
(3) If interlocks have been provided or are required to prevent unintentional operation of the aerial device, verify that the interlocks or locking devices are operating properly.

**23.8.4.19 Load Limit Indicators.** The load limit indicators shall be inspected for proper operation and legibility.

**23.8.4.20 Emergency Hand-Crank Controls.** The emergency hand-crank controls shall be inspected for proper operation.

**23.8.4.21 Auxiliary Hydraulic Power.** The auxiliary hydraulic power shall be inspected for proper operation.

**23.8.4.22 Turntable Alignment Indicator.** When the aerial device is stowed in the cradle, the presence and accuracy of the turntable alignment indicator shall be verified.

**23.8.4.23 Throttle Control.**

**23.8.4.23.1** The throttle control shall be inspected for proper operation.

**23.8.4.23.2** The operating speed of the engine shall be measured using a tachometer or a revolution counter and checked against the manufacturer's specifications.

**23.8.4.24 Communication System.** The communication system shall be inspected for proper installation and operation.

**23.8.4.25 Relief Hydraulic Pressure.** The main hydraulic pump relief pressure shall be tested to determine that it does not exceed the manufacturer's specifications.

**23.8.4.26 Unit Main Frame.** The unit main frame shall be inspected as follows:

(1) Visually inspect the main frame for any cracks, bends, dents, twists, or other weldment defects.
(2) Visually inspect any welds for fractures.
(3) (+) Inspect all main frame welds.

**23.8.4.27 Transmission/Aerial Device Interlocks.** If interlocks have been provided that prevent operation of the aerial device until both the parking brakes have been set and the transmission has been positioned properly, the interlocks shall be inspected to verify they are operating properly.

**23.8.4.28 Engine Speed Interlocks.** If interlocks have been provided that allow operation of the engine speed control only after both the parking brakes have been set and the transmission has been positioned properly, the interlocks shall be inspected to verify they are operating properly.

**23.8.4.29 Breathing Air Systems.** If a breathing air system is provided, the system shall be inspected as follows:

(1) Verify that the breathing air system — including the integrity of the air cylinder mounting, the regulator, and the air lines from the air cylinder(s) to the top of the aerial device — is properly installed.
(2) Verify that all the component parts of the system are present and in serviceable condition.
(3) Visually inspect the air cylinder mounting brackets for defects and the welds for fractures.
(4) (+) Inspect all welds on air cylinder mounting brackets.
(5) Check that the air pressure regulator is set at the apparatus manufacturer's recommended pressure.

**23.8.5 Stabilizer Inspection and Test.** The stabilizer components, where applicable, shall be inspected on all aerial ladder apparatus in accordance with 23.8.5.1 through 23.8.5.16.

**23.8.5.1 Stabilizer Structural Components.** The stabilizer structural components shall be inspected as follows:

(1) Visually inspect all of the stabilizer components for defects and all of the welds for fractures.
(2) (+) Inspect all stabilizer structural component welds.

**23.8.5.2 Stabilizer Pads.** The stabilizer pads shall be inspected to verify that they are present, are of proper construction, and are in serviceable condition.

**23.8.5.3 Stabilizer Mounting to Frame or Torque Box.**

**23.8.5.3.1** The stabilizer mounting to the frame or torque box attachment shall be visually inspected for defects such as dents and bends.

**23.8.5.3.2** If the stabilizer mounting to the frame or torque box is welded, it shall be further inspected as follows:

(1) Visually inspect the stabilizer to frame or torque box mounting for weld cracks.
(2) (+) Inspect the stabilizer to frame or torque box mounting welds.

**23.8.5.3.3** If the stabilizer mounting to the frame or torque box is bolted, it shall be further inspected as follows:

(1) Inspect all bolts for proper fastener grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the torque on all bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all bolts for internal flaws.

**23.8.5.4 Hydraulic Lines and Hoses in Stabilizer System.** All hydraulic lines and hoses in the stabilizer system shall be inspected for kinks, cuts and abrasions, and leakage at connectors and fittings.

**23.8.5.5 Stabilizer Interlock System.** The stabilizer interlock system shall be inspected to verify that it is operating properly.

**23.8.5.6 Stabilizer Warning Device.** The stabilizer warning device shall be inspected to verify that it is operating properly.

**23.8.5.7 Stabilizer Extension Cylinder Pins and Hinge Pins.** The stabilizer extension cylinder pins and hinge pins shall be inspected as follows:

(1) Inspect all stabilizer cylinder pins and hinge pins for proper installation, lubrication, operation, and retention.
(2) (+) Inspect all stabilizer pins and hinge pins for internal flaws.

**23.8.5.8 Stabilizer Extension Cylinders.**

**23.8.5.8.1** The stabilizer extension cylinders shall be inspected as follows:

(1) Inspect the stabilizer extension cylinder rods for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seals and the end gland seals for external hydraulic fluid leakage that exceeds the manufacturer's specifications.

**23.8.5.8.2*** The stabilizer extension cylinder shall be subjected to a drift test as follows:

(1) With the hydraulic fluid at ambient temperature, properly set the stabilizer's cylinders.
(2) Mark the cylinder position.
(3) Measure the drift after 1 hour with the engine off.
(4) Verify that the results do not exceed the manufacturer's specification for allowable stabilizer cylinder drift.

**23.8.5.9 Holding Valves on Extension Cylinders.** The holding valves on extension cylinders shall be inspected for external leakage of hydraulic fluid.

**23.8.5.10 Operating Controls.** The operating controls shall be inspected as follows:

(1) Inspect the operating controls to ensure control handles are not damaged or missing, functions are identified, operating instructions and warnings are posted, and no hydraulic fluid leakage has occurred.
(2) Verify that the controls operate smoothly, return to the neutral position when released, and do not bind during operation.
(3) If interlocks have been provided or are required to prevent unintentional operation of the aerial device, verify that the interlocks or locking devices are operating properly.

**23.8.5.11 Leveling Indicator.** If a leveling indicator(s) is provided to aid the operator in leveling the apparatus, the accuracy and legibility of the leveling indicator shall be checked.

**23.8.5.12 Diverter Valve.** The diverter valve shall be inspected for external hydraulic fluid leakage.

**23.8.5.13 Positive Stops.** The mechanical stabilizers shall be inspected for proper operation of the positive stops that prevent overextension.

**23.8.5.14 Stabilizer Deployment.** If the stabilizer system is operated hydraulically, the system shall be inspected to verify that it can be deployed within the time frame designated by the aerial device manufacturer.

**23.8.5.15 Manual Spring Locks.** The stabilizer manual spring locks shall be inspected for proper condition and operation.

**23.8.5.16 Tractor Lockout Device.** If the aerial ladder is tractor drawn, the spring lockout or fifth wheel lockout device(s), if supplied, shall be inspected for any discontinuities and for proper operation.

**23.8.6 Aerial Ladder Inspection and Test.** The aerial ladder shall be inspected in accordance with 23.8.6.1 through 23.8.6.30.

**23.8.6.1 Structural Modifications, Improper Repairs, or Added Weight.**

**23.8.6.1.1** The aerial ladder shall be inspected for structural modifications or improper repairs.

**23.8.6.1.2** The aerial ladder shall be inspected to determine that no extra equipment has been added to the aerial ladder without subtracting the weight of such equipment from the rated capacity.

**23.8.6.1.3** Details of any structural modifications, improper repairs, or added weight shall be contained in the record required by 23.8.12.

**23.8.6.2 Aerial Ladder Weldments.** All aerial ladder weldments shall be inspected as follows:

(1) Visually inspect all of the accessible aerial ladder weldments for defects and all of the welds for fractures.
(2) (+) Inspect all accessible welds on the ladder.

**23.8.6.3 Aerial Ladder Fasteners.** All aerial ladder structural fasteners and fastened connections shall be inspected visually for cracked fasteners and material cracks around the fasteners.

**23.8.6.4 Ladder Section Alignment.** Measurements shall be taken to determine that the amount of ladder section twist or bow in the aerial ladder does not exceed the manufacturer's specifications for allowable ladder section twist or bow.

**23.8.6.5 Hydraulic, Pneumatic, and Electrical Lines in Ladder Sections.** All hydraulic, pneumatic, and electrical lines in ladder sections shall be inspected for proper mounting and for wear, cracking, kinks, and abrasions.

**23.8.6.6 Top Rails.** The top rails shall be inspected as follows:

(1) Inspect the top rails for straightness or any signs of misalignment.
(2) If the ladder is constructed of aluminum, perform one of the following:
    (a) (+) Take hardness readings at intervals of 12 in. (305 mm) or less on the last 10 ft (3 m) of each top rail section and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the top rail.
    (b)* (+) If heat sensors are installed on the top rails, visually inspect the heat sensors for discoloration.
(3) (+) If the aerial device is constructed of aluminum and is painted, follow the manufacturer's recommendations for inspection.
(4) (+) If there is discoloration of heat sensor(s) or any indication of heat damage anywhere on an aluminum aerial device, take hardness readings at intervals of 12 in. (305 mm) or less between the heat-affected areas and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the top rail.

**23.8.6.7 Vertical and Diagonal Braces.** The vertical and diagonal braces shall be inspected as follows:

(1) Inspect the verticals and diagonals for straightness, dents, and other deformities.
(2) (+) Inspect all accessible attachment welds.

**23.8.6.8 Base Rails.** The base rails shall be inspected as follows:

(1) Inspect the base rail for straightness and any signs of wear, ironing, dents, or corrosion.
(2)* (+) Inspect the bottom of all hollow I-beam base rails to determine that the thickness of the rail is not less than the manufacturer's minimum specifications.
(3) If the ladder is constructed of aluminum, perform one of the following:
    (a) (+) Take hardness readings at intervals of 28 in. (710 mm) or less along the entire length of both bottom rails and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the top rail.
    (b)* (+) If heat sensors are installed on the base rails, visually inspect the heat sensors for discoloration.
    (c) (+) If the aerial ladder is painted, follow the manufacturer's recommendations for inspection.
(4) (+) If there is discoloration of a heat sensor(s) or any indication of heat damage anywhere on an aluminum aerial device, take hardness readings at intervals of 12 in. (305 mm) or less between the heat-affected areas and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the base rail.

**23.8.6.9 Rungs.** All rungs of the aerial ladder shall be inspected for straightness, signs of ladder lock damage, damaged or loose rung covers and rung cap castings, and signs of cracks or missing rivets, if applicable.

**23.8.6.10 Folding Steps.** The folding steps on the ladder shall be inspected as follows:

(1) Visually inspect the folding steps and folding step mounting brackets for defects and the welds for fractures.
(2) (+) Inspect all welds on the folding step(s) and folding step mounting brackets.

**23.8.6.11 Rollers.** All rollers shall be inspected for proper lubrication and operation and for any signs of wear.

**23.8.6.12 Guides, Babbitts, Wear Strips, Pads, and Slide Blocks.**

**23.8.6.12.1** The guides shall be visually inspected for cracked welds, loose rivets, alignment problems, and any irregularities.

**23.8.6.12.2** The babbitted areas of the base rail shall be free of paint and inspected for signs of wear.

**23.8.6.12.3** The wear strips, pads, and slide blocks shall be inspected for wear and gouging and for proper mounting.

**23.8.6.13 Extension Sheaves.** The extension sheaves shall be inspected as follows:

(1) Inspect extension sheaves for signs of wear, free movement during operation, proper retainers, and proper lubrication.
(2) Visually inspect all extension sheave mounting brackets for defects and the welds for fractures.
(3) (+) Inspect all welds of extension sheave mounting brackets.

**23.8.6.14 Extension Cables.** The extension cables shall be inspected for compliance with Chapter 5-2 of ASME B30.5, *Mobile and Locomotive Cranes*.

**23.8.6.15 Extension and Retraction Motor.** The extension and retraction motor shall be inspected for signs of external hydraulic fluid leakage and, where applicable, brake wear and brake alignment with the shaft.

**23.8.6.16 Cable Separation Guide.** During operation of the aerial ladder, the cable separation guide shall be inspected visually for free travel and any signs of misalignment.

**23.8.6.17 Winch Holding Capacity.** The winch shall be inspected for holding capacity as follows:

(1) Fully elevate the aerial ladder and extend it 10 ft (3 m).
(2) Measure the winch slippage for a 5-minute period.
(3) Verify that the slippage does not exceed the manufacturer's specifications.

**23.8.6.18 Brake-Holding Capacity.** The brake-holding capacity of the extension motor shall be inspected as follows:

(1) Fully elevate the aerial ladder and extend it 10 ft (3 m).
(2) Measure the brake slippage for a 5-minute period.
(3) Verify that the slippage does not exceed the manufacturer's specifications.

**23.8.6.19 Extension, Elevation, and Rung Alignment Indicators.** The elevation, extension, and rung alignment indicators shall be inspected for legibility, clarity, and accuracy.

**23.8.6.20 Ladder Locks.** The ladder lock mechanisms shall be inspected for proper mounting, alignment, lubrication, and operation.

**23.8.6.21 Ladder Cradle.**

**23.8.6.21.1** The aerial ladder cradle shall be inspected as follows:

(1) Inspect the ladder cradle for wear and proper alignment, and inspect the cradle pad for damage.
(2) Visually inspect the ladder cradle for defects such as weld cracks, dents, or bends.
(3) (+) Inspect the ladder cradle welds and bracket attachments.

**23.8.6.21.2** If the aerial ladder cradle is bolted, it shall be further inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the bolt torque on all accessible cradle-to-chassis-frame mounting bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all accessible bolts for internal flaws.

**23.8.6.22 Ladder Bed Lock.**

**23.8.6.22.1** The ladder bed lock mechanism and hydraulic lines shall be inspected for proper mounting, signs of wear, and hydraulic fluid leakage at fittings.

**23.8.6.22.2** The ladder bed lock shall be inspected to verify proper operation.

**23.8.6.23 Stop Mechanism.** The stop mechanisms shall be inspected to ensure that they prevent overextension or overretraction of the aerial ladder.

**23.8.6.24 Maximum Extension Warning Device.** During operation, if the aerial ladder is equipped with an audible device that warns of the approach of maximum extension, the device shall be inspected to verify proper operation.

**23.8.6.25 Ladder Illumination.** The lights that are used to illuminate the ladder shall be inspected for proper operation.

**23.8.6.26 Extension Cylinder Anchor Ears and Plates.**

**23.8.6.26.1** The extension cylinder anchor ears and plates shall be inspected as follows:

(1) Visually inspect the extension cylinder anchor ears and plates for defects and the attaching welds for fractures.
(2) (+) Inspect the attaching welds of the extension cylinder anchor ears and plates.

**23.8.6.26.2** If the extension cylinder anchor is bolted, it shall be further inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a properly calibrated torque wrench, verify that the bolt torque on all accessible bolts meets the manufacturer's specifications.
(3) (+) Inspect all accessible bolts for internal flaws.

**23.8.6.27 Extension Cylinder Pins.** The extension cylinder pins shall be inspected as follows:

(1) Inspect the cylinder pins for proper installation and retention.
(2) (+) Inspect the cylinder pins for internal flaws.

**23.8.6.28 Extension Cylinder.**

**23.8.6.28.1** The extension cylinder shall be inspected as follows:

(1) Inspect the cylinder rods for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seal and the end gland seal for external hydraulic fluid leakage that exceeds the manufacturer's specifications.

**23.8.6.28.2*** The extension cylinder shall be subjected to a drift test as follows:

(1) With the hydraulic fluid at ambient temperature, place the aerial device at 60 degrees elevation at full extension.
(2) Mark the cylinder position or the second aerial ladder section in relation to the base section.
(3) Allow the ladder to stand for 1 hour with the engine off.
(4) Measure the drift and verify that the results do not exceed the manufacturer's specifications for allowable cylinder drift.

**23.8.6.29 Holding Valves on Extension Cylinder.** The holding valves shall be inspected for external and internal hydraulic fluid leakage.

**23.8.6.30 Tip Controls.** If the aerial ladder is equipped with a secondary operating position at the tip, the controls shall be inspected as follows:

(1) Check that the control handles are not damaged or missing, functions are identified, and operating instructions and warnings are posted.
(2) Verify that the controls operate smoothly, return to neutral when released, and do not bind during operation.
(3) Verify that the turntable or lower controls will override the tip controls.
(4) Verify that any safety devices that are designed to operate in conjunction with the tip controls are fully operational.
(5) If the aerial ladder was built to the 1996 through 2016 edition of NFPA 1901 or to NFPA 1900, verify that the speed of the aerial ladder, when being operated from the tip controls, does not exceed the speeds permitted in the edition of NFPA 1901 or NFPA 1900 to which the aerial ladder was manufactured.

**23.8.7 Load Testing.**

**23.8.7.1*** Tests shall be conducted when the wind velocity is less than 10 mph (16 km/hr).

**23.8.7.2** Only those personnel who are essential to conduct the test shall be permitted near the apparatus during the test.

**23.8.7.3** A watch shall be maintained during all load tests for any signs of instability, the development of conditions that could cause damage or permanent deformation, or twist that exceeds the aerial ladder manufacturer's allowance.

**23.8.7.3.1** If any of the conditions described in 23.8.7.3 develop, the test shall be discontinued immediately.

**23.8.7.4 Horizontal Load Test.**

**23.8.7.4.1** The aerial apparatus shall be on a hard, level surface with the stabilizers deployed in accordance with the manufacturer's instructions, and with the turntable level.

**23.8.7.4.2*** A test cable hanger shall be attached to the top section of the ladder as follows:

(1) If the ladder is rated at 500 lb (227 kg) or less, the cable hanger is to be attached to the top rung and centered.
(2) If the ladder is rated at greater than 500 lb (227 kg), the test cable hanger is to be attached to both base rails at the top rung.

**23.8.7.4.3** The rated capacity that the ladder is designed to support in the horizontal position at full extension shall be determined from the manufacturer's load chart or operator's manual.

**23.8.7.4.3.1** If full extension is not permitted in the horizontal position with a specified rated capacity, the maximum permissible extension with a specified rated capacity shall be used for the purpose of this test.

**23.8.7.4.4** The ladder shall be positioned as follows:

(1) For single-chassis apparatus, the ladder is to be rotated, if necessary, until it is positioned over the rear, and parallel to, the vehicle centerline.
(2) For a tractor-drawn apparatus, the ladder is to be positioned in the most stable position, as recommended by the manufacturer.

**23.8.7.4.5** The ladder shall be placed in the horizontal position and extended to full extension or the maximum permitted extension as determined in 23.8.7.4.3.

**23.8.7.4.5.1** The base section shall not be permitted to rest in the bed.

**23.8.7.4.6** The ladder section locks, either manual pawls or hydraulic holding valves, shall be applied properly.

**23.8.7.4.7** The elevation cylinders' integral holding valve or shutoff safety valve shall be properly closed or applied.

**23.8.7.4.8*** A free-hanging weight that is equal to the rated capacity, as determined in 23.8.7.4.3, shall be applied gradually to the top section of the aerial ladder by utilizing a test weight container or other suitable means of applying the weight.

**23.8.7.4.8.1** The weight shall be suspended by a cable not more than 3 ft (1 m) above the ground.

**23.8.7.4.8.2** The combined weight of the test cable hanger and cable, the test weight container, and the test weights shall not exceed the rated capacity.

**23.8.7.4.8.3** The weights shall be added to the ladder in a manner that does not shock load the ladder.

**CAUTION:** Dropping the weights and shock loading the ladder can damage the ladder.

**23.8.7.4.9** The test weight shall be sustained by the unsupported aerial ladder for 5 minutes.

**23.8.7.4.10** The test weight shall hang freely from the tip of the aerial ladder.

**23.8.7.4.11** If the test weight hanger and ladder deflection are such that the test weight comes to rest on the ground, the ladder elevation shall be permitted to be raised slightly above the horizontal position.

**23.8.7.4.12** The ladder shall not be moved while the test weight is applied.

**CAUTION:** Moving the ladder with a test weight applied could result in the application of forces that damage the ladder.

**23.8.7.4.13** After removal of the test weight, a complete visual inspection shall be made of all load-supporting elements.

**23.8.7.4.14** The aerial ladder shall be determined as noncompliant with load tests requirements and placed out of service if any visually detectable signs of damage, permanent deformation, or twist exceeding the manufacturer's specifications are observed.

**23.8.7.5 Maximum Elevation Load Test.**

**23.8.7.5.1** The aerial apparatus shall be on a hard, level surface with the stabilizers deployed in accordance with the manufacturer's instructions, and with the turntable level.

**23.8.7.5.2*** A test cable hanger shall be attached to the top section of the ladder as follows:

(1) If the ladder is rated at 500 lb (227 kg) or less, the cable hanger is to be attached to the top rung and centered.
(2) If the ladder is rated at greater than 500 lb (227 kg), the test cable hanger is to be attached to both base rails at the top rung.

**23.8.7.5.3** The maximum rated capacity that the ladder is designed to support in the maximum elevated position at full extension shall be determined from the manufacturer's load chart or operator's manual.

**23.8.7.5.4** The ladder shall be rotated, if necessary, until the ladder is positioned over the rear and parallel to the vehicle centerline.

**23.8.7.5.4.1** Midship-mounted aerial ladders shall be permitted to be rotated slightly off of the vehicle centerline to apply the test load without interfering with the body of the apparatus.

**23.8.7.5.5** The ladder shall be positioned at its maximum elevation and full extension.

**23.8.7.5.6** The ladder section locks, either manual pawls or hydraulic holding valves, shall be applied properly.

**23.8.7.5.7** The elevation cylinders' integral holding valve or shutoff safety valve shall be properly closed or applied.

**23.8.7.5.8** A free-hanging weight that is equal to the rated capacity, as determined in 23.8.7.5.3, shall be applied gradually to the top rung of the aerial ladder by utilizing a test weight container or other suitable means of applying the weight.

**23.8.7.5.8.1** The weight shall be suspended by a cable not more than 3 ft (1 m) above the ground.

**23.8.7.5.8.2** The combined weight of the test cable hanger and cable, the test weight container, and the test weights shall not exceed the rated capacity.

**23.8.7.5.8.3** The weights shall be added to the ladder in a manner that does not shock load the ladder.

**CAUTION:** Dropping the weights and shock loading the ladder can damage the ladder.

**23.8.7.5.9** The test weight shall be sustained by the unsupported aerial ladder for 5 minutes.

**23.8.7.5.10** The test weight shall hang freely from the tip of the aerial ladder.

**23.8.7.5.11** The ladder shall not be moved while the test weight is applied.

**CAUTION:** Moving the ladder with a test weight applied could result in the application of forces that damage the ladder.

**23.8.7.5.12** After removal of the test weight, a complete visual inspection shall be made of all load-supporting elements.

**23.8.7.5.13** The aerial ladder shall be determined as noncompliant with load tests requirements and placed out of service if any visually detectable signs of damage, permanent deformation, or twist exceeding the manufacturer's specifications are observed.

**23.8.8 Operating Test.**

**23.8.8.1** After the load tests have been conducted, the ladder shall be fully elevated out of the bed, rotated 90 degrees, and fully extended.

**23.8.8.2*** The procedure specified in 23.8.8.1 shall be completed smoothly and without undue vibration within the time permitted by the edition of NFPA 1901 or NFPA 1900 in effect at the time of manufacture.

**23.8.8.3** After completing the procedure specified in 23.8.8.1, the ladder shall be retracted, the turntable rotation completed through 360 degrees, and the ladder lowered to its bed.

**23.8.8.4** During the test, the proper operation of all ladder controls shall be verified.

**23.8.8.5** After the procedure specified in 23.8.8.1 through 23.8.8.4 is completed, a thorough inspection shall be made of all moving parts.

**23.8.8.6** The security and adjustment of the ladder cables or chains shall be checked for proper tension and retention in accordance with the manufacturer's specifications.

**23.8.9 Waterway System Test.**

**23.8.9.1** The following inspection and test shall apply only to permanently piped, aerial ladder waterway systems.

**23.8.9.2** The waterway system shall be inspected as follows:

(1) Inspect the system for proper operation of all components.
(2) Inspect the system for rust, corrosion, blockage, or other defects.

**23.8.9.3** The waterway-attaching brackets shall be inspected as follows:

(1) Inspect the brackets for loose bolts, weld fractures, or other defects.
(2) (+) Inspect all attaching welds.

**23.8.9.4 Pressure Test.** The water system shall be pressure tested as specified in 23.8.9.4.1 through 23.8.9.4.3.

**23.8.9.4.1*** The aerial device shall be positioned between 0 degrees and 10 degrees elevation and fully retracted.

**23.8.9.4.1.1** If there is no valve located at the discharge end, a valve shall be attached for the purpose of the test.

**23.8.9.4.1.2*** The water system shall be filled with water, and the valve at the discharge end shall be closed.

**CAUTION:** For safety reasons, all air must be removed from the system.

**23.8.9.4.1.3** The pressure on the system shall be raised to the water system manufacturer's maximum rated working pressure and be maintained while the operations and inspections required by 23.8.9.4.1.4 and 23.8.9.4.1.5 are conducted.

**23.8.9.4.1.4** The aerial device shall be raised to full elevation and rotated 360 degrees.

**23.8.9.4.1.5** The water system, including the turntable swivel, shall be checked for leaks.

**23.8.9.4.1.6** Care shall be taken not to overheat the water pump during this test.

**23.8.9.4.2*** The aerial device shall then be positioned between 0 degrees and 10 degrees elevation and extended to its maximum permissible limit.

**23.8.9.4.2.1** The water system shall be filled with water, all air shall be removed from the system, and the valve at the discharge end shall be closed.

**CAUTION:** Failure to remove all air from the water system could result in injury if there is a component failure during the test.

**23.8.9.4.2.2** The pressure on the system shall be raised to the water system manufacturer's maximum rated working pressure and maintained while the inspections required by 23.8.9.4.2.3 are conducted.

**23.8.9.4.2.3** The entire length of the water system shall be checked for leaks.

**23.8.9.4.2.4** Care shall be taken not to overheat the water pump during the test.

**23.8.9.4.3*** The water system shall operate properly and with an absence of leaks during the tests.

**23.8.9.5 Flowmeters.**

**23.8.9.5.1** If the waterway system is equipped with a flowmeter(s), the flowmeter(s) shall be tested for accuracy as recommended by the apparatus manufacturer.

**23.8.9.5.2** Any meter that reads off by more than 10 percent shall be recalibrated, repaired, or replaced.

**23.8.9.6 Water Pressure Gauges.**

**23.8.9.6.1** If the waterway system is equipped with a water pressure gauge(s), each water pressure gauge(s) shall be checked for accuracy at a minimum of three points at 50 psi (345 kPa) intervals without exceeding the maximum rated working pressure of the waterway system.

**23.8.9.6.2** Any gauge that reads off by more than 10 psi (70 kPa) shall be recalibrated, repaired, or replaced.

**23.8.9.7 Relief Valve.**

**23.8.9.7.1** If the waterway system is equipped with a relief valve, the relief valve shall be checked to verify that it is operational at the waterway manufacturer's recommended pressure setting.

**23.8.9.7.2** Any relief valve that fails to operate within 10 psi (70 kPa) of the manufacturer's required setting shall be repaired, recalibrated, or replaced.

**23.8.10 Signs.** All signs shall be inspected to verify they are in place and legible.

**23.8.11* Hydraulic Fluid.** After the operating tests have been performed, a sample of the hydraulic fluid shall be removed from the hydraulic reservoir and subjected to spectrochemical analysis, particle count, viscosity check, and water content analysis.

**23.8.12* Records.** A comprehensive record shall be completed for all inspections and tests of the aerial ladder and signed by the person responsible for the test.

**23.8.12.1** When the torque verification of mounting bolts is performed as required by this standard, the bolt size, grade, and torque specifications shall be recorded.

**23.8.12.2** When an NDT is conducted, the test record shall indicate the NDT method used in each inspected area.

**23.8.12.3** Where this standard requires measurements to be taken — such as bearing clearance and backlash, cylinder drift, relief pressure, ladder section twist, hardness readings, base rail thickness, extension brake drift, and winch drift — these measurements shall be recorded in the test record so that a year-to-year comparison can be made.

**23.9 Inspecting and Testing Elevating Platforms.**

**23.9.1 General.**

**23.9.1.1** In addition to the manufacturer's recommendations for annual inspections and tests, the inspections and tests detailed in 23.9.2 through 23.9.16 shall be performed.

**23.9.1.2** An inspection preceded by a plus sign (+) indicates that an appropriate NDT shall be conducted as required by 23.1.2.

**23.9.2 Service Records.** The elevating platform's service records shall be checked for any reports that indicate defective conditions.

**23.9.3 Hydraulic Components.** Hydraulic components shall not have Class 3 leakage.

**23.9.3.1** A component shall be considered to be leaking if hydraulic fluid (i.e., oil) droplets form and fall to the ground.

**23.9.3.2** A film of hydraulic fluid (Class 1 leakage) on the component shall not be considered severe enough to categorize the component as leaking.

**23.9.4 Turntable and Torque Box Inspection and Test.** The turntable and torque box components, where applicable, shall be inspected in accordance with 23.8.4.1 through 23.8.4.29.

**23.9.5 Stabilizer Inspection and Test.** The stabilizer components, where applicable, shall be inspected in accordance with 23.8.5.1 through 23.8.5.14.

**23.9.6 Platform and Boom Inspection and Test.** The platform and booms shall be inspected in accordance with 23.9.6.1 through 23.9.6.12.

**23.9.6.1 Structural Modifications, Improper Repairs, or Added Weight.**

**23.9.6.1.1** The platform and booms shall be inspected for structural modifications or improper repairs.

**23.9.6.1.2** The platform shall be inspected to determine that no extra equipment has been added to the platform without subtracting the weight of such equipment from the rated capacity.

**23.9.6.1.3** Details of any structural modifications, improper repairs, or added weight shall be contained in the required report.

**23.9.6.2 Platform Mounting Brackets.** The platform mounting brackets shall be inspected as follows:

(1) Visually inspect all platform mounting brackets for defects, such as weld cracks, dents, or bends.
(2) (+) Inspect all welds in the platform mounting brackets.
(3) (+) Inspect all bolts and pins structurally involved with the platform mounting to the ladder or boom for internal flaws.

**23.9.6.3 Platform.** The platform shall be inspected as follows:

(1) Visually inspect the platform for defects, such as weld cracks, dents, or bends.
(2) (+) Inspect all welds on the platform.

**23.9.6.4 Hydraulic, Pneumatic, and Electrical Lines in the Platform.** All hydraulic, pneumatic, and electrical lines shall be inspected for proper mounting, wear, cracking, kinks, and abrasions.

**23.9.6.5 Auxiliary Winch Mounting.** The auxiliary winch mounting shall be inspected as follows:

(1) Inspect all mounting bolts for proper grade and installation as specified by the apparatus manufacturer.
(2) Using a calibrated torque wrench, verify that the torque on all winch mounting bolts meets the apparatus manufacturer's specifications.
(3) If welded, visually inspect the winch mounting for weld fractures.
(4) (+) Inspect the mounting bolts for internal flaws.
(5) (+) If brackets are welded, inspect all welds on the mounting brackets.

**23.9.6.6 Winch Controls.** The winch controls shall be inspected as follows:

(1) Inspect controls for proper identification as to function and operation.
(2) Verify smooth operation of the winch controls.

**23.9.6.7 Elevating Platform Rated Capacity Identification.** The elevating platform rated capacity identification label or electronic display shall be verified as present and legible.

**23.9.6.8 Platform Gate Latches and Hinge Points.**

**23.9.6.8.1** The platform gate latches shall be inspected for proper alignment.

**23.9.6.8.2** The latch and hinges shall be inspected for smooth operation.

**23.9.6.9 Platform Hinge Pins.** The platform hinge pins shall be inspected as follows:

(1) Inspect platform hinge pins for proper installation, lubrication, and any irregularities.
(2) (+) Inspect the platform hinge pins for internal flaws.

**23.9.6.10 Platform Controls.** The platform controls shall be inspected as follows:

(1) Inspect the platform operating controls to ensure control handles are not damaged or missing, functions are identified, and operating instructions and warnings are posted.
(2) Verify that the controls operate smoothly, return to neutral when released, and do not bind during operation.
(3) Verify that the turntable or lower controls will override the platform controls.

**23.9.6.11 Platform Monitor and Nozzle.** The platform monitor and nozzle shall be inspected as follows:

(1) Inspect the complete operation of the platform monitor and nozzle.
(2) Inspect the monitor mounting brackets for any defects and their welds for fractures.

**23.9.6.12 Boom Illumination.** The operation of spotlights used to illuminate the boom shall be verified.

**23.9.7 Articulating Boom–Lower Boom Inspection and Test.** For apparatus equipment with an articulating boom, the lower boom shall be inspected and tested in accordance with 23.9.7.1 through 23.9.7.14.

**23.9.7.1 Hinge Pins.** The hinge pins shall be inspected as follows:

(1) Inspect the boom hinge pins for proper installation, lubrication, operation, and any discontinuities.
(2) (+) Inspect the boom hinge pins for internal flaws.

**23.9.7.2 Lower Boom Elevation Cylinder Anchor Ears and Plates.** The lower boom elevation cylinder anchor ears and plates shall be inspected as follows:

(1) Visually inspect the anchor ears and plates for defects and the attaching welds for fractures.
(2) (+) Inspect all welds on the anchor ears and plates.

**23.9.7.3 Lower Boom Elevation Cylinders.**

**23.9.7.3.1** The lower boom elevation cylinder(s) shall be inspected as follows:

(1) Inspect the cylinder rod(s) for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seal and the end gland seal for external hydraulic fluid leakage that exceeds the manufacturer's specifications.

**23.9.7.3.2*** The lower boom elevation cylinder shall be subjected to a drift test as follows:

(1) With the hydraulic fluid at ambient temperature, take measurements of the drift in accordance with the manufacturer's recommendations.
(2) Verify that the results of the measurements do not exceed the manufacturer's specifications for allowable lower boom cylinder drift.

**23.9.7.4 Holding Valves on Lower Boom Elevation Cylinder.** The holding valve(s) shall be inspected for signs of external hydraulic fluid leakage.

**23.9.7.5 Boom Assembly.** The lower boom assembly shall be inspected as follows:

(1) Visually inspect the boom for defects, such as weld cracks, dents, or bends.
(2) Visually inspect all structural fasteners and fastener connections for cracked fasteners and material cracks around the fasteners.
(3) (+) Inspect all welds on the boom for any structural discontinuities.
(4) If the lower boom assembly is constructed of aluminum, perform one of the following:
    (a) (+) Take hardness readings at intervals of 28 in. (710 mm) or less along the length of the lower boom assembly and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the lower boom assembly.
    (b)* (+) If heat sensors are installed on the lower boom assembly, visually inspect the heat sensors for discoloration.
    (c) (+) If the boom assembly is painted, follow the manufacturer's recommendations for inspection.
(5) (+) If there is discoloration of a heat sensor(s) or any indication of heat damage anywhere on an aluminum boom assembly, take hardness readings at intervals of 12 in. (305 mm) or less between the heat-affected areas and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the boom assembly.

**23.9.7.6 Cylinder Link Pins.** The cylinder link pins shall be inspected as follows:

(1) Inspect the cylinder link pins for proper installation, lubrication, operation, and any fractures.
(2) (+) Inspect the cylinder link pins for internal flaws.

**23.9.7.7 Platform-Leveling Linkages.** The platform-leveling linkages shall be inspected as follows:

(1) Visually inspect linkages for defects, such as weld cracks, dents, and bends.
(2) (+) Inspect all welds of the leveling assembly.
(3) (+) Inspect all leveling linkage pins for any internal flaws.

**23.9.7.8 Hydraulic Lines and Hoses in Lower Boom.** All hydraulic lines and hoses in the lower boom shall be inspected for proper mounting, abrasion, hydraulic fluid leakage, and wear.

**23.9.7.9 Hydraulic Lines in Knuckle.** All hydraulic lines in the knuckle shall be inspected for hydraulic fluid leakage, abrasion, and any signs of wear.

**23.9.7.10 Cables, Chains, and Rods.** All cables, chains, and rods shall be inspected for signs of wear and for proper adjustment.

**23.9.7.11 Sprockets, Pulleys, and Hooks.** All sprockets, pulleys, and hooks shall be inspected for lubrication, signs of wear, distortion, and proper operation.

**23.9.7.12 Boom Support.**

**23.9.7.12.1** The boom support shall be inspected as follows:

(1) Inspect the boom support for wear and proper alignment, and inspect the cradle pad for damage.
(2) Visually inspect the boom support for defects, such as weld cracks, dents, or bends.
(3) (+) Inspect the boom support welds and bracket attachment.

**23.9.7.12.2** If the boom support is bolted, it shall be further inspected as follows:

(1) Inspect all accessible bolts for proper grade and installation as specified by the manufacturer.
(2) Using a properly calibrated torque wrench, verify that the bolt torque on all accessible boom-support-to-chassis-frame mounting bolts meets the apparatus manufacturer's specifications.
(3) (+) Inspect all accessible bolts for internal flaws.

**23.9.7.13 Lower Boom Angle Indicator Lights.** The lower boom angle indicator lights shall be inspected to verify that they are operating properly.

**23.9.7.14 Pneumatic and Electrical Lines.** All pneumatic and electrical lines in the lower boom and the knuckle shall be inspected for proper mounting, wear, cracking, kinks, and abrasions.

**23.9.8 Articulating Boom–Upper Boom Inspection and Test.** For apparatus equipment with an articulating boom, the upper boom shall be inspected and tested in accordance with 23.9.8.1 through 23.9.8.15.

**23.9.8.1 Upper Boom for Alignment with Lower Boom.** The upper boom shall be inspected to verify it is aligned with the lower boom.

**23.9.8.2 Platform-Leveling Linkages.** The platform-leveling linkages shall be inspected as follows:

(1) Visually inspect linkages for defects, such as weld cracks, dents, and bends.
(2) (+) Inspect all welds of the leveling assembly.
(3) (+) Inspect all leveling linkage pins for any internal flaws.

**23.9.8.3 Boom Boost Cylinder Brackets.** The boom boost cylinder brackets shall be inspected as follows:

(1) Visually inspect the boom boost cylinder brackets for defects, such as weld cracks, dents, or bends.
(2) (+) Inspect the boom boost cylinder bracket welds.

**23.9.8.4 Boom Boost Cylinders.** The boom boost cylinders shall be inspected for any external hydraulic fluid leakage.

**23.9.8.5 Cylinder Link Pins.** The cylinder link pins shall be inspected as follows:

(1) Visually inspect the cylinder link pins for proper installation, lubrication, operation, and any irregularities.
(2) (+) Inspect the cylinder link pins for internal flaws.

**23.9.8.6 Boom Assembly.** The upper boom assembly shall be inspected as follows:

(1) Visually inspect the boom for defects, such as weld cracks, dents, or bends.
(2) Visually inspect all structural fasteners and fastener connections for cracked fasteners and material cracks around the fasteners.
(3) (+) Inspect all welds on the boom.
(4) If the upper boom assembly is constructed of aluminum, perform one of the following:
    (a) (+) Take hardness readings at intervals of 28 in. (710 mm) or less along the length of upper boom assembly and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the upper boom assembly.
    (b)* (+) If heat sensors are installed on the upper boom assembly, visually inspect the heat sensors for discoloration.
    (c) (+) If the boom assembly is painted, follow the manufacturer's recommendations for inspection.
(5) (+) If there is discoloration of a heat sensor(s) or any indication of heat damage anywhere on an aluminum boom assembly, take hardness readings at intervals of 12 in. (305 mm) or less between the heat-affected areas and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the boom assembly.

**23.9.8.7 Hydraulic Lines and Hoses in Upper Boom.** All hydraulic lines and hoses in the upper boom shall be inspected for proper mounting, abrasions, hydraulic fluid leakage, and wear.

**23.9.8.8 Cables, Chains, and Rods.** All cables, chains, and rods shall be inspected for signs of wear and for proper adjustment.

**23.9.8.9 Sprockets, Pulleys, and Hooks.** All sprockets, pulleys, and hooks shall be inspected for lubrication, signs of wear, distortion, and proper operation.

**23.9.8.10 Upper Boom Hold-Down Device.** The upper boom hold-down device shall be inspected as follows:

(1) Visually inspect the upper boom hold-down device for defects and for proper operation.
(2) (+) Inspect all welds of the upper boom hold-down device.

**23.9.8.11 Safety Stop Mechanism.** The safety stop mechanism shall be verified to be operating properly.

**23.9.8.12 Upper Boom Elevation Cylinder Anchor Ears and Plates.** The upper boom elevation anchor ears and plates shall be inspected as follows:

(1) Visually inspect the anchor ears and plates for defects and the attaching welds for fractures.
(2) (+) Inspect all welds on the anchor ears and plates.

**23.9.8.13 Upper Boom Elevation Cylinder(s).**

**23.9.8.13.1** The upper boom elevation cylinder(s) shall be inspected as follows:

(1) Inspect the cylinder rod(s) for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seal and the end gland seal for external hydraulic fluid leakage that exceeds the manufacturer's specifications.

**23.9.8.13.2*** The upper boom elevation cylinder(s) shall be subjected to a drift test as follows:

(1) With the hydraulic fluid at ambient temperature, take measurements of the drift in accordance with the manufacturer's recommendations.
(2) Verify that the results of the measurements do not exceed the manufacturer's specifications for allowable upper boom cylinder drift.

**23.9.8.14 Holding Valves on Upper Boom Elevation Cylinder.** The holding valve(s) shall be inspected for signs of external hydraulic fluid leakage.

**23.9.8.15 Pneumatic and Electrical Lines.** All pneumatic and electrical lines in the upper boom shall be inspected for proper mounting, wear, cracking, kinks, and abrasions.

**23.9.9 Telescoping Boom Inspection and Test.** For platforms equipped with a telescoping boom, the boom shall be inspected and tested in accordance with 23.8.4.14 through 23.8.4.17, 23.9.7.10 through 23.9.7.12, and 23.9.9.1 through 23.9.9.14.

**23.9.9.1 Boom Assemblies.** The boom assemblies shall be inspected as follows:

(1) Visually inspect the boom assembly for defects, such as weld cracks, dents, or bends.
(2) Visually inspect all structural fasteners and fastener connections for cracked fasteners and material cracks around the fasteners.
(3) (+) Inspect all welds on booms.
(4) If the boom assembly is constructed of aluminum, perform one of the following:
    (a) (+) Take hardness readings at intervals of 28 in. (710 mm) or less along the length of boom assembly and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the boom assembly.
    (b)* (+) If heat sensors are installed on the boom assembly, visually inspect the heat sensors for discoloration.

(c) (+) If the boom assembly is painted, follow the manufacturer's recommendations for inspection.

(5) (+) If there is discoloration of a heat sensor(s) or any indication of heat damage anywhere on an aluminum boom assembly, take hardness readings at intervals of 12 in. (305 mm) or less between the heat-affected areas and compare the results with the manufacturer's specifications for the hardness of the material used for construction of the boom assembly.

**23.9.9.2 Ancillary Boom Ladder.** The ancillary boom ladder shall be inspected as follows:

(1) Inspect the ancillary boom ladder for any defects and the welds for fractures.
(2) Inspect the mounting brackets for loose bolts, weld fractures, or other defects.
(3) (+) Inspect all welds on the ladder and attaching welds.

**23.9.9.3 Guides, Wear Strips and Pads, and Slide Blocks.** Guides, wear strips and pads, and slide blocks shall be inspected for proper installation and signs of wear.

**23.9.9.4 Extension Sheaves.** The extension sheaves shall be inspected as follows:

(1) Inspect the extension sheaves for proper mounting, alignment, and signs of wear.
(2) (+) Inspect all welds of the extension sheave mounting brackets.
(3) (+) Inspect the retaining bolt for internal flaws.

**23.9.9.5*** The aerial extension and retraction cables shall be inspected to verify that the cables are tensioned according to the manufacturer's requirements and inspected to comply with Chapter 5-2 of ASME B30.5, *Mobile and Locomotive Cranes*.

**23.9.9.6 Elevation Indicator.** The elevation cylinder indicator shall be inspected for legibility and clarity.

**23.9.9.7 Maximum Extension Warning Device.** During operation, if the elevating platform is equipped with an audible device that warns of the approach of maximum extension, the device shall be inspected to verify proper operation.

**23.9.9.8 Platform-Leveling Cylinders.** The platform-leveling cylinders shall be inspected as follows:

(1) Inspect the cylinder rod(s) for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seal and the end gland seal for external hydraulic fluid leakage that exceeds the manufacturer's specifications.
(3) Visually inspect the leveling system for proper installation.
(4) Visually inspect the mounting of the leveling system for defects and the welds for fractures.
(5) (+) Inspect all welds for mounting of the leveling system.
(6) (+) Inspect all leveling cylinder pins for any internal flaws.

**23.9.9.9 Hydraulic Lines and Hoses in Boom Assemblies.** All hydraulic lines and hoses in the boom assemblies shall be inspected for hydraulic fluid leakage, abrasions, and any signs of wear.

**23.9.9.10 Extension Cylinder Anchor Ears and Plates.** The extension cylinder anchor ears and plates shall be inspected as follows:

(1) Visually inspect the extension cylinder anchor ears and plates for defects and the attaching welds for fractures.
(2) (+) Inspect the extension cylinder anchor ears and the plate-attaching welds.

**23.9.9.11 Extension Cylinder Pins.** The extension cylinder pins shall be inspected as follows:

(1) Inspect the cylinder pins for proper installation and retention.
(2) (+) Inspect the cylinder pins for internal flaws.

**23.9.9.12 Extension Cylinder.**

**23.9.9.12.1** The extension cylinder shall be inspected as follows:

(1) Inspect the cylinder rods for pitting, scoring, and other defects.
(2) Inspect the cylinder rod-to-barrel seal and the end gland seal for external hydraulic fluid leakage that exceeds the manufacturer's specifications.

**23.9.9.12.2*** The extension cylinder shall be subjected to a drift test as follows:

(1) With the hydraulic fluid at ambient temperature, place the aerial device at full elevation and 10 ft (3 m) of extension.
(2) Mark the cylinder position or the second boom section in relation to the base section.
(3) Allow the elevating platform to stand for 1 hour with the engine off.
(4) Measure the drift, and verify that the results do not exceed the manufacturer's specifications for allowable cylinder drift.

**23.9.9.13 Holding Valves on Extension Cylinder.** The holding valves shall be inspected for external hydraulic fluid leakage.

**23.9.9.14 Pneumatic and Electrical Lines.** All pneumatic and electrical lines in the booms shall be inspected for proper mounting, wear, cracking, kinks, and abrasions.

**23.9.10 Diagnostic Check from Lower Controls.**

**23.9.10.1** With engine speed set to allow maximum speed as permitted by the manufacturer, the elevating platform shall be operated in all positions, as allowed by the manufacturer, using the lower or ground controls.

**23.9.10.2** The operation of the elevating platform shall include, but not be limited to, moving the platform from ground to maximum elevation, as well as rotating the platform 30 degrees and returning to the starting point in the opposite direction while the aerial device is at its maximum horizontal extension.

**23.9.10.3** All safety devices shall operate properly.

**23.9.10.4** All controls shall operate smoothly, return to the neutral position when released, and not bind during operation.

**23.9.10.5** Rollers, slides, and sheave wheels on telescoping elevating platforms shall be checked for proper alignment, function, and free operation.

**23.9.11 Diagnostic Check from Platform Controls.**

**23.9.11.1** With engine speed set to allow maximum speed as permitted by the manufacturer, the elevating platform shall be operated from the platform control station through all posi-

tions, as allowed by the manufacturer, with only the operator on the platform.

**23.9.11.2** The operation of the elevating platform shall include, but not be limited to, moving the platform from ground to maximum elevation, as well as rotating the platform a minimum of 30 degrees and returning to the starting point in the opposite direction while the aerial device is at its maximum horizontal extension.

**23.9.11.3** All safety devices shall operate properly.

**23.9.11.4** The platform deactivation control, from the ground or lower controls, shall be demonstrated to operate properly.

**23.9.11.5** The platform shall level properly as the booms are moved through all allowable positions.

**23.9.11.6** The mechanical override on a hydraulically leveled platform shall operate properly during emergency lowering of the boom without hydraulic power.

**23.9.12 Load Test.**

**23.9.12.1** The aerial apparatus shall be positioned on a hard, level surface with room for unrestricted boom movements.

**23.9.12.2** The stabilizers shall be deployed in accordance with the manufacturer's instructions.

**23.9.12.3** A watch shall be maintained during all load tests for any signs of instability, the development of conditions that could cause damage or permanent deformation, or twist that exceeds the elevating platform manufacturer's allowance.

**23.9.12.3.1** If any of the conditions described in 23.9.12.3 develop, the test shall be discontinued immediately.

**23.9.12.4** The platform shall be placed near the ground and loaded to the elevating platform's rated capacity minus the weight of equipment added to the platform after delivery.

**23.9.12.5** The platform load shall be secured properly.

**23.9.12.6** The unit shall be operated from the lower controls through all allowable phases of operation.

**23.9.12.6.1** The manufacturer's operational limits shall not be exceeded.

**23.9.12.7** Boom movements shall exhibit no abnormal noise, vibration, or deflection.

**23.9.12.8** The platform shall level properly as the booms are moved through all allowable positions.

**23.9.12.9** At the conclusion of the load test, weld joints at the stabilizer structure, stabilizers, frame, main frame, frame reinforcements, turntable, cylinder anchors, boom joints, leveling system, platform, and pivot pin bosses shall be inspected and show no signs of deterioration.

**23.9.13 Operating Test.**

**23.9.13.1** After the load tests have been conducted, a complete test of the elevating platform's operation shall be conducted using the lower or ground controls.

**23.9.13.2** The elevating platform shall be raised out of the bed, extended to its full height, and rotated through a 90-degree turn.

**23.9.13.3*** The procedure specified in 23.9.13.2 shall be completed smoothly and without undue vibration within the time permitted by the edition of NFPA 1901 or NFPA 1900 in effect at the time of manufacture.

**23.9.13.4** After the procedure specified in 23.9.13.2 is completed, the following shall be performed:

(1) Retract the elevating platform.
(2) Complete the turntable rotation through 360 degrees.
(3) Lower the elevating platform to its bed.

**23.9.13.5** During the test, the proper operation of all elevating platform controls shall be verified.

**23.9.13.6** After the procedure specified in 23.9.13.1 through 23.9.13.5 is completed, a thorough inspection shall be made of all moving parts.

**23.9.14 Water System Inspection and Test.**

**23.9.14.1** The waterway system shall be inspected as follows:

(1) Inspect the system for proper operation of all components.
(2) Inspect the system for rust, corrosion, blockage, or other defects.

**23.9.14.2** The waterway-attaching brackets shall be inspected as follows:

(1) Inspect the brackets for loose bolts, weld fractures, or other defects.
(2) (+) Inspect all attaching welds.

**23.9.14.3 Pressure Test.** The water system shall be pressure tested.

**23.9.14.3.1** If the elevating platform has a telescoping boom, the water system shall be tested following the procedures in 23.8.9.4.1 and 23.8.9.4.2.

**23.9.14.3.2*** If the elevating platform has an articulating boom, the water system shall be tested in accordance with 23.9.14.3.2.1 through 23.9.14.3.2.6.

**23.9.14.3.2.1** The boom shall be positioned in the road-travel position.

**23.9.14.3.2.2** If no valve is located at the discharge end of the water system, a valve shall be attached for the purpose of the test.

**23.9.14.3.2.3** The water system shall be filled with water, all air shall be removed from the system, and the valve at the discharge end shall be closed.

**CAUTION:** Failure to remove all air from the water system could result in injury if there is a component failure during the test.

**23.9.14.3.2.4** The pressure on the system shall be raised to the water system manufacturer's maximum rated working pressure and maintained while the elevating platform is raised to its rated vertical height and rotated 360 degrees.

**23.9.14.3.2.5** The water system, including the turntable swivel, shall be checked for leaks.

**23.9.14.3.2.6** Care shall be taken not to overheat the water pump.

**23.9.14.3.3** If the elevating platform has both a telescoping boom and an articulating boom, it shall be tested in accordance with 23.9.14.3.1 and 23.9.14.3.2.

**23.9.14.3.4*** The water system shall operate properly and with an absence of leaks during the pressure test.

**23.9.14.4 Flowmeters.**

**23.9.14.4.1** If the waterway system is equipped with a flowmeter(s), the flowmeter(s) shall be tested at the water system manufacturer's maximum rated water system flow.

**23.9.14.4.2** Any meter that reads off by more than 10 percent shall be recalibrated, repaired, or replaced.

**23.9.14.5 Water Pressure Gauges.**

**23.9.14.5.1** If the waterway system is equipped with a water pressure gauge(s), each water pressure gauge(s) shall be checked for accuracy at a minimum of three points at 50 psi (345 kPa) intervals without exceeding the maximum rated working pressure of the waterway system.

**23.9.14.5.2** Any gauge that reads off by more than 10 psi (70 kPa) shall be recalibrated, repaired, or replaced.

**23.9.14.6 Relief Valve.**

**23.9.14.6.1** If the waterway system is equipped with a relief valve, the relief valve shall be checked to verify that it is operational at the waterway manufacturer's recommended pressure setting.

**23.9.14.6.2*** Any relief valve that fails to operate within 10 psi (70 kPa) of the manufacturer's required setting shall be repaired, recalibrated, or replaced.

**23.9.14.7 Water Curtain System.**

**23.9.14.7.1** The water curtain system control shall be identified for function and direction.

**23.9.14.7.2** The water curtain system shall be inspected for function and operation with a minimum of 100 psi (690 kPa) water pressure to produce a fog pattern.

**23.9.14.7.3** Any device within the system that is found inoperable shall be repaired or replaced.

**23.9.15 Signs.** All signs shall be inspected to verify they are in place and legible.

**23.9.16* Hydraulic Fluid.** After the operating tests have been performed, a sample of the hydraulic fluid shall be removed from the hydraulic reservoir and subjected to spectrochemical analysis, particle count, viscosity check, and water content analysis.

**23.9.17* Records.** A comprehensive record shall be completed for all inspections and tests of the elevating platform and signed by the person responsible for the test.

**23.9.17.1** When the torque verification of mounting bolts is performed as required by this standard, the bolt size, grade, and torque specifications shall be recorded.

**23.9.17.2** When an NDT is conducted, the test record shall indicate the NDT method used in each inspected area.

**23.9.17.3** Where this standard requires measurements to be taken — such as bearing clearance and backlash, cylinder drift, relief pressure, ladder section twist, hardness readings, base rail thickness, extension brake drift, and winch drift — these measurements shall be recorded in the test record so that a year-to-year comparison can be made.

**23.10 Inspecting and Testing Water Towers.**

**23.10.1 General.**

**23.10.1.1** In addition to the manufacturer's recommendations for annual inspections and tests, the inspections and tests detailed in 23.10.2 through 23.10.13 shall be performed.

**23.10.1.2** An inspection preceded by a plus sign (+) indicates that an appropriate NDT shall be conducted as required by 23.1.2.

**23.10.2 Service Records.** The water tower's service records shall be checked for any reports that indicate defective conditions.

**23.10.3 Hydraulic Components.** Hydraulic components shall show no signs of hydraulic fluid leakage.

**23.10.3.1** A component shall be considered to be leaking if hydraulic fluid (oil) droplets are forming on the component.

**23.10.3.2** A film of hydraulic fluid on the component shall not be considered severe enough to categorize the component as leaking.

**23.10.4 Turntable and Torque Box Inspection and Test.** The turntable and torque box components, where applicable, shall be inspected on all water tower apparatus in accordance with 23.8.4.1 through 23.8.4.29.

**23.10.5 Stabilizer Inspection and Test.** The stabilizer components, where applicable, shall be inspected on all water tower apparatus in accordance with 23.8.5.1 through 23.8.5.14.

**23.10.6 Aerial Ladder Inspection and Test.** For a water tower apparatus that is equipped with an aerial ladder, the aerial ladder shall be inspected and tested in accordance with 23.8.6 and 23.8.7.

**23.10.7 Articulating Boom–Lower Boom Inspection and Test.** For a water tower apparatus that is equipped with an articulating boom, the lower boom shall be inspected and tested in accordance with 23.9.7.1 through 23.9.7.6 and 23.9.7.8 through 23.9.7.14, as applicable.

**23.10.8 Articulating Boom–Upper Boom Inspection and Test.** For a water tower apparatus that is equipped with an articulating boom, the upper boom shall be inspected and tested in accordance with 23.9.8.1 and 23.9.8.3 through 23.9.8.15, as applicable.

**23.10.9 Telescoping Boom Inspection and Test.** For a water tower apparatus that is equipped with a telescoping boom, the boom shall be inspected and tested in accordance with 23.9.7.10 through 23.9.7.14, 23.9.9.1 through 23.9.9.7, and 23.9.9.9 through 23.9.9.14, as applicable.

**23.10.10 Operating Test.**

**23.10.10.1** After starting the engine, setting the stabilizers, and transmitting power to the water tower, the water tower shall be fully elevated out of the bed, rotated 90 degrees, and fully extended.

**23.10.10.2*** The procedure specified in 23.10.10.1 shall be completed smoothly and without undue vibration within the

time permitted by the edition of NFPA 1901 or NFPA 1900 in effect at the time of manufacture.

**23.10.10.3** After completing the procedure specified in 23.10.10.1, the following shall be performed:

(1) Retract the water tower.
(2) Complete the turntable rotation through 360 degrees.
(3) Lower the water tower to its bed and inspect all moving parts.

**23.10.10.4** The test shall demonstrate successful operation of all water tower controls.

**23.10.11 Water System Inspection and Test.**

**23.10.11.1** The waterway system shall be inspected as follows:

(1) Inspect the system for proper operation of all components.
(2) Inspect the system for rust, corrosion, blockage, or other defects.

**23.10.11.2** The waterway-attaching brackets shall be inspected as follows:

(1) Inspect the brackets for loose bolts, weld fractures, or other defects.
(2) (+) Inspect all attaching welds.

**23.10.11.3** The water system shall be pressure tested.

**23.10.11.3.1** If the water tower has a telescoping boom, the water system shall be tested following the procedures in 23.8.9.4.1 and 23.8.9.4.2.

**23.10.11.3.2** If the water tower has an articulating boom, the water system shall be tested following the procedure in 23.9.14.3.2.

**23.10.11.3.3** If the water tower has both a telescoping boom and an articulating boom, it shall be tested in accordance with 23.10.11.3.1 and 23.10.11.3.2.

**23.10.11.3.4*** The water system shall operate properly and with an absence of leaks during the pressure test.

**23.10.11.4 Flowmeters.**

**23.10.11.4.1** If the waterway system is equipped with a flowmeter(s), the flowmeter(s) shall be tested at the water system manufacturer's maximum rated water system flow.

**23.10.11.4.2** Any meter that reads off by more than 10 percent shall be recalibrated, repaired, or replaced.

**23.10.11.5 Water Pressure Gauges.**

**23.10.11.5.1** If the waterway system is equipped with a water pressure gauge(s), each water pressure gauge(s) shall be checked for accuracy at a minimum of three points at 50 psi (345 kPa) intervals without exceeding the maximum rated working pressure of the waterway system.

**23.10.11.5.2** Any gauge that reads off by more than 10 psi (70 kPa) shall be recalibrated, repaired, or replaced.

**23.10.11.6 Relief Valve.**

**23.10.11.6.1** If the waterway system is equipped with a relief valve, the relief valve shall be checked to verify that it is operational at the waterway manufacturer's recommended pressure setting.

**23.10.11.6.2** Any relief valve that fails to operate within 10 psi (70 kPa) of the manufacturer's required setting shall be repaired, recalibrated, or replaced.

**23.10.12 Signs.** All signs shall be inspected to verify that they are in place and legible.

**23.10.13* Hydraulic Fluid.** After the operating tests have been performed, a sample of the hydraulic fluid shall be removed from the hydraulic reservoir and subjected to spectrochemical analysis, particle count, viscosity check, and water content analysis.

**23.10.14* Records.** A comprehensive record shall be completed for all inspections and tests of the water tower and signed by the person responsible for the test.

**23.10.14.1** When the torque verification of mounting bolts is performed as required by this standard, the bolt size, grade, and torque specifications shall be recorded.

**23.10.14.2** When an NDT is conducted, the test record shall indicate the NDT method used in each inspected area.

**23.10.14.3** Where this standard requires measurements to be taken — such as bearing clearance and backlash, cylinder drift, relief pressure, ladder section twist, hardness readings, base rail thickness, extension brake drift, and winch drift — these measurements shall be recorded in the test record so that a year-to-year comparison can be made.

## Chapter 24 Performance Testing of Foam Proportioning Systems (NFPA 1911)

**24.1 General.** If the apparatus is equipped with a foam proportioning system, a test shall be performed to determine if the foam proportioning system is capable of delivering foam solution at a concentrate setting established for the agent(s) used.

**24.1.1** At a minimum, the foam proportioning system shall be tested annually.

**24.1.2** Prior to the foam proportioner system test, all foam system components shall be inspected in accordance with Chapter 12.

**24.2 Performance Level.** The foam proportioner system shall be operated at the proportioning ratio specified by the AHJ and at the water flow and pressure for the agent(s) employed.

**24.2.1** The system output shall be measured to determine calibration accuracy.

**24.2.2** The system shall be operated at the same proportioning ratio, water flow, and pressure each time the system is tested.

**24.3* Testing Methods.** One of the following four methods for testing a foam proportioning system for calibration accuracy shall be used:

(1) Substituting water for foam concentrate
(2) Measuring foam concentrate pump output directly
(3) Determining foam percentage by use of a refractometer
(4) Determining foam percentage by use of a conductivity meter

**24.4 Multiple Concentrate Systems.** If the apparatus is equipped with multiple foam concentrates, the system shall be tested with each concentrate being carried.

**24.5 Accuracy Level.** Foam proportioner system accuracy shall meet the minimum requirements in effect at the time the proportioner system was installed.

## Chapter 25 Performance Testing of Compressed Air Foam Systems (CAFS) (NFPA 1911)

**25.1 General.** If the apparatus is equipped with a compressed air foam system (CAFS), a test shall be performed to determine if the compressed air system is capable of delivering the manufacturer's maximum recommended airflow at rated pressures.

**25.2 Frequency.** At a minimum, the compressed air system for CAFS shall be tested annually.

**25.3 Inspection.** Prior to testing the compressed air system for CAFS, all system components shall be inspected in accordance with Chapter 13.

**25.4 Test Method.**

**25.4.1** All tests shall be conducted using either a calibrated airflow meter in conjunction with a standard cubic feet per minute (SCFM) flow chart, or a fixed orifice flowmeter in conjunction with various size of orifices to test the flow volume in SCFM *(see Table 25.4.1 for volume in SCFM for different orifice sizes and psi loss).*

**25.4.2** Test procedures shall be as follows:

(1) Run the compressed air system at the CAFS manufacturer's recommended maximum airflow at 125 psi (862 kPa) for 20 minutes.
(2) Record the airflow, air pressure, and compressor temperature at start up and in 5 minute increments.
(3) Record the maximum air pressure developed by the compressed air system.
(4) Connect one 100 ft (30 m), 1½ in. (38 mm) or smaller hoseline to a CAFS discharge and stretch it out on level ground.
(5) Secure the nozzle end of the hoseline to a stationary object with rope, with straps, or in some other manner such that when the nozzle is opened as specified in 25.4.2(10) the operator is protected from nozzle movement.
(6) Engage the water pump and establish a 125 psi (862 kPa) pump pressure, but do not charge the hoseline with water.
(7) Maintain the water temperature in the pump by circulating pump water through the water tank.
(8) Ensure that air pressure and water pressure are within ±10 percent.
(9) Fill the hoseline with compressed air.
(10) Slowly (no faster than in 3 seconds, and no slower than in 10 seconds) open the nozzle until it is no more than one-quarter open.
(11) Check to ensure that the air pressure and water pressure are within ±10 percent of the original set point.
(12) Close the nozzle.
(13) Continue to operate the air and water system for 5 minutes.
(14) Check to see that the water pressure and air pressure remain within ±10 percent of the original set point.

**25.4.3** If the CAFS does not maintain the water pressure and air pressure within ±10 percent of the original set point, or if the air compressor temperature exceeds the manufacturer's

**Table 25.4.1 Volume of Air in Standard Cubic Feet per Minute (SCFM)**

| Pressure Loss Across Orifice (psi) | Orifice Diameter (in.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1/64 | 1/32 | 1/16 | 1/8 | 1/4 | 3/8 | 1/2 | 5/8 | 3/4 | 7/8 | 1 |
| 5 | 0.062 | 0.249 | 0.993 | 3.97 | 15.9 | 35.7 | 63.5 | 99.3 | 143 | 195 | 254 |
| 7 | 0.073 | 0.293 | 1.17 | 4.68 | 18.7 | 42.2 | 75.0 | 117 | 168 | 260 | 300 |
| 9 | 0.083 | 0.331 | 1.32 | 5.30 | 21.2 | 47.7 | 84.7 | 132 | 191 | 260 | 339 |
| 12 | 0.095 | 0.379 | 1.52 | 6.07 | 24.3 | 54.6 | 97.0 | 152 | 218 | 297 | 388 |
| 15 | 0.105 | 0.420 | 1.68 | 6.72 | 26.9 | 60.5 | 108 | 168 | 242 | 329 | 430 |
| 20 | 0.123 | 0.491 | 1.96 | 7.86 | 31.4 | 70.7 | 126 | 196 | 283 | 385 | 503 |
| 25 | 0.140 | 0.562 | 2.25 | 8.98 | 35.9 | 80.9 | 144 | 225 | 323 | 440 | 575 |
| 30 | 0.158 | 0.633 | 2.53 | 10.1 | 40.5 | 91.1 | 162 | 253 | 365 | 496 | 648 |
| 35 | 0.176 | 0.703 | 2.81 | 11.3 | 45.0 | 101 | 180 | 281 | 405 | 551 | 720 |
| 40 | 0.194 | 0.774 | 3.10 | 12.4 | 49.6 | 112 | 198 | 310 | 446 | 607 | 793 |
| 45 | 0.211 | 0.845 | 3.38 | 13.5 | 54.1 | 122 | 216 | 338 | 487 | 662 | 865 |
| 50 | 0.229 | 0.916 | 3.66 | 14.7 | 58.6 | 132 | 235 | 366 | 528 | 718 | 938 |
| 60 | 0.264 | 1.06 | 4.23 | 16.9 | 67.6 | 152 | 271 | 423 | 609 | 828 | 1082 |
| 70 | 0.300 | 1.20 | 4.79 | 19.2 | 76.7 | 173 | 307 | 479 | 690 | 939 | 1227 |
| 80 | 0.335 | 1.34 | 5.36 | 21.4 | 85.7 | 193 | 343 | 536 | 771 | 1050 | 1371 |
| 90 | 0.370 | 1.48 | 5.92 | 23.7 | 94.8 | 213 | 379 | 592 | 853 | 1161 | 1516 |
| 100 | 0.406 | 1.62 | 6.49 | 26.0 | 104 | 234 | 415 | 649 | 934 | 1272 | 1661 |
| 110 | 0.441 | 1.76 | 7.05 | 28.2 | 113 | 254 | 452 | 705 | 1016 | 1383 | 1806 |
| 120 | 0.476 | 1.91 | 7.62 | 30.5 | 122 | 274 | 488 | 762 | 1097 | 1494 | 1951 |
| 130 | 0.494 | 1.98 | 7.90 | 31.6 | 126 | 284 | 503 | 790 | 1138 | 1549 | 2023 |

Notes:
(1) SCFM = 0.028 standard cubic meters per minute (SCMM); 1 psi = 6.895 kPa; 1 in. = 25.40 mm.
(2) Values calculated based on dry air at atmospheric pressure of 14.7 psi (101.4 kPa), 70°F (21°C).

limit during the test, the test shall be stopped and considered a failure.

## Chapter 26 Performance Testing of Line Voltage Electrical Systems (NFPA 1911)

**26.1 General.** If the fire emergency vehicle is equipped with a line voltage electrical system, the system and components shall be tested as required by this chapter.

**26.2* Frequency.** Performance tests shall be conducted at least annually, unless otherwise noted, and whenever major repairs or modifications to the line voltage electrical system or any component of the system have been made.

**26.3 Power Source Testing.**

**26.3.1** The line voltage power source shall be tested annually except when the full load test in Section 26.7 is performed.

**26.3.2** The power source shall be tested at between 50 percent and 100 percent of the limit specified in 26.3.3.

**26.3.2.1** The test shall be performed using the electrical loads typically carried on the emergency vehicle, with additional loads if necessary.

**26.3.2.2** The test shall be permitted to be conducted using a load bank.

**26.3.3** The total electrical load applied shall not exceed the continuous rating as specified on the power source specification label, or the power source nameplate rating if there is no power source specification label.

**26.3.4** The power source shall be run for a minimum of 10 minutes under the test load specified in 26.3.2.

**26.3.5** The voltage, frequency, and load shall be measured and recorded at the following times:

(1) At the beginning of the test under no load conditions
(2) After the test load has been applied
(3) After 10 minutes under test load
(4) At the end of the test when the test load has been removed

**26.3.5.1** If the power source has a minimum turn-on load threshold, the conditions specified in 26.3.5(1) and 26.3.5(4) shall include sufficient load to exceed the minimum turn-on load threshold.

**26.3.6** The voltage shall be within ±10 percent of the rated voltage at all points throughout the test.

**26.3.7** The frequency shall be within ±3 Hz of the rated frequency at all points throughout the test.

**26.4 Receptacle Wiring.**

**26.4.1*** The polarity of the wiring, the ground continuity, and the neutral bonding or isolation of all 120-volt outlets shall be tested, including receptacles on the body, cord reels, and aerial device.

**26.4.1.1*** If the neutral conductor is bonded to the vehicle frame, the testing shall be done with a tester that verifies that the hot and neutral wires are connected to the correct receptacle pins and that the ground is connected.

**26.4.1.2*** If the neutral is not bonded to the vehicle frame, the testing shall be done with the power off using a continuity tester or ohmmeter to verify that both of the current-carrying conductors are isolated from the vehicle body and frame, and that the protective ground is connected to the vehicle body and frame.

**26.4.2*** Any receptacle that can be powered both from an on-board power source and from a shore line shall be tested both ways.

**26.4.3** Duplex receptacles shall be tested in each receptacle.

**26.5* GFCI Testing.** If the wiring system or any appliances on the emergency vehicle incorporate ground fault circuit interrupters (GFCIs), they shall be operationally checked in accordance with this section.

**26.5.1** All GFCIs shall be checked, whether they are integrated into receptacles or circuit breakers or they are separate devices.

**26.5.2** The operational check shall verify the following:

(1) That the integrated test button trips the GFCI
(2) That the reset button restores the GFCI
(3)* That the GFCI trips when a ground fault is simulated with an external tester

**26.6* Line Voltage Equipment Testing.**

**26.6.1*** All line voltage equipment on the emergency vehicle shall be run for a minimum of 10 minutes.

**26.6.2** The testing shall include, but not be limited to, the following components:

(1) Light towers
(2) Permanently wired lights
(3) Electric motors
(4) Fixed wired appliances
(5) Receptacles (each individual receptacle if in multiples), fixed cords, and cord reels each loaded to at least 50 percent of the rating of the circuit breaker for that circuit

**26.6.3*** All equipment shall operate properly without arcing, failure, or excessive heating.

**26.7 Full Load Test of Power Source.**

**26.7.1** The full load test of the power source shall be performed at least every 5 years.

**26.7.2*** The test load shall be at least 95 percent of the power source specification label rating, if present, or otherwise be at least 80 percent of the nameplate rating label.

**26.7.3** If the emergency vehicle is equipped with a fire pump, during the power source test, the fire pump shall be running at the pressures and flows specified in 22.7.8.

**26.7.4 Test Procedure.** The power source shall be tested as follows:

(1) Start the power source with no load; measure and record the voltage and frequency. If the power source has a minimum turn-on load threshold, apply sufficient load to exceed the minimum turn-on threshold for this step.

(2) Load the power source to 50 percent ±10 percent of the load specified in 26.7.2; measure and record the voltage and frequency.
(3) Load the power source to the load specified in 26.7.2; measure and record the voltage and frequency.
(4) Operate the power source for 40 minutes; measure and record the voltage and frequency at the start of operation and every 10 minutes thereafter.
(5) Unload the power source to 50 percent ±10 percent of the load specified in 26.7.2; measure and record the voltage and frequency.
(6) Completely unload the power source; measure and record the voltage and frequency. If the power source has a minimum turn-on load threshold, apply sufficient load to exceed the minimum turn-on load threshold for this step.

**26.7.4.1** The voltage shall be within ±10 percent of the rated voltage at all points throughout the test.

**26.7.4.2** The frequency shall be within ±3 Hz of the rated frequency at all points throughout the test.

## Chapter 27 Performance Testing of Aircraft Rescue and Firefighting (ARFF) Vehicle Water Pumps

### 27.1 Combined Discharge Test.

**27.1.1** A stopwatch shall be used for time measurement.

**27.1.2** The ARFF vehicle's water system shall be fully operational with all preconnected handlines deployed.

**27.1.3** The ARFF vehicle's water supply shall be supplied by the onboard storages.

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

(1) Fill the water tank completely with water.
(2) Set the manual relief valve, if equipped, to the recommended OEM pressure.
(3) Verify the system will maintain a set pressure.
(4) Check the piping system for leaks.
(5) Set the agent system to operate in water mode, set the system pressure for optimum performance, and engage the pump.
(6) Initiate discharge through all turrets, ground sweeps, and preconnected handlines and under truck nozzles until all are discharging simultaneously in a straight stream.
(7) As each nozzle is turned on, observe the range along with the system pressure.
(8) Test the extendable turret in both fully bedded and fully vertically extended positions.
(9) Continue discharging until the system pressure has stabilized with all nozzles discharging.

**27.1.5** The system pressure shall maintain the recommended pressure as prescribed by the vehicle OEMs during all discharging.

### 27.2 Discharge Rate Calculation.

#### 27.2.1 Primary Turret.

**27.2.1.1** A stopwatch shall be required for this test.

**27.2.1.2** The agent system shall be fully operational.

**27.2.1.2.1** The agent system pressure shall be set in accordance with the manufacturer's recommendations.

**27.2.1.2.2** The water tank shall be filled completely.

**27.2.1.3** The test shall be conducted as follows:

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

**27.2.1.4** The average measured discharge rate shall comply with the nominal discharge rate specified.

#### 27.2.2 Bumper Turret.

**27.2.2.1** A stopwatch shall be required for this test.

**27.2.2.2** The agent system shall be fully operational.

**27.2.2.2.1** The agent system pressure shall be set in accordance with the manufacturer's recommendations.

**27.2.2.2.2** The water tank shall be filled completely.

**27.2.2.3** The test shall be conducted as follows:

(1) Simultaneously initiate discharge through the bumper turret 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.
(3) Record the elapsed time.
(4) Divide the rated water tank capacity, in gallons (liters), by the elapsed discharge time to determine the average discharge rate.

**27.2.2.4** The average measured discharge rate shall comply with the nominal discharge rate specified.

#### 27.2.3 Handline.

**27.2.3.1** A stopwatch shall be required for this test.

**27.2.3.2** The agent system shall be fully operational.

**27.2.3.2.1** The agent system pressure shall be set in accordance with the manufacturer's recommendations.

**27.2.3.2.2** The water tank shall be filled completely.

**27.2.3.3** The test shall be conducted as follows:

(1) Simultaneously initiate discharge through the handline 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.
(3) Record the elapsed time.
(4) Divide the rated water tank capacity, in gallons (liters), by the elapsed discharge time to determine the average discharge rate.

**27.2.3.4** The average measured discharge rate shall comply with the nominal discharge rate specified.

**27.3 Discharge Distances.** All discharge distances shall comply with Table 4.2.1.2(c) or Table 4.2.1.2(d) of NFPA 1900.

## Chapter 28 Performance Testing of Breathing Air Compressor Systems (NFPA 1911)

**28.1 General.**

**28.1.1** If the emergency vehicle is supplied with a breathing air compressor system, the compressor system shall be tested annually by the manufacturer or the manufacturer's authorized representative to verify that the system still meets the manufacturer's requirements for the system when it was new.

**28.1.2** If the manufacturer of the breathing air compressor system is no longer in business and therefore is not available to test the system, the system shall be tested using accepted industry practices by a service company that has experience with high-pressure breathing air systems.

**28.2 Air Quality.**

**28.2.1** The quality of air produced by the breathing air compressor system shall be tested in accordance with NFPA 1989 following completion of the annual test.

**28.2.2** If the annual test of the breathing air compressor system is conducted at the same time that the system is serviced as required by 15.1.1, a single test of the air quality shall be permitted following both the servicing and testing.

**28.3 Records.** Records shall be maintained of all annual testing of the breathing air compressor system.

## Chapter 29 General Requirements (NFPA 1912)

**29.1 Administration.**

**29.1.1* Scope.** Chapters 29 through 31 specify the minimum requirements for the refurbishing of automotive fire apparatus utilized for firefighting and rescue operations, whether the refurbishing is done at the fire department or municipal maintenance facilities, or at the facilities of private contractors or apparatus manufacturers.

**29.1.2 Purpose.** Chapters 29 through 31 specify the minimum requirements for the refurbishing of automotive fire/rescue apparatus, to ensure that any apparatus refurbished in accordance with this standard meets applicable motor vehicle regulations and applicable portions of the appropriate edition of the NFPA automotive fire apparatus standard.

**29.1.2.1** Apparatus that receives a Level I refurbishing is intended to meet the requirements of the applicable chapters of NFPA 1900.

**29.1.2.2** Apparatus that receives a Level II refurbishing is intended to meet the appropriate NFPA automotive fire apparatus standard in effect when the apparatus was originally constructed.

**29.1.3 Application.**

**29.1.3.1** This standard is applicable to fire apparatus contracted for refurbishing on or after January 1, 2024; however, nothing shall prevent the use of the standard prior to January 1, 2024, if the purchaser and contractor agree. The standard is not intended to be applied retroactively.

**29.1.3.2** This standard shall not apply to the repair of fire apparatus.

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

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

**29.1.4.2** The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

**29.1.5* Units of Measure.** In this standard, values for measurement in US units are followed by an equivalent in metric units. Either set of values can be used but the same set of values (either US units or metric units) shall be used consistently.

**29.2* General.**

**29.2.1** Fire apparatus receiving Level I refurbishing shall meet the requirements of the applicable chapters of NFPA 1900, except as noted in Chapter 30.

**29.2.2** Fire apparatus receiving Level II refurbishing shall meet the requirements of applicable chapters of the edition of the NFPA automotive fire apparatus standard that was in effect at the time of its original manufacture, except as noted in Chapter 31.

**29.3* Responsibility of Purchaser.** It shall be the responsibility of the purchaser to specify the details of the fire apparatus refurbishing; its required performance, including where operations at elevations above 2000 ft (600 m) or on grades greater than 6 percent are required; the maximum number of firefighters to ride within the apparatus; specific added continuous electrical loads that exceed the minimum of this standard; and any hose, ground ladders, or equipment to be carried by the apparatus that exceed the minimum requirements of this standard.

**29.4 Responsibility of the Contractor.**

**29.4.1*** The contractor shall provide a detailed description of the refurbished fire apparatus, a list of equipment to be furnished, and other construction and performance details to which the apparatus is to conform.

**29.4.2*** Responsibility for the fire apparatus and equipment shall remain with the contractor until such responsibilities are accepted by the purchaser.

**29.5 Fire Apparatus Components.** All components shall be installed in accordance with that component manufacturer's installation instructions.

**29.5.1 Fire Pump.** If the fire apparatus is equipped with a new fire pump, the pump and its associated equipment shall meet the requirements for fire pumps in NFPA 1900.

**29.5.2 Auxiliary Pump.** If the fire apparatus is equipped with a new auxiliary pump, the pump and its associated equipment shall meet the requirements for auxiliary pumps in NFPA 1900.

**29.5.3 Wildland Water Pump.** If the fire apparatus is equipped with a new wildland water pump, the pump and its associated equipment shall meet the requirements for wildland water pumps in NFPA 1900.

**29.5.4 Water Tank.** If the fire apparatus is equipped with a new water tank, the water tank shall meet the requirements for water tanks in the applicable chapter of NFPA 1900.

**29.5.5 Aerial Device.** If the fire apparatus is equipped with a new aerial device (i.e., aerial ladder, elevating platform, or water tower), the aerial device shall meet the requirements for aerial devices in NFPA 1900.

**29.5.6 Foam Proportioning System.** If the fire apparatus is equipped with a new foam proportioning system, the apparatus shall meet the requirements for foam proportioning systems in the applicable chapter of NFPA 1900.

**29.5.7 Compressed Air Foam System.** If the fire apparatus is equipped with a new compressed air foam system, the system shall meet the requirements for compressed air foam systems in the applicable chapter of NFPA 1900.

**29.5.8 Line-Voltage Electrical System.** If the fire apparatus is equipped with a new line-voltage electrical system or components, the system or components shall meet the requirements for line-voltage electrical systems in NFPA 1900.

**29.5.9 Command and Communications.** If the fire apparatus is equipped with a new command and communications area, the area shall meet the requirements for command and communications areas in NFPA 1900.

**29.5.10 Air System.** If the fire apparatus is equipped with a new air system, the system shall meet the requirements for air systems in NFPA 1900.

**29.5.11 Winch System.** If the fire apparatus is equipped with a new winch system, the system shall meet the requirements for winches in the applicable chapter of NFPA 1900.

**29.6 Chassis Components.** Each component shall be installed in accordance with that component manufacturer's installation instructions.

**29.6.1 Engine.** If the fire apparatus is equipped with a new engine, the system shall meet the requirements for engines in the applicable chapter of NFPA 1900.

**29.6.2 Transmission/Transfer Case.** If the fire apparatus is equipped with a new transmission or transfer case, the component(s) shall meet the requirements for transmissions or transfer cases in the applicable chapter of NFPA 1900.

**29.6.3 Braking System.** If the fire apparatus is equipped with a new braking system, the system shall meet the requirements for braking systems in the applicable chapter of NFPA 1900.

**29.6.4 Axle(s).** If the fire apparatus is equipped with a new axle(s), the component(s) shall meet the requirements for axles in the applicable chapter of NFPA 1900.

**29.6.5 Suspension, Wheels, and Tires.** If the fire apparatus is equipped with new suspension, wheels, or tires, the component(s) shall meet the requirements for new suspension, wheels, or tires in the applicable chapter of NFPA 1900.

**29.6.6 Cooling System.** If the fire apparatus is equipped with a new cooling system, the system shall meet the requirements for cooling systems in the applicable chapter of NFPA 1900.

**29.6.7 Low-Voltage Electrical System.** If the fire apparatus is equipped with a new low-voltage electrical system or components, the system or components shall meet the requirements for low-voltage electrical systems in the applicable chapter of NFPA 1900.

**29.6.8 Frame.** If the fire apparatus is equipped with a new chassis frame, the frame shall meet the requirements for chassis frames in the applicable chapter of NFPA 1900.

**29.6.9 Driveline.** If the fire apparatus is equipped with a new driveline, the components shall meet the requirements for drivelines in the applicable chapter of NFPA 1900.

**29.6.10 Lubrication System.** If the fire apparatus is equipped with a new lubrication system, the system shall meet the requirements for lubrication systems in the applicable chapter of NFPA 1900.

**29.6.11 Fuel and Air System.** If the fire apparatus is equipped with a new fuel and air system, the system shall meet the requirements for fuel and air systems in the applicable chapter of NFPA 1900.

**29.6.12 Exhaust System.** If the fire apparatus is equipped with a new exhaust system, the system shall meet the requirements for exhaust systems in the applicable chapter of NFPA 1900.

**29.6.13 Driving and Crew Compartment.** If the fire apparatus is equipped with a new driving and crew compartment, the assembly shall meet the requirements for driving and crew compartments in the applicable chapter of NFPA 1900.

**29.7 Governmental Requirements.** The fire apparatus shall comply with all applicable federal and state motor vehicle laws and regulations.

**29.8 Personnel Protection.**

**29.8.1*** Guards, shields, or other protection shall be added to refurbished fire apparatus where necessary to prevent injury to personnel by hot, moving, or rotating parts during normal nonmaintenance operations.

**29.8.2** Electrical insulation or isolation shall be provided where necessary to prevent electrical shock from onboard electrical systems.

**29.8.3** Vehicular workmanship shall ensure a safe operating environment free of accessible sharp projections and edges.

**29.8.4*** Safety signs with text shall conform to the general principles of ANSI/NEMA Z535.4, *Product Safety Signs and Labels*. Safety signs without text shall conform to the general principles for two-panel safety signs of ISO 9244, *Earth-moving machinery — Machine safety labels — General principles.* [**1900:**7.10.4]

**29.8.4.1** Apparatus built for sale in the United States shall employ safety signage that complies with ANSI/NEMA Z535.4. [**1900:**7.10.4.1]

**29.8.4.2** Apparatus built for sale outside the United States shall employ safety signage that complies with either ANSI/NEMA Z535.4 or ISO 9244. [**1900:**7.10.4.2]

**29.9* Carrying Capacity.** The GAWR and GCWR or GVWR of the chassis shall be adequate to carry the weight of the fire apparatus when loaded to its estimated in-service weight as defined in 29.9.2.

**29.9.1** The contractor shall establish the estimated in-service weight during the design of the work to be done in refurbishing the fire apparatus.

**29.9.2** The estimated in-service weight shall include the following:

(1) The chassis, body, and tank(s)
(2) Full fuel, lubricant, and other chassis or component fluid tanks or reservoirs
(3) Full water and other agent tanks
(4)* 200 lb (90 kg) in each seating position
(5) 70 lb (32 kg) for each seating position for personal gear unless specified as not applicable
(6) Fixed equipment such as pumps, aerial devices, generators, reels, and air systems as installed
(7) Ground ladders, suction hose, designed hose load in their hose beds and on their reels
(8) An allowance for miscellaneous equipment as provided by the purchaser

**29.9.3** The contractor shall engineer and design the work that will occur to the fire apparatus during the refurbishment such that the completed apparatus, when loaded to its estimated in-service weight, with all movable weights distributed as close as practicable to their intended in-service configuration, does not exceed the gross vehicle weight rating (GVWR).

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

**29.9.4.1** For each category of equipment listed in 29.9.4.5, the purchaser shall specify what equipment the contractor needs to supply and install.

**29.9.4.2** For each category of equipment listed in 29.9.4.5, the purchaser shall specify what purchaser-supplied equipment the contractor needs to install.

**29.9.4.3*** For each category of equipment listed in 29.9.4.5, the purchaser shall specify what accommodations such as space, power, and antenna bases the contractor needs to provide to support purchaser-installed equipment.

**29.9.4.4** For each category of equipment listed in 29.9.4.5, the purchaser shall specify if no equipment needs to be supplied or installed, or if there are no accommodations that need to be provided.

**29.9.4.5** The purchaser shall provide the information identified in 29.9.4.1 through 29.9.4.4 for the following:

(1) Radio communication equipment
(2) Mobile data terminals or other computer equipment
(3) Traffic preemption equipment
(4)* Vehicle data recorder (VDR)
(5)* Vehicle to everything (V2X) communications

## Chapter 30 Level I Refurbishing (NFPA 1912)

**30.1* General.** Fire apparatus refurbished to Level I standards shall meet the requirements of the applicable chapter of NFPA 1900 unless specified otherwise in this chapter.

**30.2* Carrying Capacity.** If a fire apparatus system or component is to be upgraded, the contractor shall ensure that the completed apparatus does not exceed the GAWR and GCWR, or GVWR, of the chassis when carrying the estimated in-service weight of the unequipped apparatus as defined in 29.9.2.

**30.3 Vehicle Stability.**

**30.3.1** When the apparatus is loaded to its estimated in-service weight, the height of the vehicle's center of gravity shall not exceed the chassis manufacturer's maximum limit.

**30.3.2** When the apparatus is loaded to its estimated in-service weight, the front-to-rear weight distribution on the vehicle shall be within the limits set by the chassis manufacturer.

**30.3.3** Front axle loads shall not be less than the minimum axle loads specified by the chassis manufacturer, under full load and all other loading conditions.

**30.3.4*** The fire apparatus, when loaded to its estimated in-service weight, shall have a side-to-side tire load variation of no more than 7 percent of the total tire load for that axle.

**30.3.5*** 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 as an alternative to tilt table testing, or in circumstances where the vehicle is unable to meet tilt table requirements in accordance with NFPA 1900.

**30.4 Frame.** The fire apparatus frame shall be replaced with a new chassis frame meeting the requirements of the applicable chapter of NFPA 1900.

**30.5 Drivetrain.**

**30.5.1** If the original drivetrain or associated components are used, the contractor shall perform a thorough inspection of the drivetrain components not scheduled for replacement (such as the drive shaft, end yokes or flanges, universal joints, and associated mountings) for wear, balance, stress cracks, or other damage.

**30.5.2** The contractor shall notify the purchaser in writing of any damage discovered during the inspection.

**30.5.3** If a new drivetrain or associated components are installed, the contractor shall certify that the installation meets the component manufacturer's recommendations.

**30.6 Engine and Engine System Design.**

**30.6.1** If the original engine and accessories are used, the contractor shall perform a thorough inspection of the engine and related accessories including, but not limited to, mountings, fan belts, and filters.

**30.6.1.1** The inspection shall check for wear, fluid leaks, loss of power, and other potential problems.

**30.6.1.2** The contractor shall notify the purchaser in writing of all necessary repairs and services needed to bring the engine and related accessories within the engine manufacturer's original specifications.

**30.6.1.3** All belts and filters shall be replaced.

**30.6.2*** If the existing engine and/or engine system is to be replaced, it shall be replaced with one that meets the requirements of the applicable chapter of NFPA 1900.

**30.6.2.1** The contractor shall furnish certification that the engine meets Environmental Protection Agency (EPA) standards that were in effect at the time of contract signing as well as certification that the installation meets the engine manufacturer's specifications.

**30.7 Cooling System.**

**30.7.1** If the original cooling system is to be reused, the contractor shall perform a thorough inspection of the cooling system for leaks, blockages, wear, or other problems that could affect vehicle engine cooling.

**30.7.1.1** The contractor shall notify the purchaser in writing of any problems discovered during the inspection.

**30.7.1.2** The cooling system shall be flushed and refilled with new coolant meeting the engine manufacturer's specifications.

**30.7.2** If the cooling system is to be replaced, it shall be replaced with one that meets the requirements of the applicable chapter of NFPA 1900, as well as the engine manufacturer's specifications.

**30.8 Lubrication System.**

**30.8.1** If the original lubrication system is to be reused, the contractor shall perform a thorough inspection of the lubrication system for leaks, blockages, or other problems that could affect vehicle lubrication.

**30.8.1.1** The contractor shall notify the purchaser in writing of any problems discovered during the inspection.

**30.8.2** If the lubrication system is to be replaced, it shall be replaced with one that meets the requirements of the applicable chapter of NFPA 1900, and the engine manufacturer's standards.

**30.9 Fuel and Air Systems.** The fire apparatus fuel and air intake systems shall be replaced with new fuel and air intake systems that meet the requirements of the applicable chapter of NFPA 1900, and the engine manufacturer's standards.

**30.10 Exhaust System.** The original fire apparatus exhaust system shall be replaced with a new exhaust system that meets the requirements of the applicable chapter of NFPA 1900, and the engine manufacturer's standards.

**30.11 Vehicle Components.**

**30.11.1 Braking System.**

**30.11.1.1** The contractor shall certify that the braking system meets the performance requirements of the applicable chapter of NFPA 1900.

**30.11.1.2** When a new braking system or brake components are installed, the contractor shall certify that the installation meets the component manufacturer's requirements.

**30.11.1.3** Parking brakes shall control the rear wheels, or all wheels, and be of the positive, mechanically actuated type.

**30.11.1.3.1*** When the fire apparatus, as delivered, is loaded to its GVWR or GCWR, if applicable, the parking brake system shall hold the apparatus on at least a 20 percent grade.

**30.11.1.3.2** A lockup device to retain applied pressure on hydraulically actuated service brake systems, or the use of the "park" position on an automatic transmission shall not be substituted for a separate parking brake system.

**30.11.1.3.3** Parking brakes on steerable axles of tiller vehicles shall be provided where necessary to meet the requirements of this standard.

**30.11.1.3.4** Air-applied brakes or mechanically actuated brakes shall be acceptable on steerable axles of tiller vehicles.

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

**30.11.2 Suspension, Wheels, and Tires.**

**30.11.2.1** The suspension system shall be replaced with a new suspension system that meets the requirements of the applicable chapter of NFPA 1900.

**30.11.2.2*** If the existing axle(s), wheels, or tires are utilized, the contractor shall inspect and verify the condition of these components for continued use in emergency service.

**30.11.2.2.1** Damaged components shall be repaired or replaced.

**30.11.2.3** The contractor shall certify that the axles, wheels, and tires of the completed fire apparatus meet all current federal and state GVWR, GCWR, and GAWR requirements.

**30.11.2.4 Angle of Approach and Departure.**

**30.11.2.4.1** If the non–wildland fire apparatus is being refurbished to NFPA 1900, an angle of approach and an angle of departure of at least 8 degrees shall be maintained at the front and rear of the vehicle when it is loaded to its GVWR or GCWR, if applicable.

**30.11.2.4.2** If the wildland fire apparatus is being refurbished to NFPA 1900, an angle of approach and an angle of departure of at least 20 degrees shall be maintained at the front and rear of the vehicle when it is loaded to its GVWR or GCWR, if applicable.

**30.11.3 Steering.** The fire apparatus steering system shall be replaced with a new steering system that meets the requirements of the applicable chapter of NFPA 1900.

**30.11.4 Transmission/Transfer Case.**

**30.11.4.1** If either the original transmission or the transfer case is reused, the contractor shall inspect the transmission or transfer case, its mountings, and any associated accessories for wear, damage, and fluid leaks.

**30.11.4.1.1** The contractor shall notify the purchaser in writing of any problems discovered during the inspection.

**30.11.4.1.2** All fluids and filters shall be changed.

**30.11.4.2** In the event a new or refurbished transmission or transfer case is installed in the fire apparatus, the contractor shall certify that the installation meets the transmission or transfer case manufacturer's specifications for installation on that specific type of apparatus.

**30.11.5 Fuel Tank.** The fire apparatus fuel tank shall be replaced with a new tank that meets the requirements of the applicable chapter of NFPA 1900.

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

**30.12 Low-Voltage Electrical Systems and Warning Devices.** The fire apparatus electrical wiring system and warning devices shall be replaced with a complete new system that meets the requirements of the applicable chapter of NFPA 1900.

**30.13* Driving and Crew Compartments.** The fire apparatus driving and crew compartments shall be replaced with new driving and crew compartments that meet the requirements of the applicable chapter of NFPA 1900, and the chassis manufacturer's standards.

**30.14 Body, Compartmentation, and Hose Storage.**

**30.14.1** If the original fire apparatus body is to be reused, it shall be inspected for serviceability and upgraded to meet the requirements of the applicable chapter of NFPA 1900.

**30.14.2** If the fire apparatus body, compartmentation, and hose storage areas are to be replaced, they shall be replaced with components that meet the requirements of the applicable chapter of NFPA 1900.

**30.14.3** If new compartments are to be added to an existing fire apparatus body, they shall meet the requirements of the applicable chapter of NFPA 1900.

**30.14.4*** The fire apparatus shall comply with the requirements for metal finish in the applicable chapter of NFPA 1900, including the application of reflective striping.

**30.15 Fire Pump and Associated Equipment.**

**30.15.1** If the original fire pump is reused, the contractor shall inspect the fire pump, its mountings, and its associated accessories for wear, damage, and leaks.

**30.15.2** The contractor shall notify the purchaser in writing of any problems discovered during the inspection.

**30.15.3** All new or upgraded parts or components shall meet the requirements of the applicable chapter of NFPA 1900.

**30.15.4** The pump packing shall be adjusted according to the pump manufacturer's recommendations.

**30.16 Water Tanks.**

**30.16.1** If the existing water tank is to be reused, the contractor shall inspect the water tank for serviceability and report any defects to the purchaser in writing.

**30.16.2*** If a new water tank is installed, it shall meet the requirements of the applicable chapter of NFPA 1900.

**30.16.2.1** Installation of a new water tank shall not result in the completed fire apparatus exceeding the GAWR and GCWR or GVWR of the chassis under the conditions specified in Section 30.2.

**30.17 Aerial Devices.**

**30.17.1** If the original aerial device is to be used, a full inspection and test as defined in Chapter 11 and Chapter 23 shall be performed.

**30.17.1.1** A test shall be performed prior to refurbishing to determine the condition of the aerial device.

**30.17.2** If the original aerial device is reused, it shall meet the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.17.3** After the aerial device upgrade has been completed, a full inspection and test as defined in Chapter 11 and Chapter 23 shall be performed.

**30.18 Equipment Carried on Fire Apparatus.**

**30.18.1** If new ground ladders are furnished, they shall meet the requirements of NFPA 1931.

**30.18.1.1** Stepladders and other types of multipurpose ladders meeting ANSI A14.2, *Ladders — Portable Metal — Safety Requirements*, or ANSI A14.5, *Ladders — Portable Reinforced Plastic — Safety Requirements*, with duty ratings of Type 1A or 1AA shall be permitted to be substituted for a folding ladder.

**30.18.1.2** Stepladders and other types of multipurpose ladders shall be permitted to be carried in addition to the minimum fire department ground ladders specified in NFPA 1900 if they meet the requirements of either ANSI A14.2 or ANSI A14.5 with duty ratings of Type 1A or 1AA.

**30.18.2** If new hose is furnished, it shall meet the requirements of NFPA 1961.

**30.18.3** If new nozzles are furnished, they shall meet the requirements of NFPA 1964.

**30.19 Tests and Delivery Data Requirements.**

**30.19.1 Fire Apparatus Certification Tests.**

**30.19.1.1** If the refurbished fire apparatus is equipped with a fire pump that has a rated capacity of 750 gpm (3000 L/min) or greater, the pump system shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus.

**30.19.1.1.1** The tests shall be conducted at the contractor's approved facility and certified by an independent testing organization approved by the purchaser.

**30.19.1.1.2** The certification shall include at least the tests defined in 30.19.2 through 30.19.6.

**30.19.1.1.3** If the apparatus is equipped with a water tank, the water tank-to-pump flow test defined in 30.19.7 shall be included.

**30.19.1.2** If the refurbished fire apparatus is equipped with a fire pump that has a rated capacity of less than 750 gpm (3000 L/min), the pump shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus.

**30.19.1.2.1** The tests shall be conducted at the contractor's approved facility and certified by the contractor.

**30.19.1.2.2** The certification shall include at least the tests defined in 30.19.2 and 30.19.4 through 30.19.6.

**30.19.1.2.3** If the apparatus is equipped with a water tank, the water tank-to-pump flow test defined in 30.19.7 shall be included.

**30.19.2 Pumping Tests.** A pumping certification test shall be conducted in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**30.19.3 Pumping Engine Overload Test.**

**30.19.3.1** If a new fire pump with a capacity of 750 gpm (3000 L/min) or greater but less than 3000 gpm (12,000 L/min) is installed, a pumping engine overload test shall be conducted in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**30.19.3.2** If the original fire pump is retained or reused, a pumping engine overload test shall be conducted in accordance with the test requirements of the NFPA automotive fire apparatus standard that was in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.19.4 Pressure Control System Test.**

**30.19.4.1** If the refurbished fire apparatus is equipped with a new pressure control system on the fire pump, it shall be tested in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**30.19.4.2** If the original pressure control system is retained or reused, it shall be tested in accordance with the pressure control device testing requirements of the applicable chapter of this standard.

**30.19.5 Priming System Test.**

**30.19.5.1** If the refurbished fire apparatus is equipped with a new priming system on the fire pump, it shall be tested in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**30.19.5.2** If the original priming system is retained or reused, it shall be tested in accordance with the priming system test requirements of the applicable chapter of this standard.

**30.19.6 Vacuum Test.**

**30.19.6.1** If the refurbished fire apparatus is equipped with a new fire pump, a vacuum test shall be conducted in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**30.19.6.2** If the original fire pump is retained or reused, a vacuum test shall be conducted in accordance with the test requirements of the applicable chapter of this standard.

**30.19.7 Water Tank-to-Pump Flow Test.**

**30.19.7.1** If the refurbished fire apparatus has a new water tank(s), fire pump(s), or pump piping, a water tank-to-pump flow test shall be conducted in accordance with the test requirements in the applicable chapter of NFPA 1900.

**30.19.7.2** If the original water tank(s), pump(s), and pump piping is retained or reused, a water tank-to-pump flow test shall be conducted to ensure the installation meets the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.19.8 Engine Speed Advancement Interlock Test.** An engine speed advancement interlock test meeting the test requirements in the applicable chapter of NFPA 1900 shall be conducted.

**30.19.9 Aerial Device Certification Tests.** If a new or reutilized aerial device is installed on the refurbished fire apparatus, the completed apparatus shall be tested at the manufacturer's approved facility and certified by an independent testing organization approved by the purchaser.

**30.19.9.1** New aerial devices shall be tested in accordance with NFPA 1900.

**30.19.9.2** Reutilized aerial devices shall be tested to the NFPA automotive fire apparatus standard in effect at the time of the original aerial device manufacture.

**30.19.10 Refurbisher's Pre-Delivery Tests.**

**30.19.10.1 Water Tank Capacity Test.** If the refurbished fire apparatus has a new water tank, the water tank manufacturer shall certify the capacity of the water tank and provide the certification to the purchaser when the apparatus is delivered.

**30.19.10.1.1** If the refurbished fire apparatus retains or reuses the original water tank, the tank shall be tested to ensure it meets the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.19.10.2 Piping Hydrostatic Test.**

**30.19.10.2.1** If the refurbished fire apparatus has a new fire pump or pump piping system, a piping hydrostatic test shall be conducted in accordance with the test requirements in the applicable chapter of NFPA 1900.

**30.19.10.2.2** If the refurbished fire apparatus retains or reuses the original pump(s) and pump piping, a piping hydrostatic test shall be conducted to ensure the integrity of the piping installation meets the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.19.10.3 Electrical System Tests.** Electrical system tests shall be conducted on all refurbished fire apparatus in accordance with the test requirements in the applicable chapter of NFPA 1900.

**30.19.10.4* Foam System Tests.**

**30.19.10.4.1** If the refurbished fire apparatus has a newly installed foam system or system components, the system shall be tested in accordance with the test requirements in the applicable chapter of NFPA 1900.

**30.19.10.4.2** If the refurbished fire apparatus reuses the original foam systems and system components, the system shall be tested to ensure it meets the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.19.11* Road Tests.**

**30.19.11.1** If the refurbished fire apparatus has any upgraded powertrain components (i.e., engine, transmission, driveline, or axles), it shall be road tested in accordance with 30.19.11.3 through 30.19.11.8.

**30.19.11.2** If the refurbished fire apparatus reuses all of the original powertrain components (engine, transmission, driveline, and axles), it shall be tested to ensure it meets the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**30.19.11.3** The tests shall be conducted at a location and in a manner that does not violate local, state, or federal traffic laws.

**30.19.11.4** The fire apparatus shall be loaded to its estimated in-service weight.

**30.19.11.4.1** The tests shall be conducted on dry, level, paved roads that are in good condition.

**30.19.11.4.2** The engine shall not be operated in excess of the maximum governed speed.

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

**30.19.11.5.1** The vehicle shall attain a speed of 35 mph (55 km/hr) from a standing start within 25 seconds.

**30.19.11.5.2** The vehicle shall attain a minimum top speed of not less than 50 mph (80 km/hr).

**30.19.11.6** If the fire apparatus is equipped with an auxiliary braking system, the manufacturer shall road test the system to confirm that the system is functioning as intended by the auxiliary braking system manufacturer.

**30.19.11.7** If the apparatus is equipped with an air brake system, the service brakes shall bring the apparatus, when loaded to its GVWR, to a complete stop from an initial speed of 20 mph (32.2 km/hr), in a distance not exceeding 35 ft (10.7 m) by actual measurement on a paved, level, dry surface road that is free of loose material, oil, or grease.

**30.19.11.8** If the apparatus is equipped with a hydraulic brake system, the service brakes shall bring the apparatus, when loaded to its GVWR, to a complete stop from an initial speed of 30 mph (48.2 km/hr), in a distance not exceeding 88 ft (26.8 m) by actual measurement on a paved, level, dry surface road that is free of loose material, oil, or grease.

**30.19.12 Tests on Delivery.**

**30.19.12.1 Acceptance Tests.**

**30.19.12.1.1** If acceptance tests are required at the point of delivery, the purchaser shall specify the details of the tests to be performed.

**30.19.12.1.2** Acceptance tests shall not be performed in a manner that requires the apparatus or a component to operate outside its designed operating range.

**30.19.12.2** Aerial device stability tests shall not be run at other than the refurbisher's or the aerial device manufacturer's facility.

**30.20 Data Required of the Contractor.**

**30.20.1** The contractor shall supply, at the time of delivery, at least two copies of complete operation, service, and parts manuals covering the completed fire apparatus as delivered and accepted.

**30.20.1.1** This requirement shall be permitted to be adjusted to cover only manuals for those new components or systems that are changed from the original configuration.

**30.20.1.2** The requirement for either complete or partial manuals shall be supplied by the purchasing authority.

**30.20.2** The contractor shall supply at least one copy of the following at the time of delivery:

(1) Engine manufacturer's certified brake horsepower curve for a new engine installation showing the maximum governed speed
(2) Contractor's record of fire apparatus refurbishing, including, if applicable, all technical information required for inspection for compliance with Chapters 1 through 28
(3) Pump manufacturer's certification of suction capabilities for new pump installations
(4) Pump manufacturer's certification of hydrostatic test for new pump installations
(5) Certification of inspection and test
(6) If the apparatus is equipped with a pump, a copy of the chassis manufacturer's approval for stationary pumping applications
(7) Weight documents from a certified scale showing actual loading on the front axle, rear axle(s), and overall vehicle (with the water tank full but without personnel, equipment, and hose) to determine compliance with Section 29.9
(8) The latest edition of FAMA's *Fire Apparatus Safety Guide*

**30.20.3** A label shall be affixed to the vehicle certifying that the vehicle is in compliance with all applicable Federal Motor Vehicle Safety Standards (FMVSS) in effect at the time of completion.

**30.20.4** If the original fire pump is replaced with a new fire pump, a new test label shall be provided on the pump operator's panel.

**30.20.4.1** The new test label shall provide the following information:

(1) The rated discharges and pressures, together with the speed of the engine, as determined by the certification test for each unit
(2) The position of the parallel–series pump, as used
(3) The governed speed of the engines, as stated by the engine manufacturer on a certified brake horsepower curve

**30.20.4.2** The test label shall be stamped with complete information at the contractor's facility and attached to the vehicle prior to delivery.

**30.21 Safety Signs.** The contractor shall ensure that the following safety signs, as appropriate to the apparatus type and features and as described and located in accordance with FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*, are on the apparatus prior to delivery:

(1) FAMA01 — Battery Explosion
(2) FAMA02 — Rotating Shafts
(3) FAMA05 — Spinning Fan
(4) FAMA06 — Seats Without Belts Not Occupied
(5) FAMA07 — Seated and Belted
(6) FAMA10 — Cab Equipment Mounting
(7) FAMA12 — Fire Service Tire Rating
(8) FAMA14 — Cab Seating
(9) FAMA15 — Helmet Worn in Cab (Structural Apparatus)
(10) FAMA17 — Vehicle Backing
(11) FAMA18 — Intake and Discharge Cap Pressure
(12) FAMA22 — Hose Restraint Required
(13) FAMA23 — Access Step Method
(14) FAMA24 — Riding on Exterior
(15) FAMA25 — Trained Personnel Only — NFPA Required
(16) FAMA26 — No-Step
(17) FAMA28 — Rope Tie-Down 9000
(18) FAMA30 — Stabilizer Crush
(19) FAMA31 — Stabilizer Pins & Pads
(20) FAMA32 — Stabilizer Pads
(21) FAMA34 — Fall Restraint Required
(22) FAMA35 — Aerial Electrocution
(23) FAMA36 — Aerial Electrocution
(24) FAMA37 — Aerial Device Load Capacity
(25) FAMA38 — Aerial Ladder Rung Pinch
(26) FAMA39 — Aerial Inspection
(27) FAMA41 — Cab Tilt

(28) FAMA42 — Siren Noise
(29) FAMA43 — Helmet Worn in Cab (Wildland Apparatus)
(30) FAMA44 — Pump-and-Roll Firefighting Position — Exterior
(31) FAMA45 — Pump-and-Roll Firefighting Position — Driver
(32) FAMA46 — Aerial Device Pinch
(33) FAMA47 — Aerial Device Operator Attention Required

## Chapter 31 Level II Refurbishing (NFPA 1912)

**31.1* General.** All new or upgraded components utilized in Level II refurbishing shall meet the requirements of the applicable chapters of NFPA 1900, unless otherwise specified in this chapter.

**31.1.1** The purchaser shall specify which components and systems are to be upgraded.

**31.1.2** Any upgraded system shall be compatible with its associated components.

**31.1.3** Systems or components that are not compatible shall not be installed on the refurbished fire apparatus.

**31.2* Carrying Capacity.** If a fire apparatus system or component is to be upgraded, the contractor shall ensure that the refurbished apparatus does not exceed the GAWR and GCWR, or GVWR, of the chassis when carrying the estimated in-service weight of the unequipped apparatus as defined in 29.9.2.

**31.3* Vehicle Stability.**

**31.3.1*** When the apparatus is loaded to its estimated in-service weight, the height of the vehicle's center of gravity shall not exceed the chassis manufacturer's maximum limit.

**31.3.2*** When the apparatus is loaded to its estimated in-service weight, the front-to-rear weight distribution on the vehicle shall be within the limits set by the chassis manufacturer.

**31.3.3** Front axle loads shall not be less than the minimum axle loads specified by the chassis manufacturer, under full load and all other loading conditions.

**31.3.4*** The fire apparatus, when loaded to its estimated in-service weight, shall have a side-to-side tire load variation of no more than 7 percent of the total tire load for that axle.

**31.4 Frame.**

**31.4.1** If the apparatus' frame is to be upgraded, all parts of the frame not scheduled to be replaced shall be inspected for wear, broken or loose bolts or other fittings, bent or damaged members, or other problems.

**31.4.2** The contractor shall notify the purchaser in writing of any problems or abnormal conditions discovered during the inspection.

**31.5 Drivetrain.**

**31.5.1** If the apparatus drivetrain is to be upgraded, the contractor shall inspect all components of the drivetrain not scheduled to be replaced for wear, balance, stress cracks, or other damage.

**31.5.1.1** The inspection shall include the drive shaft, end yokes or flanges, universal joints, and associated mountings.

**31.5.1.2** The contractor shall notify the purchaser in writing of any damaged components or other problems discovered during the inspection.

**31.5.2** If a new drivetrain or associated components are installed or existing components are modified, the contractor shall ensure that the installation meets the component manufacturer's recommendations.

**31.6 Engine and Engine System Design.**

**31.6.1*** If the engine or an engine system component(s) is upgraded, the contractor shall inspect the engine and all related accessories that are not scheduled to be replaced for wear, fluid leaks, loss of power, excessive smoke, or other potential problems.

**31.6.1.1** The contractor shall notify the purchaser in writing of all necessary repairs and services needed to bring the engine and related accessories within applicable manufacturers' specifications.

**31.6.1.2** All belts and filters shall be replaced.

**31.6.2*** If the existing engine or engine system is to be replaced, it shall be replaced with one that meets or exceeds the requirements of the NFPA automotive fire apparatus standard that was in effect at the time the apparatus was manufactured.

**31.6.2.1** The contractor shall furnish certification that the engine meets or exceeds the EPA standards that were in effect at the time of the original apparatus construction, as well as certification that the installation meets the engine manufacturer's requirements.

**31.7 Cooling System.**

**31.7.1** If the cooling system or any related component(s) are to be upgraded, the contractor shall inspect all portions of the cooling system that are not scheduled to be replaced for leaks, blockages, wear, and other conditions that could affect the cooling of the vehicle's engine.

**31.7.1.1** The contractor shall notify the purchaser in writing of any problems or abnormal conditions discovered during the inspection.

**31.7.1.2** The cooling system shall be flushed and refilled with new coolant that meets the engine manufacturer's requirements.

**31.7.2** If the cooling system or cooling system components are upgraded, the contractor shall certify that the upgraded cooling system meets the requirements of the applicable chapter of NFPA 1900 and the engine manufacturer.

**31.7.3** The upgraded engine cooling system shall maintain a temperature in the engine at or below the engine manufacturer's maximum temperature rating under all conditions of operation for which the fire apparatus is designed.

**31.8 Lubrication System.**

**31.8.1** If the lubrication system or any related component(s) is to be upgraded, the contractor shall inspect all portions of the lubrication system that are not scheduled to be replaced for leaks, wear, and other problems that could affect the performance of the system.

**31.8.2** The contractor shall notify the purchaser in writing of any problems or abnormal conditions discovered during the inspection.

**31.8.3** The upgraded lubrication system shall meet the engine manufacturer's requirements.

**31.9 Fuel and Air Systems.**

**31.9.1** If the fuel system or air intake system is to be upgraded, the contractor shall inspect all portions of the system not scheduled to be replaced for leaks, wear, and other problems that could affect the performance of the system.

**31.9.2** The contractor shall notify the purchaser in writing of any problems or abnormal conditions discovered during the inspection.

**31.9.3** The contractor shall certify that the upgraded fuel system or air intake system meets the requirements of the applicable chapter of NFPA 1990 and the engine manufacturer.

**31.10 Exhaust System.**

**31.10.1** If the exhaust system components are to be upgraded, the contractor shall inspect all portions of the system that are not scheduled to be replaced for leaks, loose hangers, rusted tubing, wear, and other problems that could affect the performance of the exhaust system.

**31.10.2** The contractor shall notify the purchaser in writing of any problems or abnormal conditions discovered during the inspection.

**31.10.3** The contractor shall certify that the upgraded exhaust system meets the requirements of the applicable chapter of NFPA 1900 and the engine manufacturer.

**31.11 Vehicle Components.**

**31.11.1 Braking System.**

**31.11.1.1*** If the braking system is to be upgraded, the contractor shall inspect all portions of the braking system and associated accessories that are not scheduled to be replaced for wear, leakage, loss of performance, and other problems that could affect the performance of the braking system.

**31.11.1.1.1** The contractor shall notify the purchaser in writing of any problems or abnormal conditions found during the inspection.

**31.11.1.2*** If a new braking system or new brake components are installed, the installation shall meet the manufacturers' recommendations.

**31.11.1.3** The contractor shall certify that the braking system meets or exceeds the performance requirements of the edition of the NFPA automotive fire apparatus standard in effect at the time of contract signing for the original manufacture of the apparatus.

**31.11.2 Suspension, Wheels, and Tires.**

**31.11.2.1*** If the suspension, wheels, or tires are to be upgraded, the contractor shall inspect the axles, wheels, tires, springs, hangers, mountings, and suspension system accessories that are not scheduled to be replaced for wear, stress cracks, sagging, improper bolt torque, and other problems.

**31.11.2.2** The contractor shall notify the purchaser in writing of any damaged components or other problems that are discovered during the inspection.

**31.11.2.3** The manufacturer shall certify that the upgraded suspension, wheels, and tires of the fire apparatus meet all applicable component manufacturers' standards as well as all GVWR, GCWR, and GAWR ratings.

**31.11.2.4** The refurbished apparatus shall meet all applicable federal and state weight ratings.

**31.11.2.5*** When the fire apparatus, as delivered, is loaded to its GVWR or GCWR, if applicable, the parking brake system shall hold the apparatus on at least a 20 percent grade.

**31.11.3 Steering.**

**31.11.3.1** If the steering system is to be upgraded, the contractor shall inspect the entire system, including the steering box, steering gear, drag links, power steering pump, hose, and accessories that are not scheduled to be replaced for wear, leakage, loss of performance, and other problems.

**31.11.3.2** The contractor shall notify the purchaser in writing of any damaged components or other problems that are discovered during the inspection.

**31.11.3.3** The contractor shall certify that the upgraded steering system meets the requirements of the applicable chapter of NFPA 1900 and the component manufacturer.

**31.11.3.4** The upgraded steering system shall be capable of turning the front wheels to an angle of at least 30 degrees to either the right or left for nondriving front axles, and at least 28 degrees for driving front axles.

**31.11.3.5** Power steering or power-assisted steering shall be provided.

**31.11.4 Transmission/Transfer Case.**

**31.11.4.1** If either the transmission or the transfer case is to be upgraded, the contractor shall inspect all components of the transmission or transfer case, their mountings, and the associated accessories that are not scheduled to be replaced for wear, damage, and fluid leaks.

**31.11.4.1.1** All fluid levels and filters shall be checked.

**31.11.4.1.2** The contractor shall notify the purchaser in writing of any damaged components or other problems that are discovered during the inspection.

**31.11.4.2** If an upgraded transmission is installed in the fire apparatus, the contractor shall certify that the installation meets the transmission manufacturer's specifications for installation in the specific type of apparatus, as well as the requirements of the applicable chapter of NFPA 1900.

**31.11.5 Fuel Tank.**

**31.11.5.1** If the fuel tank is to be upgraded, the contractor shall inspect all components of the fuel tank, its mountings, and associated accessories that are not scheduled to be replaced for wear, damage, and fluid leaks.

**31.11.5.2** The contractor shall notify the purchaser in writing of any damaged components or other problems that are discovered during the inspection.

**31.11.5.3** Fuel tanks that need replacing shall be replaced with new tanks that meet the requirements of the applicable chapter of NFPA 1900.

**31.11.6* Tow Hooks.** If upgraded front or rear tow hooks or tow eyes are installed on the fire apparatus, they shall be attached to the frame structure to allow towing (not lifting) of the apparatus without damage.

**31.12 Low-Voltage Electrical Systems and Warning Devices.**

**31.12.1* General.** Any upgraded 12 V or 24 V electrical systems or warning devices installed on the fire apparatus shall be appropriate for the service intended and meet the specific requirements of Section 31.12.

**31.12.2*** If the low-voltage electrical system is upgraded, the contractor shall inspect the components of the electrical system not scheduled to be replaced for problems that could affect the vehicle's electrical performance.

**31.12.2.1** The inspection shall include the condition of wires, connectors, relays, fuses, and/or circuit breakers and related components.

**31.12.2.2** The contractor shall notify the purchaser in writing of any damaged components or problems that are discovered during the inspection.

**31.12.3 Power Supply.**

**31.12.3.1** If the alternator is to be upgraded, it shall be replaced by a 12 V or 24 V alternator.

**31.12.3.2** The alternator shall have a minimum output at idle to meet the minimum continuous electrical load of the fire apparatus as defined in 31.12.3.3 at 200°F (93°C) ambient temperature within the engine compartment and be provided with full automatic regulation.

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

(1) The propulsion engine and transmission
(2) All legally required clearance and marker lights, headlights, and other electrical devices except windshield wipers and four-way hazard flashers
(3) The radio(s) at a duty cycle of 10 percent transmit and 90 percent receive (for calculation and testing purposes, a default value of 5 A continuous)
(4) If the fire apparatus is not a wildland fire apparatus, the lighting necessary to produce 1 fc (10 lx) of illumination on all walking surfaces on the apparatus and on the ground at all egress points off of the apparatus, 5 fc (50 lx) of illumination on all control and instrument panels, and 50 percent of the total compartment lighting loads.
(5) The minimum optical warning system required where the apparatus is blocking 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

**31.12.3.4 Load Management.**

**31.12.3.4.1*** If the total connected electrical load of the upgraded low-voltage electrical system exceeds the minimum continuous electrical output rating of the installed alternator(s) operating under the conditions specified in 31.12.3.2, an automatic electrical load management system shall be required.

**31.12.3.4.2** The minimum continuous electrical load defined in 31.12.3.3 shall not be subject to automatic load management.

**31.12.4* Optical Warning Devices.** If the optical warning devices are to be upgraded, the contractor shall inspect the components of the optical warning system that are not scheduled to be replaced for problems that could affect the vehicle's warning devices.

**31.12.4.1** The inspection shall include the condition of wires, connectors, relays, fuses and/or circuit breakers, motors, lenses, and related components.

**31.12.4.2** The contractor shall notify the purchaser in writing of any problems or discrepancies that are discovered during the inspection.

**31.12.5 Audible Warning Devices.**

**31.12.5.1** Audible warning equipment in the form of at least one automotive traffic horn and one electric or electronic siren shall be provided.

**31.12.5.2** A means shall be provided to allow the activation of the siren within convenient reach of the driver.

**31.12.5.3** If upgraded or additional air horns, electric siren(s), or electronic siren speaker(s) are installed, they shall be mounted as low and as far forward on the fire apparatus as practicable.

**31.12.5.4** Upgraded or additional audible warning equipment shall not be mounted on the roof of the apparatus.

**31.13* Driving and Crew Compartments.**

**31.13.1** If the driving and/or crew compartment(s) is to be upgraded, the contractor shall inspect the driving and crew compartments, their mountings, and associated accessories for wear, damage, and corrosion.

**31.13.1.1** The contractor shall notify the purchaser in writing of any damaged components that are discovered during the inspection.

**31.13.2*** If a new driving and/or crew compartment is installed, it shall be a fully enclosed design that meets the requirements of the applicable chapter of NFPA 1900.

**31.13.2.1** The driving compartment shall have a seating capacity for a minimum of two firefighters except as permitted by 31.13.2.1.1.

**31.13.2.1.1** At a tiller driving position, the driving compartment shall be permitted to have a seating capacity for at least one person.

**31.13.2.2** The driving and crew compartments shall have a combined seating capacity at least equal to the maximum number of persons expected to ride within the fire apparatus *(See Section 29.2.)*

**31.13.3** If the new driving and/or crew compartment is of a tilt-up design, it shall be arranged so that all the manufacturer's recommended routine maintenance checks of lubricant and

fluid levels can be performed easily by the operator without raising the driving and/or crew compartment and without the need for hand tools.

**31.13.4** After installation of the new driving and/or crew compartment, airflow through the radiator shall be sufficient to comply with the cooling system requirements as defined in 31.7.3.

**31.13.5 Fully Enclosed Crew Compartment Conversions.** If an existing two-door open canopy–style crew compartment is converted into a fully enclosed crew compartment, the added-on portion of the crew compartment shall comply with all applicable requirements of NFPA 1900.

**31.14 Body, Compartmentation, and Hose Storage.**

**31.14.1** If the body, compartmentation, or hose storage areas are to be upgraded, the contractor shall inspect all portions of the body, compartmentation, or hose storage areas that are not scheduled to be replaced for wear, damage, and corrosion.

**31.14.1.1** The contractor shall notify the purchaser in writing of any damaged components that are discovered during the inspection.

**31.14.2*** If a new body, compartmentation, or hose storage area is installed, it shall meet the requirements of the applicable chapter of NFPA 1900.

**31.14.3** If additional compartments are added to an existing body, they shall meet the requirements of the applicable chapter of NFPA 1900.

**31.14.4 Metal Finish.**

**31.14.4.1** The fire apparatus, when refinished, shall comply with the requirements for metal finish in the applicable chapter of NFPA 1900, including the application of reflective striping.

**31.14.4.2** If the metal finish is to be upgraded, all exposed ferrous metal surfaces that are not plated or stainless steel shall be cleaned, prepared, and painted or coated.

**31.14.4.2.1** The paint or coating, including any primer, shall be applied in accordance with the paint or coating manufacturer's recommendations.

**31.14.4.2.2** The purchaser shall specify whether nonferrous body components are to be painted and any lettering, numbering, or decorative striping to be furnished.

**31.15 Fire Pump and Associated Equipment.** If the fire pump or associated equipment is to be upgraded, the contractor shall inspect all portions of the fire pump, its mountings, and any associated accessories that are not scheduled to be replaced for wear, damage, and leaks.

**31.15.1** The contractor shall notify the purchaser in writing of any damaged components or other problems that are discovered during the inspection.

**31.15.2** All upgraded parts or components shall be compatible with the original fire pump.

**31.15.3** The fire pump packing shall be adjusted to the pump manufacturer's recommended tolerances.

**31.16 Water Tank.**

**31.16.1** If the existing water tank is to be reused, the contractor shall inspect the tank for serviceability and report any defects to the purchaser in writing.

**31.16.2*** If a new water tank is installed, it shall meet the requirements of the applicable chapter of NFPA 1900.

**31.16.3** Installation of a new water tank shall not result in the refurbished apparatus exceeding the GAWR and GCWR or GVWR of the chassis under the conditions specified in Section 31.2.

**31.17 Aerial Devices.**

**31.17.1** If the aerial device is to be upgraded, the contractor shall inspect all components of the aerial device, its mountings, controls, and associated accessories that are not scheduled to be replaced for wear, damage, corrosion, and other deficiencies.

**31.17.1.1** The contractor shall notify the purchaser in writing of any damaged components or other problems that are discovered during the inspection.

**31.17.1.2** All new or replacement parts or components shall be compatible with the design of the original aerial device and meet the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.17.2** If a replacement aerial device is installed, the new device shall meet the requirements of NFPA 1900 and be certified as such by the contractor.

**31.17.3** After the aerial device upgrade has been completed, a full inspection and test as defined in Chapters 1 through 28 shall be performed.

**31.18 Equipment Carried on the Fire Apparatus.**

**31.18.1** If new ground ladders are furnished, they shall meet the requirements of NFPA 1931.

**31.18.1.1** Stepladders and other types of multipurpose ladders meeting ANSI A14.2, *Ladders — Portable Metal — Safety Requirements*, or ANSI A14.5, *Ladders — Portable Reinforced Plastic — Safety Requirements*, with duty ratings of Type 1A or 1AA shall be permitted to be substituted for a folding ladder.

**31.18.1.2** Stepladders and other types of multipurpose ladders shall be permitted to be carried in addition to the minimum fire department ground ladders specified in NFPA 1900 if they meet the requirements of either ANSI A14.2 or ANSI A14.5 with duty ratings of Type 1A or Type 1AA.

**31.18.2** If new hose is furnished, it shall meet the requirements of NFPA 1961.

**31.18.3** If new nozzles are furnished, they shall meet the requirements of NFPA 1964.

**31.19 Tests and Delivery Data Requirements.**

**31.19.1 Pump Certification Tests.**

**31.19.1.1** If the refurbished fire apparatus is equipped with a new or upgraded fire pump that has a rated capacity of 750 gpm (3000 L/ min) or greater, the pump system shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus.

**31.19.1.1.1** The tests shall be conducted at the contractor's approved facility and certified by an independent testing organization that is approved by the purchaser.

**31.19.1.1.2** The certification shall include at least the tests defined in 31.19.2 through 31.19.6.

**31.19.1.1.3** If the apparatus is equipped with a water tank, the water tank-to-pump flow test as defined in 31.19.7 shall be included in the certification.

**31.19.1.2** If the refurbished fire apparatus is equipped with a new or upgraded fire pump that has a rated capacity of less than 750 gpm (3000 L/min), the pump system shall be tested after the pump and all its associated piping and equipment have been installed on the apparatus.

**31.19.1.2.1** The tests shall be conducted at the manufacturer's approved facility and certified by the contractor.

**31.19.1.2.2** The certification shall include at least the tests defined in 31.19.2 and 31.19.4 through 31.19.6.

**31.19.1.2.3** If the apparatus is equipped with a water tank, the water tank-to-pump flow test as defined in 31.19.7 shall be included in the certification.

**31.19.1.3** If the refurbished fire apparatus is equipped with an existing fire pump that is neither upgraded nor replaced, the pump shall be tested after the refurbishing is complete.

**31.19.1.3.1** The tests shall be conducted at the manufacturer's approved facility and certified by the contractor.

**31.19.1.3.2** The certification shall include at least the tests defined in 31.19.2 and 31.19.4 through 31.19.6.

**31.19.1.3.3** If the apparatus is equipped with a water tank, the water tank-to-pump flow test as defined in 31.19.7 shall be included in the certification.

**31.19.2 Pumping Tests.**

**31.19.2.1** If the refurbished fire apparatus is equipped with a new or upgraded fire pump, the pumping test shall be conducted in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**31.19.2.2** If the original fire pump is retained, the pumping test shall be conducted in accordance with the test requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.19.3 Pumping Engine Overload Test.**

**31.19.3.1** If the refurbished fire apparatus is equipped with a new or upgraded fire pump, a pumping engine overload test meeting the test requirements in the applicable chapter of NFPA 1900 shall be conducted.

**31.19.3.2** If the refurbished fire apparatus retains its original pump(s), a pumping engine overload test shall be conducted in accordance with the test requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.19.4 Pressure Control Device Test.**

**31.19.4.1** If the refurbished fire apparatus is equipped with a new or upgraded pressure control device on the fire pump, the pressure control device shall be tested in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**31.19.4.2** If the original pressure control device is retained and work has been done on it or it has not been tested within the last 12 months, it shall be tested in accordance with the pressure control system test requirements of Chapters 1 through 28.

**31.19.5 Priming System Test.**

**31.19.5.1** If the refurbished fire apparatus is equipped with a new or upgraded priming system on the fire pump, the priming system shall be tested in accordance with the test requirements defined in the applicable chapter of NFPA 1900.

**31.19.5.2** If the original priming system is retained and work has been done on it or it has not been tested within the last 12 months, it shall be tested in accordance with the priming system test requirements of Chapters 1 through 28.

**31.19.6 Vacuum Test.**

**31.19.6.1** If the refurbished fire apparatus has a new or upgraded fire pump or pump piping, a vacuum test shall be conducted in accordance with the test requirements in the applicable chapter of NFPA 1900.

**31.19.6.2** If the original fire pump and pump piping are retained and work has been done on them or they have not been tested within the last 12 months, a vacuum test shall be conducted in accordance with the vacuum test requirements of Chapters 1 through 28.

**31.19.7 Water Tank-to-Pump Flow Test.**

**31.19.7.1** If the refurbished apparatus has a new or upgraded water tank(s), pump(s), or pump piping, a water tank-to-pump flow test shall be conducted in accordance with the test requirements in the applicable chapter of NFPA 1900.

**31.19.7.2** If the original water tank(s), pump(s), and pump piping are reused and they have been worked on or they have not been tested within the last 12 months, a water tank-to-pump flow test shall be conducted in accordance with the water tank-to-pump flow test requirements of Chapters 1 through 28.

**31.19.8 Engine Speed Advancement Interlock Test.** An engine speed advancement interlock test meeting the test requirements in the applicable chapter of NFPA 1900 shall be conducted.

**31.19.9 Aerial Device Certification Tests.**

**31.19.9.1** If a new or upgraded aerial device is installed on the refurbished fire apparatus, the completed apparatus shall be tested according to the test requirements of NFPA 1900 at the manufacturer's approved facility and certified by an independent testing organization approved by the purchaser.

**31.19.9.2** If the original aerial device is reused and it has been worked on or it has not been tested within the last 12 months, the completed apparatus shall be inspected and tested in accordance with the complete requirements of Chapters 1 through 28

**31.19.10 Refurbisher's Pre-Delivery Tests.**

**31.19.10.1 Water Tank Capacity Test.**

**31.19.10.1.1** A water tank capacity test meeting the requirements of the applicable chapter of NFPA 1900 shall be conducted on all refurbished fire apparatus having newly installed water tanks.

**31.19.10.1.2** Fire apparatus retaining their original water tanks shall be tested to the requirements in the edition of the applicable standard in effect at the time of the original contract signing if any work has been done to the tank or its related systems.

**31.19.10.2 Low-Voltage Electrical System Tests.**

**31.19.10.2.1*** If any work is conducted that substantially changes the original low-voltage electrical system of the fire apparatus or adds new loads (e.g., new load management system, new lights, new relay boards), the apparatus shall be tested according to the requirements of the applicable chapter of NFPA 1900.

**31.19.10.2.2** If any work is conducted on the low-voltage electrical system that leaves the original electrical system configuration intact (such as tightening connections, replacing individual wires, etc.), the apparatus shall be tested according to the requirements of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.19.10.3 Line-Voltage Electrical System Tests.**

**31.19.10.3.1*** If a new line-voltage electrical system is added or any work is conducted that substantially changes the original line-voltage electrical system on the fire apparatus or adds new line-voltage electrical loads (e.g., lights, permanently connected equipment, receptacles, cord reels), the apparatus shall be tested according to the applicable requirements of NFPA 1900.

**31.19.10.3.2** If any work is conducted on the line-voltage electrical system that leaves the original line-voltage electrical system configuration intact (e.g., tightening connections, replacing individual wires), the apparatus shall be tested according to the requirements of the edition of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.19.10.3.2.1** If a new pump is installed and the generator shares the same power source as the pump, the line-voltage electrical system test shall be run concurrently with the pump test.

**31.19.10.4* Foam System Tests.**

**31.19.10.4.1** If the refurbished fire apparatus has a new foam system, the foam system shall be tested in accordance with the requirements in the applicable chapter of NFPA 1900.

**31.19.10.4.2** If the refurbished fire apparatus retains its original foam system and system components, and if any work has been done to the foam system or it has been upgraded, the system shall be tested to ensure it meets the requirements of the edition of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.19.11 Road Tests.**

**31.19.11.1*** If the refurbished fire apparatus has upgraded powertrain components (engine, transmission, driveline, or axles), it shall be road tested in accordance with 31.19.11.2 through 31.19.11.6.

**31.19.11.1.1** If the refurbished fire apparatus reuses the original powertrain (engine, transmission, driveline, and axles), the powertrain shall be tested to ensure it meets the requirements of the edition of the NFPA automotive fire apparatus standard in effect at the time of the contract signing for the original manufacture of the apparatus.

**31.19.11.1.2** The tests shall be conducted at a location and in a manner that does not violate local, state, or federal traffic laws.

**31.19.11.2** The fire apparatus shall be loaded to its estimated in-service weight.

**31.19.11.2.1** The tests shall be conducted on dry, level, paved roads that are in good condition.

**31.19.11.2.2** The engine shall not be operated in excess of the maximum governed speed.

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

**31.19.11.3.1** The vehicle shall attain a speed of 35 mph (55 km/hr) from a standing start within 25 seconds.

**31.19.11.3.2** The vehicle shall attain a minimum top speed of not less than 50 mph (80 km/hr).

**31.19.11.4** If the fire apparatus is equipped with an auxiliary braking system, the manufacturer shall road test the system to confirm that the system is functioning as intended by the auxiliary braking system manufacturer.

**31.19.11.5** If the apparatus is equipped with an air brake system, the service brakes shall bring the apparatus, when loaded to its GVWR, to a complete stop from an initial speed of 20 mph (32.2 km/hr), in a distance not exceeding 35 ft (10.7 m) by actual measurement on a paved, level, dry surface road that is free of loose material, oil, or grease.

**31.19.11.6** If the apparatus is equipped with a hydraulic brake system, the service brakes shall bring the apparatus, when loaded to its GVWR, to a complete stop from an initial speed of 30 mph (48.2 km/hr), in a distance not exceeding 88 ft (26.8 m) by actual measurement on a paved, level, dry surface road that is free of loose material, oil, or grease.

**31.19.12 Tests on Delivery.**

**31.19.12.1 Acceptance Tests.**

**31.19.12.1.1** If acceptance tests are required at the point of delivery, the purchaser shall specify the details of the tests to be performed.

**31.19.12.1.2** Acceptance tests shall not be performed in a manner that requires the apparatus or a component to operate outside its designed operating range.

**31.19.12.2** Aerial device stability tests shall not be run at other than the refurbisher's or the aerial device manufacturer's facility.

**31.20 Data Required of the Contractor.**

**31.20.1** If applicable, the contractor shall supply at least one copy of the following at the time of delivery:

(1) Engine manufacturer's certified brake horsepower curve for a new engine installation showing the maximum governed speed
(2) Contractor's record of fire apparatus refurbishing including, if applicable, all technical information required for inspection for compliance with Chapters 1 through 28
(3) Pump manufacturer's certification of suction capabilities for new pump installations
(4) Pump manufacturer's certification of hydrostatic test for new pump installations
(5) Certification of required inspections and tests
(6) If equipped with a pump, a copy of the chassis manufacturer's approval for stationary pumping applications
(7) Weight documents from a certified scale showing actual loading on the front axle, rear axle(s), and overall vehicle (with the water tank full but without personnel, equipment, and hose) supplied with the completed vehicle to determine compliance with Section 29.8
(8) The latest edition of FAMA's *Fire Apparatus Safety Guide*

**31.20.2** A label shall be affixed to the vehicle certifying that the vehicle is in compliance with all applicable Federal Motor Vehicle Safety Standards (FMVSS) in effect at the time of completion.

**31.20.3** If the original fire pump is replaced with a new fire pump, a new test label shall be provided on the pump operator's panel providing the following information:

(1) The rated discharges and pressures together with the speed of the engine, as determined by the certification tests required by 31.19.1
(2) The position of the parallel-series pump, as used
(3) The governed speed of the engine, as stated by the engine manufacturer on a certified brake horsepower curve

**31.20.3.1** The test label shall be stamped with complete information at the contractor's facility and attached to the vehicle prior to delivery.

**31.21 Safety Signs.** The contractor shall ensure that the following safety signs, as appropriate to the apparatus type and features and as described and located in accordance with FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*, are on the apparatus prior to delivery:

(1) FAMA01 — Battery Explosion
(2) FAMA02 — Rotating Shafts
(3) FAMA05 — Spinning Fan
(4) FAMA06 — Seats Without Belts Not Occupied
(5) FAMA07 — Seated and Belted
(6) FAMA10 — Cab Equipment Mounting
(7) FAMA12 — Fire Service Tire Rating
(8) FAMA14 — Cab Seating
(9) FAMA15 — Helmet Worn in Cab (Structural Apparatus)
(10) FAMA17 — Vehicle Backing
(11) FAMA18 — Intake and Discharge Cap Pressure
(12) FAMA22 — Hose Restraint Required
(13) FAMA23 — Access Step Method
(14) FAMA24 — Riding on Exterior
(15) FAMA25 — Trained Personnel Only — NFPA Required
(16) FAMA26 — No-Step
(17) FAMA28 — Rope Tie-Down 9000
(18) FAMA30 — Stabilizer Crush
(19) FAMA31 — Stabilizer Pins & Pads
(20) FAMA32 — Stabilizer Pads
(21) FAMA34 — Fall Restraint Required
(22) FAMA35 — Aerial Electrocution
(23) FAMA36 — Aerial Electrocution
(24) FAMA37 — Aerial Device Load Capacity
(25) FAMA38 — Aerial Ladder Rung Pinch
(26) FAMA39 — Aerial Inspection
(27) FAMA41 — Cab Tilt
(28) FAMA42 — Siren Noise
(29) FAMA43 — Helmet Worn in Cab (Wildland Apparatus)
(30) FAMA44 — Pump-and-Roll Firefighting Position — Exterior
(31) FAMA45 — Pump-and-Roll Firefighting Position — Driver
(32) FAMA46 — Aerial Device Pinch
(33) FAMA47 — Aerial Device Operator Attention Required

## Chapter 32 Design Considerations (NFPA 1925)

**32.1 Administration**

**32.1.1 Scope.**

**32.1.1.1** Chapters 32 through 48 shall provide minimum requirements for marine firefighting vessels.

**32.1.1.2** Chapters 32 through 48 shall also provide minimum maintenance and testing requirements for marine firefighting vessels.

**32.1.2 Purpose.**

**32.1.2.1** The purpose of this standard shall be to provide the minimum requirements for the construction of new marine firefighting vessels or for the conversion of existing vessels to become marine firefighting vessels.

**32.1.2.2** This standard is not intended to serve as a detailed manufacturing or purchase specification, but it shall be permitted to be referenced in purchase specifications as minimum requirements.

**32.1.2.3** This standard is not intended to serve as a staffing document for marine firefighting vessels.

**32.1.3 Application.** This standard shall apply to both the construction of new vessels and the conversion of existing vessels for firefighting purposes.

**32.1.4 Retroactivity.** This standard shall not be retroactive unless an existing vessel is undergoing a major conversion to become a marine firefighting vessel.

**32.1.5 Equivalency.**

**32.1.5.1** Nothing herein shall be construed as reducing relevant government regulations regarding marine firefighting vessels.

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

**32.1.5.3** The technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

**32.1.5.4** The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

**32.1.6 Units.**

**32.1.6.1** In this standard, values for measurement are followed by an equivalent in SI units, but only the first stated value shall be considered as the requirement.

**32.1.6.2** Equivalent values in parentheses shall not be considered as the requirement as these values might be approximate.

**32.2 General.** The vessel shall comply with all relevant governmental regulations governing the design, operation, and navigation of vessels.

**32.3 Vessel Performance.**

**32.3.1 General.**

**32.3.1.1** The overall performance of a marine firefighting vessel shall be permitted to be determined after a careful evaluation of all perceived operational requirements.

**32.3.1.2** Elements of performance requiring definition shall include, but are not limited to, speed, range, capacity, endurance, and seakeeping capability, as well as the capability of the firefighting system(s).

**32.3.1.3** The performance criteria shall be permitted to be defined after the completion of a Determination of Needs Study as described in 32.3.2, or equivalent assessment as determined by the AHJ.

**32.3.2* Determination of Needs Study.** See also Annex G.

**32.3.2.1** Prior to the construction of a new marine firefighting vessel or the major conversion of a vessel for firefighting purposes, a study shall be undertaken to clearly identify the mission and capability requirements of the vessel.

**32.3.2.2** Some of the issues that the study shall be permitted to cover are as follows:

(1) General specifications as follows:
   (a) Geographical size of the area to be protected by the vessel
   (b) Nature of the waterfront facilities and vessels to be protected
   (c) Maximum desirable response times
   (d) Maximum wake permissible
   (e) Nature of the marine environment in which the vessel will operate, including mutual aid operations
   (f) Anticipated future growth in the service area and the service needs from the marine firefighting vessel
   (g) Projected or anticipated years of service
(2) Crew — The expected number of personnel in the vessel's crew
(3) Firefighting mission requirements as follows:
   (a) Requirements for supplying shoreside water systems
   (b) Number of pier fires in the jurisdiction to which marine firefighting vessels have responded or would have responded
   (c) Number of vessel fires in the jurisdiction to which marine firefighting vessels have responded or would have responded
   (d) Number of land fires in the jurisdiction to which marine firefighting vessels have responded or would have responded
   (e) Maximum expected duration of a mission
   (f) Pumping capacity used or required during previous major fires
   (g) Maximum pumping capacity to be reasonably expected of a marine firefighting vessel
   (h)* Minimum pumping capacity for expected handline use
   (i) Hose and equipment used or required at previous fires by marine firefighting vessels
   (j) Requirements to remain on station during previous fires in the jurisdiction
   (k) Self protection such as, but not limited to, heat protection, spray, and CBRN
(4) Rescue and emergency medical services (EMS) requirements as follows:
   (a) Number of rescue incidents in the jurisdiction in which marine firefighting vessels have been involved
   (b) Type of rescue missions that the marine firefighting vessel could become involved with during service life
(5) Fire prevention requirements as follows:
   (a) Building inspection requirements
   (b) Subpier inspection requirements
   (c) Hazardous cargo inspection requirements
   (d) Prefire inspection requirements
(6) Effect of standards and requirements as follows:
   (a) NFPA standards
   (b) US Coast Guard (USCG) requirements
   (c) American Boat and Yacht Council (ABYC) standards
   (d) Local insurance considerations

**32.3.3 Mission of the Vessel.**

**32.3.3.1** The mission of the vessel shall be defined as a result of the Determination of Needs Study as determined in accordance with 32.3.2.

**32.3.3.2** Where the vessel is used for the sole purpose of firefighting, it shall meet all the stated objectives of Chapters 32 through 48.

**32.3.3.3** Where the vessel is assigned additional duties, it shall meet all the objectives of Chapters 32 through 48, as well as those for each of the designated special operations.

**32.3.4 Vessel Requirements Specification.**

**32.3.4.1** Based upon the outcome of the Determination of Needs Study, the details of the vessel shall be specified.

**32.3.4.2** The services of an experienced professional shall be considered to prepare this document and properly define the vessel.

**32.4 Command and Control Spaces.**

**32.4.1 Helm Control Station.**

**32.4.1.1** All vessels shall have a field of vision from the helm suitable for safe navigation in all operating conditions.

**32.4.1.2** Polarized or tinted windows that would interfere with safe navigation shall be prohibited.

**32.4.1.3** Machinery, alarm, and monitoring equipment shall be provided at the primary helm or master control station and be adequate for the safe and proper operation of the vessel.

**32.4.2 Machinery Control Stations.** Vessels that are not equipped with remote controls for machinery shall have an engine room communication system in accordance with 46 CFR 184, "Vessel Control and Miscellaneous Systems and Equipment."

**32.4.3 Firefighting Control Centers.**

**32.4.3.1** Firefighting control centers shall provide control of the fire pump and associated remote control equipment.

**32.4.3.2** Firefighting control centers shall be located in close proximity to the navigation control center.

**32.4.3.3** The control center shall provide maximum visual observation of firefighting operations.

**32.4.3.4** When the control center is to be used as an incident command center, adequate communications for the incident commander shall be provided.

**32.4.3.5** Firefighting control stations on Type I through Type IV vessels shall be insulated from heat and protected from spray in accordance with the Determination of Needs Study.

**32.5 Construction.**

**32.5.1 General.** Placement of equipment shall allow for its removal from the vessel with minimal disruption of permanently installed structural members, or equipment shall be situated to allow for maintenance and repair.

**32.5.2 Materials.**

**32.5.2.1** All parts of the vessel shall be constructed of materials appropriate for the environment in which the vessel will operate.

**32.5.2.2** All construction materials for the vessel and the systems shall be selected to minimize the effects of corrosion.

**32.5.3 Fuel Tanks.**

**32.5.3.1** Diesel fuel systems shall comply with *ABS Rules for Building and Classing Steel Vessels*, for Types I and II and ABYC H-33, *Diesel Fuel Systems*, for Types III, IV, and V.

**32.5.3.2** Gasoline fuel systems shall comply with ABYC H-24, *Gasoline Fuel Systems.*

**32.5.3.3** Portable fuel tanks shall comply with ABYC H-25, *Portable Marine Gasoline Fuel Systems.*

**32.5.3.4** The use of liquid hydrocarbon alternative fuels shall be permitted in accordance with accepted industry practices.

**32.5.4 Void Spaces.**

**32.5.4.1** Access and lightening holes shall be arranged clear of concentrated loads or areas of high stresses.

**32.5.4.2** Air and limber holes shall be arranged to eliminate air pockets and to avoid any accumulation of water or other liquids.

**32.5.5 Open Decks.**

**32.5.5.1** Openings in weather decks shall comply with *ABS Rules for Conditions of Classification — High Speed Craft* or ABYC H-3, *Exterior Windows, Windshields, Hatches, Doors, Portlights, and Glazing Materials.*

**32.5.5.2** All vessels shall be equipped with freeing ports or drains to provide rapid drainage of water, including fire flow, from the weather deck under all operating conditions.

**32.5.6 Machinery Spaces.**

**32.5.6.1** Within practicable limits, machinery spaces shall be designed so that all equipment that requires inspection, adjustment, or maintenance is readily accessible.

**32.5.6.2** Within practicable limits, all equipment shall be arranged so that it is not damaged by bilge water.

**32.5.6.3** Compartments in which flammable gases, acid fumes, and oil vapors can accumulate shall be ventilated to reduce the possibility of explosion.

**32.5.6.4** Openings and ventilators shall be arranged to minimize risk of water ingress onto equipment.

**32.6 Human Factors Engineering.**

**32.6.1** The vessel shall comply with the requirements in NFPA 302; *ABYC Standards and Technical Information Reports for Small Craft*; *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*; 46 CFR Subchapter C, "Uninspected Vessels"; or 46 CFR Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)," as appropriate.

**32.6.2** Instructions for operation of vessel safety equipment shall be the equipment manufacturers' instructions and shall be adequately posted.

**32.6.3** Escape plans, operating instructions, diagrams, safety checklists, and other pertinent data shall be available to those onboard.

**32.7 Third-Party Certification of Test Results.** Where this standard requires the results of tests to be certified by an independent third-party certification organization, that organization shall meet the requirements of this section.

**32.7.1** All certification shall be performed by a certification organization that is accredited for inspection and testing systems on fire apparatus in accordance with ISO/IEC 17020, *Conformity assessment — Requirements for the operation of various types of bodies performing inspection*, or ISO/IEC 17065, *Conformity assessment — Requirements for bodies certifying products, process and services.*

**32.7.2** The certification organization shall not be owned or controlled by manufacturers or vendors of the product that is being tested.

**32.7.3** The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

**32.7.4** The certification organization shall witness all tests and shall refuse to certify any test results for a system if all components of that system requiring testing do not pass the testing required by this standard.

**32.7.5** There shall be no conditional, temporary, or partial certification of test results.

**32.7.6** Appropriate forms or data sheets shall be provided and used during the testing.

**32.7.7** Programs shall be in place for training, proficiency testing, and performance verification of any staff involved with certification.

**32.7.8** The certification organization's operating procedures shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include provisions for the presentation of information from representatives of both sides of a controversy to a designated appeals panel.

## Chapter 33 Classifications (NFPA 1925)

**33.1* Classifications.** Marine firefighting vessels shall be classified and equipped in accordance with Table 33.1 for classification of emergency response vessel resources.

**33.2 Requirements for Vessel Classification.**

**33.2.1** Marine firefighting vessels designated as Type I shall meet the following minimum requirements:

(1) Minimum number of pumps: 2
(2) Minimum water pumping capacity: 20,000 gpm (80,000 L/min) @ 150 psi (10 bar)
(3) Foam production in accordance with Chapter 9 of NFPA 11
(4) Minimum number of generators: 2
(5) On-station fuel capacity: 48 hours
(6) Minimum number of monitors: 4
(7) Minimum number of discharge outlets: 24; 6 [1½ in. (38 mm)]; 10 [2½ in. (65 mm) or larger]; 4 [≥3½ in. (89 mm)]; 4 [5 in. (127 mm)]

**33.2.2** Marine firefighting vessels designated as Type II shall meet the following minimum requirements:

(1) Minimum number of pumps: 2
(2) Minimum pumping capacity: 10,000 gpm (40,000 L/min) @ 150 psi (10 bar)
(3) Foam production in accordance with Chapter 9 of NFPA 11
(4) Minimum number of generators: 2
(5) On-station fuel capacity: 24 hours
(6) Minimum number of monitors: 4
(7) Minimum number of discharge outlets: 8; 3 [≥3½ in. (89 mm)]; 5 [5 in. (127 mm)]

**33.2.3** Marine firefighting vessels and special purpose firefighting vessels designated as Type III shall meet the following minimum requirements:

(1) Minimum number of pumps: 2
(2) Minimum pumping capacity: 4500 gpm (18,000 L/min) @ 150 psi (10 bar)
(3) Foam production in accordance with Chapter 9 of NFPA 11
(4) Minimum number of generators: 1 with direct power source
(5) On-station fuel capacity: 8 hours
(6) Minimum number of monitors: 4
(7) Minimum number of discharge outlets: 4; 2 [≥3½ in. (89 mm)]; 2 [5 in. (127 mm)]

**33.2.4** Marine firefighting vessels and special purpose firefighting vessels designated as Type IV shall meet the following minimum requirements:

(1) Minimum number of pumps: 1
(2) Minimum pumping capacity: 1500 gpm (6000 L/min) @ 150 psi (10 bar)
(3) Foam production in accordance with Chapter 9 of NFPA 11
(4) On-station fuel capacity: 6 hours
(5) Minimum number of monitors: 2
(6) Minimum number of discharge outlets: 2 [≥3½ in. (89 mm)]

**33.2.5** Marine firefighting vessels and special purpose firefighting vessels designated as Type V shall meet the following minimum requirements:

(1) Minimum number of pumps: 1
(2) Minimum pumping capacity: 500 gpm (2000 L/min) @ 150 psi (10 bar)
(3) On-station fuel capacity: 4 hours
(4) Minimum number of monitors: 1

**Table 33.1 Minimum Capabilities of Vessel Classification**

| Component | Type I | Type II | Type III | Type IV | Type V |
|---|---|---|---|---|---|
| Pumps | 2 | 2 | 2 | 1 | 1 |
| Pumping water capacity (gpm) | 20,000 | 10,000 | 4500 | 1500 | 500 |
| Foam production | Per Chapter 11 of NFPA 11 | Per Chapter 11 of NFPA 11 | Per Chapter 11 of NFPA 11 | Per Chapter 11 of NFPA 11 | None |
| Generators | 2 | 2 | 1 with direct power source | 0 | 0 |
| On-station fuel capacity (hours) | 48 | 24 | 8 | 6 | 4 |
| Monitors | 4 | 4 | 4 | 2 | 1 |
| Discharge outlets | Per 33.2 | Per 33.2 | Per 33.2 | Per 33.2 | N/A |

N/A: Not applicable.
Note: Additional firefighting equipment requirements for all types of vessels are found in Chapter 38.

## Chapter 34 Firefighting System Capabilities (NFPA 1925)

### 34.1 General.

**34.1.1** The selection of pumps and design of distribution piping shall be done in consideration of the Determination of Needs Study per 32.3.2 and the following:

(1) Number, sizes, and types of distribution devices expected to be used singularly or simultaneously
(2) Pressure required at the inlets of the discharge devices
(3) Required full-range fire flow

**34.1.1.1** Where the fire pumps and distribution piping are used to supply thrusters for station keeping, the fire pump capacity and distribution pipe size shall be increased to permit station keeping without decreasing fire flow capacity.

**34.1.1.2** Where the distribution piping from the fire pumps also supplies the vessel protection systems, the demand for those vessel protection systems shall be added to the fire pump distribution piping to permit simultaneous use without decreasing the fire flow capability.

### 34.2 System Design.

**34.2.1*** Firefighting piping systems shall be designed for not less than the maximum potential flow rate, cut-off pressure of the pump(s), or relief valve setting of the pump.

**34.2.2** The pump suction velocity shall generally not exceed 6.5 ft/sec (2 m/sec), and discharge piping shall generally not exceed 13 ft/sec (4 m/sec) at the design flow rate for each section of pipe.

**34.2.3** Recommended flow rates shall be permitted to be exceeded where other aspects of the design could be compromised by fitting larger or heavier pipes and fittings, provided the impact of the higher rates on erosion in piping and fittings is identified and accepted by the owner/operator, and the higher flow resistance does not impair the performance of the system.

**34.2.4** Where a common suction or discharge header is connected to more than one pump, the design flow rate in the header shall reflect the combined capacity of all connected pumps operating simultaneously.

**34.2.5** Means shall be provided to prevent the pump from overheating with distribution devices closed, such as an overboard discharge.

**34.2.6** Where multiple pumps are installed, the failure of any single pump shall not reduce fire flow by more than 50 percent.

**34.2.7** Where piping serves multiple pumps, the failure of any piping shall not reduce fire flow by more than 50 percent.

**34.2.8** Pump discharge piping shall include a check valve and isolation valve for each pump in a multiple pump system.

**34.2.9** Isolation valves shall be installed where necessary for each device or outlet and where necessary for continued operation of the system in case of piping or component failure.

**34.2.10** A shutoff valve shall be provided in the supply to each monitor.

**34.2.11 Suction Arrangement.**

**34.2.11.1*** The suction arrangements for each pump shall include at least one dedicated sea chest with screened inlet, a valve at the sea chest outlet, and a valved vent to atmosphere.

**34.2.11.2** Where pump suctions are arranged in a manifold (sea main), an isolation valve shall be provided at or near the suction inlet of each pump.

**34.2.11.3*** The open area of the screen shall be at least two times the cross-sectional area of the suction pipe, and the individual openings shall not be larger than the pump manufacturer's maximum particle size.

**34.2.11.4** The intakes to all fire pumps shall be fitted with a means of clearing while the vessel is afloat.

**34.2.12 System Pressure Ratings and Control.**

**34.2.12.1** Firefighting pump discharge piping shall be designed for a working pressure not less than the maximum cut-off pressure of the pump(s) fitted, except as noted in 34.2.12.3 and 34.2.12.4.

**34.2.12.2** Piping systems shall be designed to avoid water hammer and similar hydraulic shocks within the system during operation by fitting valve operators with controlled opening/closing rates in accordance with 34.3.6.3 and by providing the means to purge air from the piping system at low flow velocities.

**34.2.12.3** The use of automatic pressure relief valves in systems shall be permitted where the piping system cannot satisfy 34.2.12.1.

**34.2.12.4*** Where pressure relief valves are fitted, the discharge(s) shall be to the pump suction or, if discharged outside the marine firefighting vessel, the discharge shall be above the waterline and in a position least likely to affect vessel operations or the safety of other vessels or personnel in the vicinity.

**34.2.13 Drains.**

**34.2.13.1** Drains shall be provided to drain all portions of the discharge and distribution piping.

**34.2.13.2** A small valved drain line that bypasses each pump check valve shall be provided to permit drainage of the discharge piping.

**34.2.14 Flushing.** All vessels operating in salt or brackish water shall have a means of flushing the distribution system with fresh water.

### 34.3 Components and Materials.

**34.3.1 General.**

**34.3.1.1** All components shall have design pressure ratings equal to or greater than the maximum pump pressure or relief valve setting.

**34.3.1.2** All piping, fittings, and valves shall be constructed of materials that resist galvanic corrosion.

**34.3.1.3** Any components and materials to be used with firefighting foams shall be compatible with the type of foam concentrate to be used.

**34.3.2 Piping.**

**34.3.2.1** Where steel pipe is joined by threaded fittings referenced in 34.3.3, the minimum wall thickness shall be in accordance with Schedule 40 for pressures up to 300 psi (20.7 bar).

**34.3.2.2** Bending of pipe and tube shall be in accordance with *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*.

**34.3.3 Fittings.**

**34.3.3.1** Threaded fittings shall not be used on pipe larger than 2 in. (50 mm).

**34.3.3.2** A one-piece reducing fitting shall be used wherever a change is made in the size of the pipe.

**34.3.3.3** All threaded pipe and fittings shall have threads cut according to ASME B1.20.1, *Pipe Threads, General Purpose, Inch*.

**34.3.3.4** Hexagonal or face bushings shall be permitted in reducing the size of openings of fittings when standard fittings of the required size are not available.

**34.3.4 Welded Pipe and Fittings.** Welding to join pipes and fittings shall be permitted provided that the welding methods comply with AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*.

**34.3.5 Brazed Joints.**

**34.3.5.1** Joints for the connection of copper tube shall be brazed or welded in accordance with 46 CFR 56.70, "Welding."

**34.3.5.2** Excess flux shall be removed after brazing.

**34.3.6 Valves.**

**34.3.6.1** All valves used in the pump piping system shall be equipped with an operating mechanism that visually indicates the position of the valve at all operating locations.

**34.3.6.2** All valves shall be arranged so that the open or closed position is clearly indicated directly on the valve.

**34.3.6.3** Discharge valves shall be capable of being opened and closed smoothly and readily at flow velocities up to 20 ft/sec (6 m/sec).

**34.3.6.3.1** The flow-regulating element of each discharge piping valve shall not change its position under any condition of operation involving discharge pressures to the maximum pressure of the pump.

**34.3.6.3.2** The means to prevent a change in position shall be incorporated in the operating mechanism and shall be either manually or automatically controlled.

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

**34.3.6.4** Suction valves shall be capable of being opened and closed smoothly and readily at flow velocities up to 15 ft/sec (4.6 m/sec).

**34.3.6.5** Valves that are remotely controlled shall have a manual override feature located at the valve.

**34.3.7* Pumps.**

**34.3.7.1** Pump materials shall be galvanically compatible and shall be suitable for the pump's rated capacity, pressure, speed, ambient water temperature, and corrosiveness.

**34.3.7.2** Pumps shall be installed below the waterline where possible, and in all cases the net positive suction head (NPSH) shall be verified for the proposed installation and pump performance.

**34.3.7.3** Pumps installed above the waterline shall be designed to operate at rated capacity with a total suction lift not to exceed 10 ft (3 m).

**34.3.7.4** Net pump pressure at rated capacity shall be 150 psi (10.34 bar) or greater for all vessels.

**34.3.7.5** The pump manufacturer shall hydrostatically test the pump at twice the rated discharge pressure of the pump.

**34.3.7.6 Certification.**

**34.3.7.6.1** The pump manufacturer shall test each pump prior to shipping and shall certify that the pump meets the provisions of this standard.

**34.3.7.6.2** The certification for each pump shall be provided to the owner.

**34.3.8 Discharge Devices.**

**34.3.8.1* General.**

**34.3.8.1.1** All discharge devices shall be supported by the vessel structure to minimize stresses on piping and valves.

**34.3.8.1.2** Discharge outlets and all fire hose connections shall have connections as specified in NFPA 1963.

**34.3.8.2 Monitors.**

**34.3.8.2.1*** For all marine firefighting vessels, a single monitor or combination of monitors shall provide an unobstructed range of horizontal operation of at least 270 degrees centered on the bow of the vessel and shall have a vertical coverage of at least 60 degrees above and 15 degrees below horizontal.

**34.3.8.2.2** Means shall be provided to prevent damage to the vessel's structure or equipment from the operation of the monitors.

**34.3.8.2.3** Monitor supports shall be designed for all operational loadings at maximum flows and pressures.

**34.3.8.2.4** Controls for nozzle rotation, elevation, and discharge pattern shall be located not less than 3 ft (0.9 m) and not more than 6 ft (1.8 m) above the deck or platform that serves as the operator's station for that monitor.

**34.3.8.2.5** Monitors equipped with remote controls shall be designed so that each can be operated manually.

**34.3.8.2.6** Remote control stations for monitors shall have operational visibility substantially equal to the operational range of the monitor.

**34.3.8.2.7** Each monitor operator position shall have an effective means of communication with the vessel's operator position.

**34.3.8.2.8** Control systems for remote-controlled monitors shall be protected with overload or circuit breaker protection.

**34.3.8.3 Discharge Outlets.**

**34.3.8.3.1** For Type III through Type V vessels, hose connections shall be provided to discharge 100 percent of the rated pump capacity. For Type I and Type II vessels, hose connections shall be determined with special consideration of the Determination of Needs Study, per 32.3.2.

**34.3.8.3.2** On vessels where a fixed foam system is installed, a means of providing foam solution to one or more hose outlets shall be provided.

**34.3.9 Installation.**

**34.3.9.1** All components and equipment shall be installed in accordance with manufacturers' requirements.

**34.3.9.2** Piping shall be supported from the vessel structure to carry the load of a completely filled piping system, allowing for the anticipated vertical design accelerations, which can reasonably be expected in the service.

**34.3.9.3** Where flanges are used to join piping or to facilitate removal of valves for service, a support shall be provided not more than 2 ft (0.6 m) from the joint.

**34.3.9.4** Bracing shall be provided to resist the nozzle reaction of discharge devices.

**34.3.9.5** Provision shall be made for the expansion or contraction of piping and for stresses in the piping due to temperature changes or flexing of the hull.

**34.3.10 Controls, Indicators, and Instruments.**

**34.3.10.1** When mechanical indicators are used, all master fire pump pressure indicators shall have a dial not less than 3½ in. (90 mm) in diameter.

**34.3.10.1.1** When mechanical indicators are used, indicator connections shall be accessible to permit back flushing of pressure tubing from remote indicator locations.

**34.3.10.2** The suction indicator, when provided, shall be a compound type ranging from 30 in. Hg (760 mm Hg) to 15 psi (1 bar).

**34.3.10.2.1** Suction indicators shall not be required on Type V vessels.

**34.3.10.3** The discharge pressure indicator range shall be from 0 psi (0 bar) to twice the maximum pressure that the pump produces.

**34.3.10.4** A pump pressure indicator shall be provided to monitor fire main pressure and shall be visible to the fire system operator.

**34.3.11 Testing.**

**34.3.11.1** The installed discharge piping shall be hydrostatically tested for not less than 1 hour at not less than 200 psi (13.8 bar), or at 50 percent greater pressure than the rated cutoff pressure of the pump(s), whichever is greater.

**34.3.11.2** Pressure test instrument connections shall be provided at each pump and monitor.

**34.3.11.3** The pressure test instrument connections at each pump shall include a connection for original and periodic testing of the pump's performance.

**34.3.11.4** A valved test connection shall be located for accessibility above deck plates as close to the gauge tap on the pump flange as possible.

## Chapter 35 Foam Systems (NFPA 1925)

**35.1 General.**

**35.1.1** Where the marine firefighting vessel is equipped with a fixed or portable foam system, the requirements of this chapter and NFPA 11 shall apply.

**35.1.2*** The selection of the foam-proportioning system shall be made only after a complete review of the foam performance necessary to satisfy the requirements of the mission and capability study.

**35.1.3** The purchaser shall provide the following minimum performance requirements for the installed system:

(1) Minimum and maximum foam solution flow rates
(2) Foam solution proportioning rate or range
(3) Minimum operating time required
(4) Minimum performance requirements of system discharge devices including at least flow, pressure, reach, whether aspirated or nonaspirated

**35.2 Design and Performance Requirements.**

**35.2.1** The vessel shall be capable of supplying the power required by the foam-proportioning system in addition to the requirements of the other power-dependent systems installed on the vessel.

**35.2.2** The foam-proportioning system shall be designed to operate with the type(s) of foam concentrate specified by the purchaser.

**35.2.3*** The materials and system components used in the construction of the foam concentrate storage and proportioning and delivery system shall be compatible with the concentrate as specified by the foam manufacturer.

**35.2.4** For Type I through Type III vessels, the foam-proportioning system shall be an integral part of the water delivery system.

**35.2.4.1** Type IV and Type V marine firefighting vessels shall be permitted to utilize portable foam delivery systems in accordance with Chapter 9 of NFPA 11.

**35.2.5** The vessel builder shall demonstrate the following:

(1) Maximum rate of foam solution delivery capable of being discharged from the system at a given rate of proportioning
(2) Maximum operating pressure of the foam-proportioning system
(3) Minimum and maximum rate of foam solution discharge available at each individual outlet equipped with a foam-proportioning device

**35.2.6** Discharge or pressure lines in the foam-proportioning system shall be designed and installed so that the velocity of the foam concentrate in the lines does not exceed 25 ft/sec (8 m/sec) at the maximum design flow.

**35.2.7** Suction lines in the foam-proportioning system shall be designed and installed so that the velocity of the foam concen-

trate in the lines does not exceed 15 ft/sec (4.6 m/sec) at the maximum design flow.

**35.2.8** The operating characteristics of the selected individual foam system components shall be reviewed to ensure that the installed system meets or exceeds the design performance requirements.

**35.2.9** Components that can be flushed with water after use shall be constructed of materials that are resistant to corrosion after being flushed with fresh water and allowed to dry.

**35.2.9.1** The components in 35.2.9, including, but not limited to, gaskets, seals, and binding of moving parts, shall also be constructed of materials resistant to deterioration by foam concentrates.

**35.2.10** Where eductors are used, their flow rating shall be matched with the flow rating of the delivery devices they serve.

**35.2.11** A check valve or similar means of isolation shall be installed in the concentrate delivery piping as close to the proportioners as possible to prevent the mixing/contamination of the concentrate with backflow of fire main water.

**35.3 Controls.**

**35.3.1** All foam-proportioning system controls shall be clearly identified and readily accessible.

**35.3.2** Foam-proportioning systems that incorporate a foam concentrate pump and tank shall include provisions to allow resupply while the system is in operation.

**35.3.3** Foam-proportioning systems that require flushing after use shall include readily accessible controls that allow the system to be flushed completely with fresh water according to the manufacturer's instructions.

**35.3.4** Foam systems that incorporate automatic proportioning features shall be equipped with controls that allow the automatic feature to be bypassed for manual operation.

**35.3.5** For foam-proportioning systems that incorporate foam concentrate metering valves, each metering valve shall be calibrated and marked to indicate the range of foam concentrate proportioning rate(s) available as determined by the design of the system.

**35.4 Gauges, Flowmeters, and Indicators.**

**35.4.1** All gauges, flowmeters, and indicators shall be located so they are readily visible.

**35.4.2** All gauges or flowmeters shall be mounted in a manner to protect the gauge from physical damage and from excessive vibration.

**35.4.3** Foam concentrate tanks with a capacity of 500 gal (2000 L) or more shall be provided with a gauging device for determining remaining foam concentrate volume in the tank.

**35.5 Labels and Instruction Plates.**

**35.5.1** All labels and marking shall be permanent in nature, capable of withstanding the effects of extreme weather and temperature, and attached in a manner that requires mechanical means to remove.

**35.5.2** A label shall be provided for each control, gauge, and indicator that is clearly marked with the identification and function of that device.

**35.5.3** An instruction plate shall be provided for the foam-proportioning system that includes, as a minimum, a piping schematic of the system and basic operation instructions.

**35.5.3.1** Foam concentrate trade names shall not be substituted for foam solution percentage ratios on instruction plates.

**35.5.4** A label that reads “Foam Tank Fill” shall be provided at any foam tank fill opening and shall indicate the type and proportioning percentage of concentrate required.

**35.6 Atmospheric Foam Concentrate Tank.**

**35.6.1** Where the vessel's foam-proportioning system incorporates an atmospheric foam concentrate tank, the requirements of this section shall apply.

**35.6.2** The foam concentrate tank and associated piping shall be constructed of materials in accordance with 35.2.3.

**35.6.3** The foam concentrate tank shall be provided with a protected fill opening that is designed to facilitate the operator's filling the tank from 5 gal (20 L) foam concentrate containers.

**35.6.3.1** Foam concentrate tanks larger than 200 gal (800 L) shall incorporate a fill opening with an area of at least 36 in.$^2$ (2320 mm$^2$).

**35.6.3.2** Where a fill opening is less than 36 in.$^2$ (2320 mm$^2$), a fill funnel with strainer shall be provided with a neck to fit the fill opening and a minimum 36 in.$^2$ (2320 mm$^2$) fill cup.

**35.6.3.3** Foam concentrate tanks of 200 gal (800 L) or less shall incorporate a fill opening with an area not less than 4 in.$^2$ (260 mm$^2$).

**35.6.4** The tank opening shall be protected by a removable cover and screen.

**35.6.4.1*** The cover shall be attached to the tank fill by mechanical means to prevent air from entering or escaping during normal service.

**35.6.5** Where the foam concentrate tank is over 100 gal (400 L), it shall incorporate an expansion compartment or dome located so that foam concentrate enters this compartment only after the entire main tank compartment is completely filled.

**35.6.5.1** The volume of the expansion compartment in 35.6.5 shall be not less than 2 percent of the total foam concentrate tank volume.

**35.6.6 Pressure/Vacuum Vent.**

**35.6.6.1** The foam concentrate tank shall be equipped with a pressure/vacuum vent that allows the tank to adjust automatically for changes in pressure when filling or withdrawing foam concentrate from the tank.

**35.6.6.2** The pressure/vacuum vent shall not permit outside air to enter the tank freely except during operation or for normal changes in volume due to changes in temperature.

**35.6.6.3** The alternative to a pressure/vacuum vent shall be permitted to be a small vented header tank, fitted with a sight glass or similar level indicator, that would present a small contact surface area of foam to the atmosphere, and ensure that the main storage tanks are void of air.

**35.6.7 Foam Isolation.**

**35.6.7.1** The foam concentrate shall be isolated from direct contact with the atmosphere to prevent drying out and to reduce risk of internal corrosion in the tank.

**35.6.7.2** The foam concentrate tank shall be fitted with a pressure vacuum vent or alternative device that allows the tank to react safely to changes in pressure when filling or removing foam concentrate from the tank.

**35.6.7.3** The pressure vacuum vent or alternative device shall not permit outside air or water to enter the tank freely except during operation or for normal changes in volume due to changes in temperature.

**35.6.7.4** An acceptable alternative to a pressure vacuum vent shall be permitted to be a small vented header tank, fitted with a sight glass or similar level indicator, which presents only a small contact surface area of foam to the atmosphere and ensures that the main storage tanks are void of air.

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

**35.6.8.1** Foam concentrate tanks larger than 200 gal (800 L) with more than one internal compartment shall incorporate a removable top allowing access to each compartment or a removable personnel access hatch with a minimum inside diameter of 20 in. (510 mm).

**35.6.8.2** Tanks equipped with a personnel access hatch shall also be equipped with a 20 in. (510 mm) minimum inside diameter opening through any internal baffles to allow personnel access to the entire tank interior.

**35.6.8.3** Single compartment foam concentrate tanks shall incorporate a removable hatch or fill opening that allows personnel access to the entire interior of the tank.

**35.6.9 Swash Partitions.**

**35.6.9.1** The foam concentrate tank shall have a sufficient number of swash partitions so that the maximum dimension of any space in the tank, either transverse or longitudinal, shall not exceed 48 in. (1220 mm) and shall be not less than 23 in. (584 mm).

**35.6.9.2** The swash partitions shall have vents and openings at the top and bottom to permit movement of air and foam concentrate between compartments to meet the maximum flow requirements of the foam-proportioning system.

**35.6.10 Discharge.**

**35.6.10.1** The foam concentrate tank outlet connection shall be connected to a sump located in the bottom of the tank and shall permit discharge of at least 95 percent of the tank's capacity.

**35.6.10.2** The discharge shall be protected by an antiswirl baffle in systems where the foam concentrate delivery rate exceeds 5 gpm (20 L/min).

**35.6.10.3** The foam concentrate tank inlet connection shall terminate within 2 in. (51 mm) of the tank bottom to prevent aerating the foam concentrate.

**35.6.11 Valved Drain.**

**35.6.11.1** A minimum 1 in. (25 mm) valved drain shall be provided in the sump of any foam concentrate tank of 20 gal (80 L) or more.

**35.6.11.2** A minimum ½ in. (13 mm) valved drain shall be provided in the sump of any foam concentrate tank of less than 20 gal (80 L).

**35.7 Foam Concentrate Pump.**

**35.7.1*** Where the vessel's foam-proportioning system incorporates a foam concentrate pump, the requirements of this section shall apply.

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

**35.7.3** Drive train components required to transmit power to the foam concentrate pump shall be capable of transmitting the power required by the pump under the maximum design condition.

**35.7.4** The foam concentrate pump shall deliver the flow and pressure required by the system when it is operating at 110 percent of rated capacity.

**35.7.5** A relief valve or other overpressure limiting device shall be provided in the foam-proportioning system to protect the foam concentrate pump.

**35.7.6*** A strainer designated by the foam concentrate manufacturer shall be installed on the intake side of the foam concentrate pump so that any foam concentrate entering the system passes through the strainer.

## Chapter 36 Manufacturer/Purchaser Responsibilities (NFPA 1925)

**36.1 Personnel Training.** After delivery of the marine firefighting vessel, the owner shall be responsible for ongoing training of its personnel to proficiency regarding the proper and safe use of the marine firefighting vessel and associated equipment as defined in NFPA 1005 and NFPA 1500.

**36.2* Compliance with Regulations.** The owner shall comply with all applicable regulations for operation of vessels in their location.

**36.3 Training and Instruction.** The firefighting vessel manufacturer/builder of the firefighting vessel shall supply a qualified person to provide operational training to fire department personnel that includes the following:

(1) A complete system component familiarization/walk-around
(2) A complete review of the system and its safety features
(3) A review of all operation, service, and maintenance documentation
(4) Hands-on familiarization of the safe operation of the vessel

## Chapter 37 Fire Protection Equipment for the Vessel (NFPA 1925)

**37.1 General.**

**37.1.1** The requirements in *ABS Guidance Notes on Fire-Fighting Systems* shall apply to Type I through Type III marine firefighting vessels.

**37.1.2** The requirements of 46 CFR Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)"; ABYC A-4, *Fire Fighting Equipment*; and NFPA 302 shall apply to Type IV and Type V marine firefighting vessels.

**37.1.3** Type I and Type II marine firefighting vessels shall be equipped with a water curtain or equivalent system to protect the vessel and its equipment during firefighting operations.

**37.1.4** The melting point of the exposed water curtain or equivalent system piping materials shall be equal to or greater than that of the hull structure material.

**37.2 Fire Detection and Alarm Systems.**

**37.2.1** Machinery, accommodation, and service spaces shall be provided with an approved automatic detection system and alarms that indicate at the control station the location of outbreak of a fire.

**37.2.2** Ventilation arrangements to the machinery, accommodation, and service spaces containing the fire detection equipment shall be such as to preclude, as far as practicable, the possibility of smoke from the fire being drawn into those spaces.

**37.2.3** Smoke, heat, or flame detectors shall be of an approved or listed type.

**37.2.4** Carbon monoxide detection shall be provided in accordance with ABYC A-24, *Carbon Monoxide Detection Systems*, and NFPA 302 for vessels fitted with inboard spark ignition engines.

**37.2.5 Detector Location.**

**37.2.5.1** Detectors shall be located in accordance with *NFPA 72* and NFPA 302.

**37.2.5.2** Positions near beams and ventilation ducts where air flow could adversely affect performance shall be avoided.

**37.2.5.3** At least one fire detector shall be provided in each crew accommodation space.

**37.2.5.4** In service spaces, at least one fire detector shall be provided in each enclosed space not normally entered.

**37.2.5.5** Detectors shall be installed and maintained according to the device manufacturer's instructions.

**37.2.6 Control Panels for Type I Through Type III Marine Firefighting Vessels.**

**37.2.6.1** Visual and audible alarm signal panels shall be arranged on the vessel's pilothouse and main control center.

**37.2.6.2** The control panel shall indicate where the detection unit has operated.

**37.2.7** All detectors shall be of a type such that they can be tested and reset to normal surveillance without the renewal of any component.

**37.2.8** Type I through Type III marine firefighting vessels with enclosed engine spaces shall have at least two sources of power for the electrical equipment used in the operation of the fire detection and fire alarm systems, one of which shall be an emergency power source.

**37.2.9** All electrical components shall meet the requirements found in Section 42.1.

**37.3 Fire Protection Water Piping and Pumps.**

**37.3.1** All Type I through Type III vessels shall have at least one fire protection pump.

**37.3.2** The fire protection pump system shall have at least the capacity and at least be powered as shown in Table 37.3.2 in accordance with 46 CFR 181, "Fire Protection Equipment."

**37.3.3** Where sanitary, ballast, bilge, or general service pumps are used as a vessel's fire pump, such pumps shall meet the capacities given in Table 37.3.2 for fire protection.

**37.3.4** All Type I through Type III vessels shall be fitted with a fire protection main.

**37.3.5** The fire protection main shall have drains installed for maintenance and protection from freezing.

**37.3.6** All piping shall be tested in accordance with Chapter 47.

**37.4 Hose Stations.**

**37.4.1** The number and position of hose stations shall be sufficient to reach any part of the vessel with an effective stream of water from a single length of hose.

**37.4.1.1** The pipes and hose stations shall be so placed that the fire hoses can be easily coupled to them.

**37.4.1.2** All hose couplings and nozzles shall be interchangeable throughout the vessel.

**37.4.2** Hose station fire hose shall have a minimum diameter of 1 in. (25 mm) and a maximum length of 75 ft (23 m).

**Table 37.3.2 Fire Protection Pump Capacity and Power Source**

| Minimum Pump Capacity | | | Vessel Length | | | |
|---|---|---|---|---|---|---|
| | | | Greater than | | Less than or Equal to | |
| gpm | L/min | Power Source | ft | m | ft | m |
| 5 | 20 | Hand, electric, or engine driven | 20 | 6 | 40 | 12 |
| 25 | 100 | Electric or engine driven | 40 | 12 | 65 | 20 |
| 50 | 200 | Electric or engine driven | 65 | 20 | 100 | 31 |
| 66.6 | 255 | Electric or engine driven | 100 | 31 | — | — |

**37.4.3** Each fire hose shall be provided with a nozzle and couplings constructed of a compatible and noncorrosive material.

**37.4.4** All fire hoses attached to hose stations in the machinery spaces shall be fitted with combination nozzles.

**37.5 Fixed Inert Gas Extinguishing Systems.**

**37.5.1*** A manually activated fixed inert gas or equivalent extinguishing system shall be installed for all Category A machinery spaces in Type I through Type III vessels.

**37.5.2** Pre-engineered systems located in a Category A machinery space shall be located as high as possible and away from mechanical and natural ventilation.

**37.5.3** Where a fixed gas fire extinguishing system is installed, access doors to the space shall be such that they remain closed at all times with no holdback arrangements.

**37.5.4** For occupiable, protected spaces, audible and visual alarms shall automatically sound and illuminate for at least 20 seconds prior to the discharge of an extinguishing medium into the space.

**37.5.5** Doors to the protected space shall open outward.

**37.5.6** The system shall have two control stations.

**37.5.6.1** One station shall be located near the entrance to the protected space, and the second station shall be located near the helm at the designated fire control station.

**37.5.6.2** These controls shall be protected to prevent accidental discharge of an inert gas extinguishing system into the space.

**37.5.6.3** Operating instructions shall be posted at all control stations.

**37.5.7** Means shall be provided for automatically stopping all ventilating fans, securing the protected space, closing all openings that would permit air to enter the space, and shutting down all internal combustion engines within the affected space.

**37.5.8** Necessary controls shall operate from outside the space.

**37.5.9** Carbon dioxide ($CO_2$) or inert extinguishing gas cylinders shall meet the US Coast Guard, Canadian Transportation Commission, or American Bureau of Shipping requirements and shall be maintained in accordance with NFPA 12 or NFPA 2001 as applicable.

**37.5.10** Cylinders and associated controls shall be securely mounted and protected from weather, corrosion, mechanical damage, and temperatures outside the system's operating range.

**37.5.11** A method of ascertaining the quantity of an inert extinguishing gas within the cylinders shall be provided.

**37.5.12** Piping, valves, and fittings shall meet the requirements of 46 CFR 56, "Piping Systems and Appurtenances"; *ABS Rules for Building and Classing Steel Vessels*; NFPA 12; and NFPA 2001 as applicable.

**37.5.13** Piping shall be arranged and discharge nozzles positioned such that uniform distribution of the medium is attained.

**37.5.14** Fixed inert gas extinguishing systems shall have sufficient quantity of inert gas to provide at least the minimum effective concentration for the gross volume of the protected space.

**37.5.15** Discharge nozzles shall be listed and approved for discharge characteristics.

**37.5.16** Each discharge nozzle shall be permanently marked to identify the equivalent single orifice diameter.

**37.5.17** The total area of all discharge nozzles shall not exceed 85 percent or be less than 35 percent of nominal cylinder outlet area or the area of the supply pipe, whichever is smaller.

**37.5.18** All dead-end lines shall extend 2 in. (50 mm) beyond the last orifice and shall be closed with a cap or plug.

**37.5.19** All piping, valves, and fittings shall be securely supported and, where necessary, protected against mechanical damage.

**37.5.20** Drains and dirt traps shall be fitted where necessary to prevent the accumulation of dirt or moisture and shall be readily accessible.

**37.6 Hand Portable/Semiportable Fire Extinguishers.**

**37.6.1*** Portable fire extinguishers shall be provided, located, and maintained in accordance with NFPA 10; Chapter 12 of NFPA 302; ABYC A-4, *Fire Fighting Equipment*; and 46 CFR 25.30, "Fire-Extinguishing Equipment."

**37.6.2** Whenever propulsion or pumping engines and generator sets are enclosed in housings, a portable extinguisher sized for the volume of the enclosed housing shall be provided so that the extinguishing agent can be discharged into the enclosure without opening it.

## Chapter 38 Firefighting and Emergency Equipment for the Vessel (NFPA 1925)

**38.1 General.**

**38.1.1** Firefighting equipment that is specified in this chapter and required for a given class of vessel shall be supplied and mounted or stowed as determined by the AHJ prior to the vessel being placed in operation in accordance with Table 38.1.1(a) and Table 38.1.1(b).

**38.1.2** Firefighting equipment specified in this chapter are minimum requirements for the given type of vessel and shall be mounted or stowed securely utilizing the manufacturer's recommendations along with standard marine practices.

**38.1.2.1** Portable gasoline equipment and containers shall be stored in a well-ventilated storage compartment so that vapors are vented overboard and away from air intakes in accordance with ABYC H-25, *Portable Marine Gasoline Fuel Systems.*

**38.1.2.2** Any electrical equipment installed within the storage compartment shall be ignition protected as defined by ABYC E-11, *AC and DC Electrical Systems on Boats.*

**Table 38.1.1(a) Firefighting Equipment (US Units)**

| | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** |
| Line gun | 1 | — | 1 | — | 1 | — | — | Optional per AHJ | — | Optional per AHJ |
| Pry bar | 2 | 6 ft | 2 | 6 ft | 2 | 6 ft | 1 | Optional/ Length per AHJ | 1 | Optional/ Length per AHJ |
| Bolt cutter | 1 | 24 in. | 1 | 24 in. | 1 | 24 in. | 1 | 24 in. | 1 | 24 in. |
| Pike pole | 2<br>2 | 15 ft<br>6 ft | 2<br>2 | 15 ft<br>6 ft | 2<br>2 | 15 ft<br>6 ft | 1<br>— | 10 ft or 6 ft<br>— | 1<br>— | 6 ft or longer<br>— |
| Scoop shovel | 2 | — | 2 | — | 2 | — | 1 | — | — | Optional per AHJ |
| Adjustable hydrant wrench | 2 | — | 2 | — | 2 | — | 1 | — | 1 | — |
| Sprinkler shutoff/ wedge | 4 | — | 4 | — | 4 | — | 2 | — | 1 | — |
| Utility rope | 2 | 100 ft | 2 | 100 ft | 2 | 100 ft | 1 | 100 ft | 1 | 100 ft |
| Floating stretcher with harness | 2 | — | 2 | — | 2 | — | 1 | — | — | Optional per AHJ |
| Portable extinguisher | 4 | 2-A:20-B:C | 4 | 2-A:20-B:C | 4 | 2-A:20-B:C | 1 | 2-A:20-B:C | 1 | 2-A:10-B:C |
| Dry chemical extinguisher | 2 | 80-B:C | 2 | 80-B:C | 2 | 80-B:C | 1 | 80-B:C | 1 | 80-B:C |
| Electrical extension cords | 2 | 100 ft | 2 | 100 ft | 2 | 100 ft | 1 | 50 ft | — | Optional per AHJ |
| Flathead axe | 1 | 6 lb | 1 | 6 lb | 1 | 6 lb | 1 | 6 lb | 1 | 6 lb |
| Pick head axe | 1 | 6 lb | 1 | 6 lb | 1 | 6 lb | — | Optional per AHJ | — | Optional per AHJ |
| Halligan tools or equivalent | 2 | 6 lb | 2 | 6 lb | 2 | 6 lb | 1 | 6 lb | — | Optional per AHJ |
| Spanner wrench | 8 | — | 8 | — | 8 | — | 4 | — | 4 | — |
| Sledgehammer | 1 | 10 lb | 1 | 10 lb | 1 | 10 lb | 1 | 10 lb | — | Optional per AHJ |
| Grappling hook | 2 | — | 2 | — | 2 | — | 1 | — | — | Optional per AHJ |
| Ropes in throw bag | 2 | 75 ft | 2 | 75 ft | 2 | 75 ft | 1 | 75 ft | 1 | 75 ft |
| Heaving line | 2 | 75 ft | 2 | 75 ft | 2 | 75 ft | 1 | 75 ft | — | Optional per AHJ |
| NFPA 2500 life safety rope | 1 | 100 ft | 1 | 100 ft | 1 | 100 ft | — | Optional per AHJ | — | Optional per AHJ |
| Jet siphons | 2<br>2 | 2½ in. to 3½ in. or larger<br>1½ in. to 2½ in. | 2<br>2 | 2½ in. to 3½ in. or larger<br>1½ in. to 2½ in. | 2<br>2 | 2½ in. to 3½ in. or larger<br>1½ in. to 2½ in. | —<br>1 | Optional per AHJ<br>1½ in. to 2½ in. | —<br>— | Optional per AHJ<br>Optional per AHJ |

*(continues)*

**Table 38.1.1(a)** *Continued*

| Equipment | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Qty | Size | Qty | Size | Qty | Size | Qty | Size | Qty | Size |
| Positive or negative pressure fan (portable) | 2 | Size per AHJ | 2 | Size per AHJ | 2 | Size per AHJ | — | N/A | — | N/A |
| Gasoline-powered chain saw | 1 | — | 1 | — | 1 | — | — | Optional per AHJ | — | N/A |
| Portable oxygen gas cutting set or equal | 1 | — | 1 | — | 1 | — | — | N/A | — | N/A |
| Hydraulic rescue tool | 1 | Gas powered or manually operated | 1 | Gas powered or manually operated | 1 | Gas powered or manually operated | — | Optional per AHJ | — | N/A |

N/A = Not applicable.

**38.1.3** All fire service equipment required by this chapter and Table 33.1 shall meet the requirements of the following NFPA standards applicable to the particular type of equipment:

(1) NFPA 10
(2) NFPA 1931
(3) NFPA 1961
(4) NFPA 1963
(5) NFPA 1964
(6) NFPA 1981
(7) NFPA 2500

**38.1.4** Type I through Type III vessels shall be outfitted with a minimum complement of the equipment identified in Table 38.1.1(a) and Table 38.1.1(b).

**38.2 Self-Contained Breathing Apparatus (SCBA).**

**38.2.1*** All SCBA shall be in accordance with this section and Table 38.2.1 and shall meet the requirements of NFPA 1981.

**38.2.2** Stowage of SCBA in compartments shall be secure and shall use racks to allow rapid donning.

**38.2.3** Stowage space shall be provided for spare breathing air cylinders in racks.

**38.3 Fire Hose and Appliances.**

**38.3.1 Fire Hose.** All fire hose shall be in accordance with Table 38.3.1(a) or Table 38.3.1(b) and shall meet the requirements of NFPA 1961.

**38.3.2 Fire Hose Storage.** Weather-protected stowage compartments shall be provided for firefighting equipment and appliances.

**38.3.3 Couplings.** All couplings on fire hose shall meet the requirements of NFPA 1963.

**38.3.4 Nozzles.**

**38.3.4.1** All nozzles shall be in accordance with Table 38.3.1(a) or Table 38.3.1(b) and meet the requirements of NFPA 1964.

**38.3.4.2** All nozzles and accessories shall be of corrosion-resistant construction.

**38.3.5 Couplings and Appliances.** All connections on appliances shall comply with the requirements of NFPA 1963.

**38.4 Rescue/Work Boat.** Type I and Type II vessels shall be outfitted with a motorized rescue/work vessel capable of safely carrying a minimum of two firefighters in full protective clothing and SCBA and a minimum weight-bearing capacity of 1500 lb (680 kg).

**38.5 Required Safety Equipment.** All vessels shall carry the appropriate US Coast Guard safety equipment required for the size and operational territory of the vessel.

**38.6* Medical and First Aid Equipment.** All vessels shall carry basic medical and first aid supplies as specified by the AHJ and coordinated with the user, as applicable, based on the intended use and mission of the vessel and the requirements of Section 43.13.

**Table 38.1.1(b) Firefighting Equipment (SI Units)**

| | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** |
| Line gun | 1 | — | 1 | — | 1 | — | — | Optional per AHJ | — | Optional per AHJ |
| Pry bar | 2 | 1.8 m | 2 | 1.8 m | 2 | 1.8 m | 1 | Optional/ Length per AHJ | 1 | Optional/ Length per AHJ |
| Bolt cutter | 1 | 610 mm | 1 | 610 mm | 1 | 610 mm | 1 | 610 mm | 1 | 610 mm |
| Pike pole | 2<br>2 | 4.5 m<br>1.8 m | 2<br>2 | 4.5 m<br>1.8 m | 2<br>2 | 4.5 m<br>1.8 m | 1<br>— | 3 m or<br>1.8 m | —<br>1 | —<br>1.8 m or longer |
| Scoop shovel | 2 | — | 2 | — | 2 | — | 1 | — | — | Optional per AHJ |
| Adjustable hydrant wrench | 2 | — | 2 | — | 2 | — | 1 | — | 1 | — |
| Sprinkler shutoff/ wedge | 4 | — | 4 | — | 4 | — | 2 | — | 1 | — |
| Utility rope | 2 | 30 m | 2 | 30 m | 2 | 30 m | 1 | 30 m | 1 | 30 m |
| Floating stretcher with harness | 2 | — | 2 | — | 2 | — | 1 | — | — | Optional per AHJ |
| Portable extinguisher | 4 | 2-A:20-B:C | 4 | 2-A:20-B:C | 4 | 2-A:20-B:C | 1 | 2-A:20-B:C | 1 | 2-A:10-B:C |
| Dry chemical extinguisher | 2 | 80-B:C | 2 | 80-B:C | 2 | 80-B:C | 1 | 80-B:C | 1 | 80-B:C |
| Electrical extension cords | 2 | 30 m | 2 | 30 m | 2 | 30 m | 1 | 15 m | — | Optional per AHJ |
| Flathead axe | 1 | 2.7 kg | 1 | 2.7 kg | 1 | 2.7 kg | 1 | 2.7 kg | 1 | 2.7 kg |
| Pick head axe | 1 | 2.7 kg | 1 | 2.7 kg | 1 | 2.7 kg | — | Optional per AHJ | — | Optional per AHJ |
| Halligan tools or equivalent | 2 | 2.7 kg | 2 | 2.7 kg | 2 | 2.7 kg | 1 | 2.7 kg | — | Optional per AHJ |
| Spanner wrench | 8 | — | 8 | — | 8 | — | 4 | — | 2 | — |
| Sledge hammer | 1 | 4.5 kg | 1 | 4.5 kg | 1 | 4.5 kg | 1 | 4.5 kg | — | Optional per AHJ |
| Grappling hook | 2 | — | 2 | — | 2 | — | 1 | — | — | Optional per AHJ |
| Ropes in throw bag | 2 | 23 m | 2 | 23 m | 2 | 23 m | 1 | 23 m | 1 | 23 m |
| Heaving line | 2 | 23 m | 2 | 23 m | 2 | 23 m | 1 | 23 m | — | Optional per AHJ |
| NFPA 2500 life safety rope | 1 | 30 m | 1 | 30 m | 1 | 30 m | — | Optional per AHJ | — | Optional per AHJ |
| Jet siphons | 2<br><br>2 | 65 mm to 90 mm or larger<br>38 mm to 65 mm | 2<br><br>2 | 65 mm to 90 mm or larger<br>38 mm to 65 mm | 2<br><br>2 | 65 mm to 90 mm or larger<br>38 mm to 65 mm | 1<br>*or*<br>1 | 65 mm to 90 mm or larger<br><br>38 mm to 65 mm | —<br><br>— | Optional per AHJ<br><br>Optional per AHJ |

*(continues)*

**Table 38.1.1(b)** *Continued*

| Equipment | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Qty | Size | Qty | Size | Qty | Size | Qty | Size | Qty | Size |
| Positive or negative pressure fan (portable) | 2 | Size per AHJ | 2 | Size per AHJ | 2 | Size per AHJ | — | N/A | — | N/A |
| Gasoline-powered chain saw | 1 | — | 1 | — | 1 | — | — | Optional per AHJ | — | N/A |
| Portable oxygen gas cutting set or equal | 1 | — | 1 | | 1 | — | — | N/A | — | N/A |
| Hydraulic rescue tool | 1 | Gas powered or manually operated | 1 | Gas powered or manually operated | 1 | Gas powered or manually operated | — | Optional per AHJ | — | N/A |

N/A = Not applicable.

**Table 38.2.1 Self-Contained Breathing Apparatus (SCBA)**

| Equipment | Type I Qty | Type II Qty | Type III Qty | Type IV Qty | Type V Qty |
|---|---|---|---|---|---|
| **SCBA (at least)** | 1 per crew<br>1 spare set | 1 per crew<br>1 spare set | 1 per crew<br>1 spare set | 1 per crew<br>1 spare set | 1 per crew<br>1 spare set |
| **Spare SCBA Cylinder** | 2 spare cylinders per crew SCBA carried | Same as Type I | Same as Type I | 1 spare cylinder per crew SCBA carried | 1 spare cylinder per crew SCBA carried |

**Table 38.3.1(a) Fire Hoses, Fittings and Appliances (US Units)**

| | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** |
| Large-diameter hose | 600 ft | 3½ in. or larger | 600 ft | 3½ in. or larger | 400 ft | 3½ in. or larger | 200 ft | 3½ in. or larger | — | N/A |
| Attack hose (large) | 600 ft | 2½ in. or 3 in. | 600 ft | 2½ in. or 3 in. | 400 ft | 2½ in. or 3 in. | 200 ft | 2½ in. or 3 in. | — | N/A |
| Attack hose (small) | 600 ft | 1½ in., 1¾ in., or 2 in. | 600 ft | 1½ in., 1¾ in., or 2 in. | 400 ft | 1½ in., 1¾ in., or 2 in. | 200 ft | 1½ in., 1¾ in., or 2 in. | 200 ft | 1½ in., 1¾ in., or 2 in. |
| Combination nozzle with shutoff | 4<br>4 | 2½ in.<br>1½ in. | 4<br>4 | 2½ in.<br>1½ in. | 4<br>4 | 2½ in.<br>1½ in. | 2<br>2 | 2½ in.<br>1½ in. | 2<br>— | 1½ in. or 2½ in.<br>N/A |
| Cellar or distributor nozzle | 2 | 2½ in. | 2 | 2½ in. | 2 | 2½ in. | 1 | 2½ in. | — | N/A |
| Foam eductor with matching nozzle (portable) | —<br>— | Optional per AHJ<br>Optional per AHJ | —<br>— | Optional per AHJ<br>Optional per AHJ | —<br>— | Optional per AHJ<br>Optional per AHJ | —<br>— | Optional per AHJ<br>Optional per AHJ | —<br>— | N/A<br>N/A |
| **Couplings:** | | | | | | | | | | |
| Double male | 2 | Consistent with large-diameter hose used | 2 | Same as Type I | 2 | Same as Type I | 2 | Same as Type I | — | N/A |
| Double female | 2 | Consistent with large-diameter hose used | 2 | Same as Type I | 2 | Same as Type I | 2 | Same as Type I | — | N/A |
| Double males | 2 | 2½ in. | 2 | 2½ in. | 2 | 2½ in. | 2 | 2½ in. | — | Consistent with hose used |
| Double females | 2 | 2½ in. | 2 | 2½ in. | 2 | 2½ in. | 2 | 2½ in. | — | Consistent with hose used |
| **Reducers:** | | | | | | | | | | |
| Large-diameter to 2½ in. | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 2½ in. to 1½ in. | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| **Increasers:** | | | | | | | | | | |
| 2½ in. to large-diameter | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| **Wyes:** | | | | | | | | | | |
| 2½ in. × 1½ in. × 1½ in. gated | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 2½ in. gated | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| Large-diameter to 2–2½ in. gated | 1 | — | 1 | — | 1 | — | — | N/A | — | N/A |
| 2½ in. plug (male thread) | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 2½ in. cap (female thread) | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 2½ in. Siamese | 2 | — | 2 | — | 1 | — | — | N/A | — | N/A |
| International shore connection | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |

N/A = Not applicable.

**Table 38.3.1(b) Fire Hoses, Fittings and Appliances (SI Units)**

| | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Equipment** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** | **Qty** | **Size** |
| Large-diameter hose | 180 m | 90 mm or larger | 180 m | 90 mm or larger | 120 m | 90 mm or larger | 60 m | 90 mm or larger | — | N/A |
| Attack hose (large) | 180 m | 65 mm or 76 mm | 180 m | 65 mm or 76 mm | 120 m | 65 mm or 76 mm | 60 m | 65 mm or 76 mm | — | N/A |
| Attack hose (small) | 180 m | 38 mm, 45 mm, or 50 mm | 180 m | 38 mm, 45 mm, or 50 mm | 120 m | 38 mm, 45 mm, or 50 mm | 60 m | 38 mm, 45 mm, 50 mm | 60 m | 38 mm, 45 mm, 50 mm |
| Combination nozzle with | 4 | 65 mm | 4 | 65 mm | 4 | 65 mm | 2 | 65 mm | 2 | 38 mm or 65 mm |
| shutoff | 4 | 38 mm | 4 | 38 mm | 4 | 38 mm | 2 | 38 mm | — | N/A |
| Cellar or distributor nozzle | 2 | 65 mm | 2 | 65 mm | 2 | 65 mm | 1 | 65 mm | — | N/A |
| Foam eductor with | — | Optional per AHJ | — | Optional per AHJ | — | Optional per AHJ | — | Optional per AHJ | — | N/A |
| matching nozzle (portable) | — | Optional per AHJ | — | Optional per AHJ | — | Optional per AHJ | — | Optional per AHJ | — | N/A |
| **Couplings:** | | | | | | | | | | |
| Double male | 2 | Consistent with large-diameter hose used | 2 | Same as Type I | 2 | Same as Type I | 2 | Same as Type I | — | N/A |
| Double female | 2 | Consistent with large-diameter hose used | 2 | Same as Type I | 2 | Same as Type I | 2 | Same as Type I | — | N/A |
| Double males | 2 | 65 mm | 2 | 65 mm | 2 | 65 mm | 2 | 65 mm | — | Consistent with hose used |
| Double females | 2 | 65 mm | 2 | 65 mm | 2 | 65 mm | 2 | 65 mm | — | Consistent with hose used |
| **Reducers:** | | | | | | | | | | |
| Large-diameter to 65 mm | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 65 mm to 38 mm | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| **Increasers:** | | | | | | | | | | |
| 65 mm to large-diameter | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| **Wyes:** | | | | | | | | | | |
| 65 mm × 38 mm × 38 mm gated | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 65 mm gated | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| Large-diameter to 50–65 mm gated | 1 | — | 1 | — | 1 | — | — | N/A | — | N/A |

*(continues)*

**Table 38.3.1(b)** *Continued*

| Equipment | Type I | | Type II | | Type III | | Type IV | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Qty | Size | Qty | Size | Qty | Size | Qty | Size | Qty | Size |
| 65 mm plug (male thread) | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 65 mm cap (female thread) | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |
| 65 mm Siamese | 2 | — | 2 | — | 1 | — | — | N/A | — | N/A |
| International shore connection | 2 | — | 2 | — | 2 | — | 1 | — | — | N/A |

N/A = Not applicable.

## Chapter 39 Marine Firefighting Vessel Stability and Subdivision (NFPA 1925)

### 39.1 Subdivision.

#### 39.1.1 Standard of Subdivision.

**39.1.1.1** Marine firefighting vessels shall meet the standard of subdivision required for the individual type, as described in Table 39.1.1.1.

**39.1.1.2** The marine firefighting vessel shall be presumed to be in a maximum design load condition when damage occurs.

**39.1.1.3** Where watertight doors are fitted in subdivision bulkheads, they shall be permitted to be fitted with indicators of open/closed status at the main control station.

#### 39.1.2 Collision Bulkheads.

**39.1.2.1** A collision bulkhead shall be fitted to all marine firefighting vessels of Types I through III, in accordance with the requirements of *ABS Rules for Building and Classing Steel Vessels*.

**39.1.2.2** A collision bulkhead shall be fitted to all marine firefighting vessels of Type IV, in accordance with the requirements of ABYC fire protection standards.

**39.1.2.3** A collision bulkhead shall be fitted to all fireboats, located at least 5 percent of the length between perpendiculars and no more than 5 percent plus 10 ft (3 m) from the point where the stem intersects the waterline.

**39.1.2.4** Penetrations or openings in the collision bulkhead shall be watertight and placed as high and as far inboard as practicable.

#### 39.1.3 Positive Flotation.

**39.1.3.1** Vessels of Type IV and V shall be fitted with positive flotation or an equivalent level of subdivision or compartmentalization.

**39.1.3.2** The amount of flotation shall be sufficient to support the weight of the fully laden boat in fresh water, plus 10 percent of that weight.

**39.1.3.3** Flotation shall be in the form of either buoyancy tanks, foam blocks, or hull structure.

**39.1.3.4** Flotation shall be secured in place and shall retain its effectiveness after submergence in fresh water after 24 hours.

### 39.2 Intact Stability.

#### 39.2.1 Design Objectives.

**39.2.1.1** Every marine firefighting vessel shall have stability characteristics commensurate with its intended service and its intended area of operation.

**39.2.1.2** Every marine firefighting vessel shall have, when new, an allowance/margin built into the design for appreciable growth in weight of systems and equipment throughout its life.

**39.2.1.3** Every marine firefighting vessel shall be designed to provide a platform that is safe and stable for the operating crews, recognizing that the crews are in most cases not likely to be seasoned seafarers.

**39.2.1.4** All possible operations of the marine firefighting vessel shall be addressed in the stability analysis of the vessel, including deployment and operation of all monitors, lateral thrusters, cranes, ladders, workboats, and so forth.

**39.2.1.5** The stability of planing and semi-planing craft shall be carefully assessed, including operation at full speed.

**Table 39.1.1.1 Vessel Subdivision Standards**

| Type of Marine Firefighting Vessel | Types I, II, and III | Type IV | Type V |
|---|---|---|---|
| Requirements for compartment | One compartment | Collision bulkhead, and able to survive largest compartment flooding, or positive flotation | Positive flotation |

**39.2.2 Stability Criteria.**

**39.2.2.1** Marine firefighting vessels, according to their type, shall comply fully with the latest published relevant standard for marine firefighting vessel stability as described in Table 39.2.2.1.

**39.2.2.2** Every new marine firefighting vessel shall have intact stability characteristics that, when new, are not less than 20 percent in excess of the minimum criteria stipulated in Table 39.2.2.1.

**39.2.2.3** In no case shall the stability characteristics of a Type I, II, or III marine firefighting vessel be less than those permitted by IMO A 18, Resolution 749, *Code on Intact Stability for All Types of Ships Covered by IMO Instruments.*

**39.2.3 Stability Calculations.**

**39.2.3.1** Detailed calculations shall be submitted to the pertinent regulatory authority for approval where applicable, and/or to the AHJ for acceptance, describing the following:

(1) The adequacy of the marine firefighting vessel's stability during all firefighting operations
(2) The adequacy of propulsion power and steering capability required for the marine firefighting vessel to maintain station and hold position during firefighting operations

**39.2.3.2** The stability information shall be placed onboard the marine firefighting vessel for the information and guidance of the master and shall become part of the vessel operating booklet.

**39.2.3.3** The master of the marine firefighting vessel shall receive training in the use of formal stability documentation.

**Table 39.2.2.1 Intact Stability Criteria for Marine Firefighting Vessels**

| | Type I | Type II | Type III | Type IV | Type V |
|---|---|---|---|---|---|
| Applicable Stability Criteria | *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length* | *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length* | *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length* | ISO 12217-1, Category C vessel[a] | ISO 12217-1, Category C or D vessel[a] |
| Maximum Heel Angle — Monitor Reactions | 7 degrees maximum 5 degrees recommended | 7 degrees maximum 5 degrees recommended | 7 degrees maximum 5 degrees recommended | An angle that would immerse a maximum of ½ the full load freeboard, or 7 degrees maximum | An angle that would immerse a maximum of ½ the full load freeboard, or 7 degrees maximum |
| Maximum Heel Angle — Crane Operations | 5 degrees, or manufacturer's maximum allowable heel or trim or combination thereof | 5 degrees, or manufacturer's maximum allowable heel or trim or combination thereof | 5 degrees, or manufacturer's maximum allowable heel or trim or combination thereof | 5 degrees, or manufacturer's maximum allowable heel or trim or combination thereof | Not applicable (Assumes no crane fitted; if a crane is fitted, apply same criteria as Type IV) |
| Passenger Heel | Full | Full | Full | Simple | Simple |
| Wind Heel | Full | Full | Full | Simple | Simple |
| Towing Criteria | Only if fitted with a towing winch | Only if fitted with a towing winch | No | No | No |
| Icing Criteria | As applicable to area of operation | As applicable to area of operation | As applicable to area of operation | As applicable to area of operation | As applicable to area of operation |
| Test Required | Inclining experiment | Inclining experiment | Inclining experiment | Physical weighing or lightship/ deadweight survey[b,c] | Physical weighing or lightship/ deadweight survey[b,c] |

[a]ISO 12217-1, *Small Craft — Stability and Buoyancy Assessment and Categorization — Part 1: Non-Sailing Boats of Hull Length Greater Than or Equal to 6 m.*
[b]If the lightship weight determined by this test varies by more than 3 percent from that calculated or defined at the time of contract signing, then an inclining experiment shall be performed to accurately establish the position of the vertical center of gravity (VCG).
[c]Acceptance of a lightship survey assumes that the position of the vessel center of gravity (CG) is defined by detailed calculation, and thus results in acceptable heel, trim, and stability characteristics. If such a calculation cannot be provided, then a full inclining experiment shall be performed.

**39.2.4 Specific Stability Concerns.**

**39.2.4.1 Monitor Heel.**

**39.2.4.1.1** Each marine firefighting vessel shall have adequate stability for the full range of firefighting operation conditions, with all firefighting monitors operating at maximum output, in the direction most unfavorable to the stability of the marine firefighting vessel.

**39.2.4.1.2** The maximum heel induced by the worst combination of thrust produced by monitor reaction and by the counteracting thrust from lateral thrusters, rudders, and so forth, shall not exceed the limits described in Table 39.2.2.1.

**39.2.4.1.3** Where compliance with the specific criteria for maximum heel angle stipulated in Table 39.2.2.1 would compromise other critical aspects of the effectiveness or safe operation of the marine firefighting vessel, stability calculations shall be developed that confirm compliance with Part 5, Chapter 9, Appendix 1, Section 5.3 of *ABS Rules for Building and Classing Steel Vessels Under 90 meters (295 ft) in Length,* and that produce a maximum heel angle that the owner is prepared to accept as safe for the operation of the vessel and its crew.

**39.2.4.2 Crane Operations.**

**39.2.4.2.1** The stability of the marine firefighting vessel shall be evaluated under the influence of the maximum heeling moment imposed by operation of any crane or similar lifting device installed aboard the marine firefighting vessel.

**39.2.4.2.2** The maximum heel induced by crane operations shall not exceed the limits defined in Table 39.2.2.1.

**39.2.4.2.3** The manufacturer's certificate for the crane shall clearly identify that the crane is certified for operation at the defined maximum angle of heel or trim or combination thereof.

**39.2.5 Wind and Weather Influences.**

**39.2.5.1** The effects of prevailing wind and weather conditions in the area of operation shall be taken into account by application of wind heel criteria.

**39.2.5.2** Stability criteria shall be met after application of applicable wind-heel criteria.

**39.2.6 Icing.**

**39.2.6.1** The effects of icing and freezing spray on the marine firefighting vessel's stability shall be considered for marine firefighting vessels operating in areas where such conditions exist.

**39.2.6.2** International Standards Organization (ISO) criteria for icing of fishing vessels shall be used as a standard to determine the effects of icing.

**39.2.6.3** Where the potential exists for icing of the marine firefighting vessel, effective means of reducing or eliminating the presence of ice accumulation on the marine firefighting vessel shall be provided.

**39.2.6.4** The vessel shall be presumed to be in a full-load condition when damage occurs.

**39.2.6.5** The use of watertight doors in subdivision bulkheads shall be avoided.

**39.3 Flotation.**

**39.3.1** Type V vessels shall be fitted with positive flotation in lieu of having subdivision.

**39.3.2** The amount of flotation shall be equivalent to the weight of the fully loaded vessel in fresh water plus 10 percent.

**39.3.3** The vessel shall be assumed to be intact but completely swamped.

**39.3.4** Flotation shall be permitted to be in the form of buoyancy tanks, foam blocks, or hull structure.

**39.3.5** Flotation shall be secured in place and shall retain its effectiveness after submergence in fresh water for 24 hours.

**39.4 Loading Conditions.**

**39.4.1** The loading conditions to be evaluated for the intact stability calculations for normal vessel loads shall include those listed as follows:

(1) Full load consists of the following:
   (a) 95 percent fuel
   (b) 100 percent foam concentrate
   (c) 100 percent potable water
   (d) 100 percent stores
   (e) Normal crew and their effects
(2) 50 percent load consists of the following:
   (a) 50 percent fuel
   (b) 100 percent foam concentrate
   (c) 50 percent potable water
   (d) 50 percent stores
   (e) Normal crew and their effects
(3) 10 percent consumables consists of the following:
   (a) 10 percent fuel
   (b) 100 percent foam concentrate
   (c) 10 percent potable water
   (d) 10 percent stores
   (e) Normal crew and their effects

**39.4.2** The loading conditions to be evaluated for the intact stability calculations for firefighting loads shall include those listed as follows:

(1) Maximum load consists of the same as full load in 39.4.1, plus the following:
   (a) Water in fire main
   (b) Elevating tower or platform at maximum extension
   (c) Extra crew and their effects
(2) Minimum load consists of the same as 10 percent consumables in 39.4.1 plus the following:
   (a) 10 percent foam concentrate
   (b) Water in fire main
   (c) Elevating tower or platform at maximum extension
   (d) Extra crew and their effects

**39.4.3** Where asymmetric loading conditions can occur due to tank configurations, their effect on stability shall also be calculated.

**39.4.4** Calculations showing the maximum passenger capacity on deck, the maximum equipment weight on deck, and the total of the two parameters previously cited shall be prepared.

## Chapter 40 Main Propulsion and Auxiliary Engines (NFPA 1925)

**40.1 General.**

**40.1.1** Installation requirements for marine propulsion systems that include engines, reduction gears, power takeoffs, and final drives shall be incorporated by reference to Chapter 5 of NFPA 302; ABYC H-2, *Ventilation of Boats Using Gasoline*; ABYC H-24, *Gasoline Fuel Systems*; ABYC H-26, *Powering of Boats*; ABYC H-32, *Ventilation of Boats Using Diesel Fuel*; ABYC H-33, *Diesel Fuel Systems*; ABYC P-1, *Installation of Exhaust Systems for Propulsion and Auxiliary Engines*; ABYC P-4, *Marine Inboard Engines and Transmissions;* ABYC P-6, *Propeller Shafting Systems*; ABYC P-14, *Mechanical Propulsion Control Systems*; ABYC P-24, *Electric/Electronic Propulsion Control Systems*, as applicable, and other standards for the type of vessel and intended use.

**40.1.2** Installation requirements for marine auxiliary engine systems that include engines, power takeoffs, and auxiliary machinery shall be incorporated by reference to Chapters 5 and 10 of NFPA 302; ABYC H-2, *Ventilation of Boats Using Gasoline*; ABYC H-24, *Gasoline Fuel Systems*; ABYC H-32, *Ventilation of Boats Using Diesel Fuel*; ABYC H-33, *Diesel Fuel Systems*; ABYC P-1, *Installation of Exhaust Systems for Propulsion and Auxiliary Engines*; ABYC P-4, *Marine Inboard Engines and Transmissions*; ABYC P-6, *Propeller Shafting Systems*; ABYC P-14, *Mechanical Propulsion Control Systems*, as applicable, and other standards for the type of vessel and its intended use.

**40.1.3** Marine propulsion systems and auxiliary engine systems shall conform to the component manufacturer's installation requirements and proposed operating requirements.

**40.1.4** The marine propulsion system(s) duty rating shall meet the component manufacturer's requirement for vessel use, considering factors such as time at full throttle, annual operating hours, final drive horsepower requirements, hull type, and probable time at severe load conditions.

**40.1.5** As constrained by Sections 40.2 and 40.3, auxiliary engines on Type I through Type III vessels shall be of the diesel fuel type.

**40.2 Outboard Engines.**

**40.2.1** Outboard engines shall be permitted to be gasoline fueled in accordance with ABYC H-25, *Portable Marine Gasoline Fuel Systems*; ABYC H-26, *Powering of Boats*; ABYC S-30, *Outboard Engine and Related Equipment Weights*; and ABYC TH-12, *Outboard Engine Mounting Guide*.

**40.2.2** Vessels shall be required to have permanently affixed fuel systems.

**40.2.3** Steering systems shall comply with ABYC P-17, *Mechanical Steering Systems*, and ABYC P-18, *Cable Over Pulley Steering Systems for Outboard Engines*.

**40.2.4** Mountings of the outboard engines and fit of the outboard(s) with a transom shall comply with ABYC TH-12, *Outboard Engine Mounting Guide*.

**40.3 Inboard Engines.**

**40.3.1 Vessel Types.**

**40.3.1.1** For Type I through Type IV vessels, inboard propulsion and auxiliary engines shall be of the diesel fuel type.

**40.3.1.2** Type I and Type II vessels shall comply with *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*.

**40.3.1.3** Type III through Type V vessels shall comply with ABYC P-4, *Marine Inboard Engines and Transmissions*.

**40.3.2** An engine governor shall be provided to limit the speed of the engine to that speed established by the manufacturer as the no-load governed speed.

**40.3.3* Propulsion Engine Horsepower.**

**40.3.3.1** Where a fire pump is driven by a propulsion engine, the pump drive system shall be rated to at least the rated capacity of the pump.

**40.3.3.2** Horsepower requirements for propulsion engines, designed for simultaneously powering one or more fire pumps and a propulsion/steering device, shall not exceed 80 percent of the engine's rated horsepower while at maximum pumping capacity, leaving a minimum 20 percent of the engine's power for maneuvering.

**40.3.4 Engine Shutdown.**

**40.3.4.1*** With the exception of outboard motors, automatic engine shutdown and power reduction shall not be permitted.

**40.3.4.2** Audible and visual warning devices for high engine temperature and low oil pressure, convenient to the operator's position at the helm, shall be installed for each engine.

**40.4 Power Trains Using Inboard Engines.**

**40.4.1** Inboard-mounted propulsion assemblies, including the diesel engine, reduction gear, power take-off (PTO) or clutch, couplings, shafting, and final drive system, shall have a torsional vibration analysis and whirling calculation conducted during the design stage to verify component compatibility and suitability for the service intended.

**40.4.2** The requirement in 40.4.1 shall also comply with *ABS Rules for Conditions of Classification — High Speed Craft* for Type I and Type II vessels.

**40.4.3** Driveline systems shall have horsepower and speed ratings compatible with the supplied propulsion engine.

**40.4.4** The reduction gear cooling system, controls, and instruments shall conform to *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* for Type I and Type II vessels and ABYC P-4, *Marine Inboard Engines and Transmissions*; ABYC P-6, *Propeller Shafting Systems*; ABYC P-14, *Mechanical Propulsion Control Systems*; ABYC P-23, *Mechanical Steering and Propulsion Controls for Jet Boats*; and ABYC P-24, *Electric/Electronic Propulsion Control Systems*, as appropriate for Type III through Type V and to the manufacturers' installation and proposed operating requirements.

**40.4.5 Shafting Requirements.** Shafting requirements shall conform to one of the following documents:

(1) *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*
(2) *ABS Rules for Conditions of Classification — High Speed Craft*
(3) ABYC P-6, *Propeller Shafting Systems*

**40.4.6 Propellers.**

**40.4.6.1** Propeller systems shall conform to the standards within *ABS Rules for Building and Classing Steel Vessels for Service*

*on Rivers and Intracoastal Waterways* or *ABS Rules for Conditions of Classification — High Speed Craft* for Type I and Type II vessels and ABYC P-6, *Propeller Shafting Systems,* for Type III through Type V vessels.

**40.4.6.2** Propellers shall be sized and pitched to allow the engine to operate within the engine manufacturers' specifications under the vessel's most severe load conditions.

**40.4.7** Steering systems shall comply with ABYC P-17, *Mechanical Steering Systems*; ABYC P-18, *Cable Over Pulley Steering Systems for Outboard Engines*; ABYC P-21, *Manual Hydraulic Steering Systems*; and ABYC P-22, *Steering Wheels*, for Type III through Type V vessels and *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* or *ABS Rules for Conditions of Classification — High Speed Craft*, for Type I and Type II vessels.

**40.4.8** Where a jet drive engine is also used to drive the fire pump, jet drives shall have infinite control capability for reversing the discharge flow to provide station keeping ability.

**40.4.9** Jet pump inlet grille(s) shall have provisions for clearing the intake area.

**40.5 Engine Systems.**

**40.5.1 General.**

**40.5.1.1** Required engine fuel, exhaust, cooling, starting, ventilation, control, and instrument systems shall be in accordance with Chapters 5, 6, 7, and 10 of NFPA 302; ABYC H-2, *Ventilation of Boats Using Gasoline*; ABYC H-24, *Gasoline Fuel Systems*; ABYC H-32, *Ventilation of Boats Using Diesel Fuel*; ABYC H-33, *Diesel Fuel Systems*; and ABYC P-1, *Installation of Exhaust Systems for Propulsion and Auxiliary Engines*, as applicable.

**40.5.1.2** The required engine fuel, exhaust, cooling, starting, ventilation, control, and instrument systems shall conform to the engine manufacturer's installation and operating requirements.

**40.5.1.3** Each inboard propulsion and auxiliary diesel engine shall be equipped with a manufacturer-approved emergency engine shutdown system.

**40.5.1.4** Where ambient temperatures warrant, inboard engines shall be provided with thermostatically controlled block heaters energized from a shore power cable for heating while the engines are shut down and the vessel is moored.

**40.5.2 Fuel System.**

**40.5.2.1** Fuel systems shall comply with Chapter 7 of NFPA 302; ABYC H-24, *Gasoline Fuel Systems*; and ABYC H-33, *Diesel Fuel Systems.*

**40.5.2.2 Fuel Capacity.**

**40.5.2.2.1** The fuel capacity shall be sufficient to provide for the transit fuel consumption to and from the scene plus the time listed in Table 33.1 of operation mode for each type of vessel.

**40.5.2.2.2** For the purpose of fuel capacity calculation, the following transit fuel consumption shall be used:

(1) Responding is the amount of fuel needed to reach the furthermost point in the jurisdiction at the maximum sustainable speed.
(2) Return is the amount of fuel needed to return from the furthermost point in the jurisdiction or assigned response area at the speed that produces the best fuel consumption.
(3) On station is when all fire pumps are operating at maximum capacity, all propulsion engines that are separate from fire pump drive engines are operating at 10 percent of their maximum rating, and generator sets are operating at their full capacity.

**40.5.2.3** Design consideration shall be given for refueling at the scene or increasing fuel capacity if operations are expected to require more fuel.

**40.5.2.4** Safety considerations shall limit gasoline refueling at the scene to nonhazardous areas.

**40.5.3 Exhaust Systems.**

**40.5.3.1** Exhaust systems shall comply with Chapter 6 of NFPA 302 and ABYC P-1, *Installation of Exhaust Systems for Propulsion and Auxiliary Engines.*

**40.5.3.2** Exhaust systems shall be arranged so as to minimize the intake of exhaust gases into occupied spaces, air-conditioning systems, and engine intakes.

**40.5.3.3** Where installed, thermal insulation for piping and machinery shall meet the requirements of ASTM F683, *Standard Practice for Selection and Application of Thermal Insulation for Piping and Machinery.*

**40.5.4 Cooling Systems.**

**40.5.4.1** Cooling system sea suctions shall comply with *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*; *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*; or *ABS Rules for Conditions of Classification — High Speed Craft* for Type I and Type II vessels and ABYC P-4, *Marine Inboard Engines and Transmissions,* for Type III through Type V vessels.

**40.5.4.2** Adequate cooling arrangements shall be provided so as to maintain all lubricating oil and engine temperatures within the manufacturer's recommended limits during all operations for which the craft is intended.

**40.5.5 Starting Systems.**

**40.5.5.1** Air, electric, or hydraulic-starting systems shall comply with NFPA 302; *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*; or *ABS Rules for Conditions of Classification — High Speed Craft* for Type I and Type II vessels and NFPA 302; ABYC E-10, *Storage Batteries*; and ABYC E-11, *AC and DC Electrical Systems on Boats*, for Type III through Type V vessels.

**40.5.5.1.1** Starting systems shall have sufficient capacity without recharging for starting each main engine for Type III through Type V vessels.

**40.5.5.1.2** At least six consecutive starts shall be required for main and auxiliary engines on Type III through Type V vessels.

**40.5.5.2** For vessels fitted with multiple main engines, the capacity of the starting system shall be two-thirds the number of main engines times the number of starts required for each engine.

**40.5.6 Ventilation Systems.**

**40.5.6.1** All machinery spaces should be adequately ventilated and comply with Chapters 4, 5, 6, and 7 of NFPA 302; ABYC H-2, *Ventilation of Boats Using Gasoline*; and ABYC H-32, *Ventilation of Boats Using Diesel Fuel*.

**40.5.6.2** Ventilation systems relative to gasoline-powered vessels shall be in accordance with Chapters 4, 5, 6, and 7 of NFPA 302.

**40.5.6.3** Machinery space ventilation openings shall be fitted with louvers or baffles to minimize the intake of spray.

**40.5.6.4** Machinery space ventilation shall comply with engine manufacturer's recommendations.

**40.5.7 Controls and Instruments.**

**40.5.7.1** Controls and instruments shall conform to *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* and *ABS Rules for Conditions of Classification — High Speed Craft* for Type I and Type II vessels and ABYC P-14, *Mechanical Propulsion Control Systems*; ABYC P-23, *Mechanical Steering and Propulsion Controls for Jet Boats*; and ABYC P-24, *Electric/Electronic Propulsion Control Systems*, as appropriate for Type III through Type V vessels.

**40.5.7.1.1** Minimum helm-mounted instruments for each inboard propulsion and auxiliary engine provided shall consist of indicators for coolant temperature, oil pressure, tachometer, engine hours, and dc voltmeter.

**40.5.7.1.2** Minimum helm-mounted instruments for each outboard propulsion provided shall consist of indicators for engine temperature, tachometer, and engine hours.

**40.5.7.2** A helm-mounted ac voltmeter shall be provided for auxiliary ac systems, if furnished, and a dc voltmeter or ammeter shall be provided for dc systems.

**40.5.7.3** Minimum helm-mounted instruments for each reduction gear provided shall consist of a temperature and pressure indicator.

**40.5.7.4** Helm-mounted instruments and audible and visual warning devices shall be identified, illuminated, and visible from the operator's position.

**40.5.7.5** Minimum helm-mounted controls shall consist of engine start/stop control(s), emergency engine shutdown, throttle control and transmission shift/engagement control(s) for each propulsion system, and control(s) for variable-pitch propellers where provided.

**40.6 Auxiliary Engine Systems.**

**40.6.1** Auxiliary AC generator system(s) shall be designed for marine use and shall have 10 percent overload capability.

**40.6.2** AC generator systems shall conform to Chapters 5, 6, 9, and 10 of NFPA 302.

**40.6.3** Auxiliary engine(s) for powering fire pumps shall be rated at the power required by the pump with a 10 percent overload capability.

**40.6.4** An engine governor shall be provided to limit the speed of auxiliary engine(s) to that speed established by the manufacturer as the no-load governed speed.

**40.6.5** Auxiliary air compressor system(s) shall be rated for marine use and shall conform to *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* or *ABS Rules for Conditions of Classification — High Speed Craft* for Type I and Type II vessels and 46 CFR Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)," for Type III through Type V vessels.

## Chapter 41 Auxiliary Machinery and Systems (NFPA 1925)

**41.1 General.**

**41.1.1*** Auxiliary machinery and systems on Type I and Type II vessels shall comply with 46 CFR Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)"; *ABS Rules for Building and Classing Steel Vessels*; NFPA 302; ABYC A-27, *Alternating Current (AC) Generator Sets*; or 46 CFR 197, "Marine Occupational Safety and Health Standards."

**41.1.2*** Type III through Type V vessels shall comply with NFPA 302 and the appropriate ABYC standards for small craft.

**41.2 Alarm and Monitoring Systems.**

**41.2.1** All vessels with enclosed bilges or engine and machinery compartments shall be equipped with bilge alarms that are installed to indicate high levels of liquids in the vessel's bilges in accordance with 46 CFR 182.530, "Bilge High Level Alarms."

**41.2.1.1** Audible and visual indicators shall be located in the vicinity of the helm.

**41.2.1.2** Bilge alarm sending units shall be buffered to compensate for vessel motions.

**41.2.1.3** Exterior visual and audible annunciation of fire, bilge, and loss of shore power shall be provided.

**41.2.2** Vessels provided with permanently installed gasoline systems shall be provided with flammable vapor detection system(s).

**41.2.2.1** Visual and audible indicators shall be located in the vicinity of the helm.

**41.2.3** Type I and Type II vessels shall be equipped with a general alarm in accordance with 46 CFR Subchapter T, "Small Passenger Vessels (Under 100 Gross Tons)."

**41.3 Compressed Air Systems.**

**41.3.1** Where vessels are equipped with service air systems that are used for propulsion control, engine starting, or fire main operation, such service air systems shall be equipped with a low-pressure alarm.

**41.3.2** Where vessels are equipped with a system for refilling SCBA, such systems shall deliver Type I, Grade D quality or better air as specified in CGA G-7.1, *Commodity Specification for Air*.

**41.4 Steering Systems.**

**41.4.1** All vessels shall have a primary and emergency steering system as required by 46 CFR 182, "Machinery Installation."

**41.4.2** Steering control and rudder angle indicator shall be provided.

**41.4.3** Where provided, secondary steering locations shall include engine start/stop, clutch/throttle, and thruster controls.

**41.5 Bilge and Ballast Systems.** Bilge pumps and bilge piping and ballast systems shall be installed in accordance with 46 CFR 182, Subpart E, "Bilge and Ballast Systems," and 46 CFR 56.50–55, "Bilge Pumps."

**41.6 Sanitary Systems.** Design and construction of marine sanitation devices shall meet the requirements of 33 USC 1251–1387, "Federal Water Pollution Control Act" (Clean Water Act), and other local and federal government requirements.

**41.7 Hydraulic Systems.** All pressure piping materials and components used in power-driven pressure systems shall comply with 46 CFR Subchapter F, "Marine Engineering."

**41.8 Wiper Systems.**

**41.8.1** Hand or mechanical wiper systems shall be provided on all forward-facing windows.

**41.8.2** Windows equipped with a wiper system shall be provided with a means of defrosting and washing.

**41.8.3*** For vessels operating where freezing conditions are possible, a means of de-icing forward-facing windows shall be provided.

**41.8.4*** Wipers shall ensure maximum practicable clear window area for each window on which they are used.

**41.8.5*** Windshield washing fluid shall be permitted to be drawn from the potable water system, provided that the water supply is filtered.

**41.9 Thruster Systems Not Involving the Fire Main System.** Vessels equipped with thrusters not supplied by the vessel's fire main system that are used for station keeping shall comply with the requirements of Section 2 of *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*; ABYC E-11, *AC and DC Electrical Systems on Boats*; and Chapter 9 of NFPA 302 as appropriate.

**41.10 Piping and Systems Insulation.**

**41.10.1** Where utilized, thermal insulation for piping systems and machinery shall meet the requirements of ASTM F683, *Standard Practice for Selection and Application of Thermal Insulation for Piping and Machinery.*

**41.10.2** Piping systems that contain high temperature gases or liquids shall be insulated in any areas where there is risk of human contact.

**41.10.3** Piping that contains cold liquids, when passing through warm spaces, shall be insulated to prevent condensation where condensation could cause damage.

**41.10.4** All piping and appliances that are designed to remain "filled" during periods of freezing temperatures shall be insulated and protected to prevent freezing of the liquid.

## Chapter 42 Electrical Systems (NFPA 1925)

**42.1 General.**

**42.1.1** Electrical systems for vessels shall comply with Chapters 9 and 10 of NFPA 302; ABYC E-11, *AC and DC Electrical Systems on Boats*; *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*; 46 CFR 111, "Electric Systems — General Requirements"; or 46 CFR 112, "Emergency Lighting and Power Systems," as appropriate and ABYC A-31, *Battery Chargers and Inverters.*

**42.1.2** All wire and cable shall be clearly marked or color-coded and verified against the electrical drawings of the vessel.

**42.1.3 Emergency Lighting.** All marine firefighting vessels shall be provided with emergency lighting in the engine room or machinery compartment.

**42.1.3.1** All Type I through Type III marine firefighting vessels shall also be provided with emergency lighting in accommodation spaces, in first aid stations, and at all means of egress.

**42.1.3.2** Emergency lighting shall have a power source independent of the main power system.

**42.1.3.2.1** The duration of the emergency lighting for Type I through Type III marine firefighting vessels shall be at least 3 hours.

**42.1.3.2.2** Where provided, the duration of the emergency lighting for Type IV and Type V marine firefighting vessels shall be at least 90 minutes.

**42.1.3.2.3** The power source shall be permitted to be any one of the following:

(1) Automatically connected or manually controlled storage battery
(2) Automatically or manually started generator
(3) Relay-controlled, battery-operated lanterns

**42.2 Battery Systems.**

**42.2.1** All vessels with battery-starting systems shall be provided with a starting battery that is separate and independent of the ship service load and that can be isolated from the ship service load when the engine is not running.

**42.2.2 Battery Banks.**

**42.2.2.1** Type I through Type IV vessels with battery-starting systems shall have a minimum of two battery banks, either of which shall be capable of starting the engine(s).

**42.2.2.2** A master switch shall allow selection of either bank.

**42.3 Navigation Lights.** Navigation lights shall comply with 33 CFR 1–124, "Navigation Rules."

**42.4 Searchlights.**

**42.4.1** Type I through Type III marine firefighting vessels shall be equipped with at least two mounted searchlights, each with a minimum of 3 million candlepower (3,000,000 candlepower).

**42.4.2** Type IV marine firefighting vessels shall be equipped with at least one mounted searchlight with a minimum of 3 million candlepower (3,000,000 candlepower).

**42.4.3** Type V marine firefighting vessels shall be equipped with at least one 1 million candlepower (1,000,000 candlepower) portable searchlight.

**42.4.4*** The combined arc of rotation of all mounted searchlights shall be not less than 360 degrees, and lights shall be mounted to permit the illumination of the water as close to the marine firefighting vessel as possible.

## Chapter 43 Outfitting (NFPA 1925)

**43.1 General.**

**43.1.1** Installation of accommodations and access and egress shall comply with NFPA 302; *ABYC Standards and Technical Information Reports for Small Craft*; *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length*; or 46 CFR 177, "Construction and Arrangement," as appropriate.

**43.1.2** All accommodation spaces below the weather deck shall be provided with mechanical ventilation.

**43.1.3** Facilities shall be provided for the additional firefighters or other emergency response personnel who are likely to be aboard the vessel.

**43.1.4** Considerations shall be given for access and egress of personnel wearing full personal protection equipment (PPE).

**43.1.5** For vessels equipped with medical treatment areas, considerations shall be given to the selection of materials for ease of cleaning and disinfection.

**43.2* Toilet Facilities.** Type I through Type IV marine firefighting vessels shall have approved marine sanitation device(s) and sink(s) commensurate with the number of the crew.

**43.3 Storage Compartments.**

**43.3.1 General.**

**43.3.1.1** Compartments for marine equipment shall provide secure stowage and quick access to ensure safe vessel operations.

**43.3.1.2** Compartments, where provided, shall have drains and vents to retard mildew and rot.

**43.4 Insulation.**

**43.4.1 Thermal and Fire Insulation.** Type I and Type II vessels shall be fitted with structural fire protection meeting the requirements of USCG NVIC 9-97, *Guide to Structural Fire Protection.*

**43.4.2 Acoustical Insulation.**

**43.4.2.1** Type I through Type IV vessels shall be insulated acoustically to provide a maximum of 85 dBA in interior spaces other than machinery spaces, and 90 dBA on exterior decks, at both full speed and full pumping capacity.

**43.4.2.2** Persons in areas that measure greater than 90 dBA shall be required to wear hearing protection according to Occupational Safety and Health Administration (OSHA) standards.

**43.5 Deck Surfaces.** Non-skid surfaces shall be used in the following areas:

(1) Exterior walkways and companionways
(2) Shower areas
(3) Weather decks
(4) Ladder steps and rungs
(5) Walkways in machinery spaces

**43.6 Ground Tackle.**

**43.6.1** Each vessel shall be equipped with fittings, ground tackle, and lines compatible with its intended use.

**43.6.2*** All Type I through Type III vessels shall carry at least one set of ground tackle that shall comply with the requirements of *ABS Rules for Building and Classing Steel Vessels Under 90 Meters (295 ft) in Length* or ABYC H-40, *Anchoring, Mooring, and Strong Points.*

**43.6.3*** All Type IV and Type V vessels shall carry at least one set of ground tackle that shall comply with the requirements for storm anchors of ABYC H-40, *Anchoring, Mooring, and Strong Points.*

**43.6.4** When selecting an anchor, consideration shall be given to the type of bottom, type of rode, and the factors of size, weight, and design of anchor.

**43.6.5*** The anchor rode for Type I through Type III vessels shall be a minimum of 300 ft (91 m) in length and for Type IV vessels, a minimum of 200 ft (61 m) in length.

**43.6.6** The anchor rode shall provide for shock absorption, rot, and decay resistance at least equivalent to that of nylon.

**43.7 Anchor Storage.**

**43.7.1** The anchor shall be stowed in such a manner that it cannot break loose under storm conditions.

**43.7.2** The anchor and its rode shall be located where they are readily accessible and can be rapidly deployed.

**43.7.3** Rodes, when attached to anchors, shall be attached by means of shackles and swivels.

**43.7.3.1** Fiber rodes shall also incorporate thimbles.

**43.7.3.2** The bitter end of the rode shall be securely attached to the vessel.

**43.7.3.3** The anchor shackles and other means of attaching the anchor to the rode shall exceed the recommended working strength of the rode.

**43.7.4** All ground tackle components shall be constructed of corrosion-resistant material or be protectively coated for use in the marine environment.

**43.8 Mooring Lines.**

**43.8.1** Dock lines shall be no less than the diameter required for the anchor rode.

**43.8.2** All Type I through Type IV vessels shall be provided with a minimum of five dock lines.

**43.8.3** Each dock line shall be at least as long as the vessel, and one shall be at least 1½ times the vessel's length.

**43.8.4** Mooring bitts and cleats shall be of sufficient size to accommodate the recommended diameter of the anchor rode or the dock lines.

**43.8.4.1** The working surfaces and edges shall be smooth and rounded to minimize chafing.

**43.8.4.2** The mooring bitt or cleats shall be secured to a foundation that is of adequate strength to carry the mooring loads.

**43.8.5** All vessels shall carry at least two boat hooks with a minimum length of 12 ft (3.8 m).

**43.9* Emergency Towing.** All marine firefighting vessels shall be equipped with a means of safely towing a vessel of comparable size and displacement in an emergency situation.

**43.10 Lifesaving and Rescue Equipment.**

**43.10.1 Capacity Number.**

**43.10.1.1** All vessels shall have a posted capacity number.

**43.10.1.2** This number shall be the sum of the assigned crew, anticipated supplementary crew, and anticipated passengers.

**43.10.2*** Whenever the freeboard of the vessel exceeds 24 in. (610 mm), the vessel shall be equipped with means to facilitate boarding from smaller vessels and from the water.

**43.11* Personal Flotation Devices.**

**43.11.1*** Where the vessel operates in cold water, the vessel shall carry an immersion suit for each crew member.

**43.11.2*** A person overboard recovery system shall be provided.

**43.11.3** Type I and Type II vessels shall have at least four Type IV throwable flotation devices provided on the vessel, Type III and Type IV vessels shall have at least two, and Type V vessels shall have at least one.

**43.11.4 Buoyant Apparatus and Life Rafts.**

**43.11.4.1** Where provided, buoyant apparatus, life rafts, or equivalent to be used only in emergencies shall be provided with secure storage on the vessel in a manner that allows quick removal and placement in the water.

**43.11.4.2** Life rafts, buoyant apparatus, and boats shall be of sufficient size to hold the posted capacity of the vessel.

**43.11.4.3** Life rafts shall be inspected periodically according to USCG and manufacturer's recommendations.

**43.12 Emergency Signaling Devices.**

**43.12.1** Each vessel shall carry an emergency position indicator radio beacon (EPIRB), and it shall be stowed to prevent accidental activation.

**43.12.2*** Each vessel type shall be required to carry a USCG-approved pyrotechnic emergency signaling kit, including, but not limited to, flares and explosive devices.

**43.12.3** The USCG-required pyrotechnic emergency signaling kits shall be stored in containers designed to prevent their accidental discharge and to protect the devices from moisture.

**43.13 Medical Equipment.**

**43.13.1*** All Type I through Type IV vessels shall be equipped with basic life support (BLS) equipment and be provided with an automated external defibrillator (AED).

**43.13.2** Type V vessels shall be equipped with a USCG-approved first aid kit.

**43.14 Recovery of Persons from the Water.**

**43.14.1** Means shall be provided for water rescue or body recovery, such as dive platform, transom gate, or davit.

**43.14.2** Where a davit or mechanized crane is fitted, it shall have a minimum safe working load of 500 lb (227 kg), at full horizontal extension.

## Chapter 44 Communications Equipment and Systems (NFPA 1925)

**44.1 General.**

**44.1.1* Fire Department Radio Systems.**

**44.1.1.1** Fire department radio systems shall be installed on the vessel.

**44.1.1.2** These systems shall be capable of operating on the frequencies assigned to the fire department, on area mutual aid frequencies, and with any fire department with which a mutual aid agreement is in force.

**44.1.2* Maritime VHF-FM Radio.**

**44.1.2.1** All Type I through Type IV vessels shall be equipped with two fixed-mount, 25 watt, VHF-FM radios.

**44.1.2.2** All Type V vessels shall be equipped with one VHF-FM radio.

**44.1.3** All vessels shall be equipped with a radio capable of receiving the local National Oceanic and Atmospheric Administration (NOAA) weather broadcasts or other weather reporting equivalents.

**44.1.4** All Type I through Type III vessels shall be equipped with a public address system for giving audible signals to persons on the vessel and for short-range direct voice communications.

**44.1.5 Hailer.**

**44.1.5.1** All Type IV and Type V vessels shall be equipped with a hailer for giving audible signals to persons on the vessel and for short-range direct voice communications.

**44.1.5.2** Volume or speaker placement at all stations shall be adequate to be heard over operational ambient noise.

**44.1.6 Intercom System.**

**44.1.6.1** All Type I through Type III vessels shall be equipped with an intercom system for communication between all operating stations and the engine room.

**44.1.6.2** Volume or speaker placement at all stations shall be adequate to be heard over operational ambient noise.

**44.1.7** Type I through Type III vessels shall be equipped with a general alarm in accordance with 46 CFR 183.550, "General Alarm Systems."

**44.2 Communications.**

**44.2.1** Fire ground communications shall be provided at all operating centers.

**44.2.2** Volume or speaker placement at all stations shall be adequate to be heard over any ambient noise.

**44.3 Helicopter Operations.** Vessels equipped for helicopter operations shall be provided with a communications system between the vessel operator and a deck person, which shall include hearing protection from excessive noise.

**44.4 Installation.** All communication equipment shall be installed according to manufacturer instructions.

**44.5 Optical Warning Devices.** All marine firefighting vessels shall be equipped with optical warning devices in accordance with 33 CFR 88, "Pilot Rules."

## Chapter 45 Navigation Equipment and Systems (NFPA 1925)

**45.1 General.**

**45.1.1*** All vessels shall carry up-to-date navigational publications for the intended operational area.

**45.1.2** All vessels shall be fitted with an illuminated compass.

**45.2 Vessel Type–Specific Requirements.**

**45.2.1** All Type I through Type IV vessels shall have a work area or chart table for navigational chart work and chart navigation tools and an area of sufficient size to store navigational charts.

**45.2.2*** All Type I and Type II vessels shall be fitted with a minimum of two radar units, one global positioning system (GPS), and a chart plotter.

**45.2.3** All Type III and Type IV vessels shall be fitted with a minimum of one radar unit, one GPS, and a chart plotter.

**45.2.4** All Type V vessels shall have a minimum of one GPS and a chart plotter.

**45.3 Depth Sounding Apparatus.** All vessels shall be fitted with an electronic depth sounding apparatus.

**45.4 Installation.** All navigation equipment shall be installed according to the manufacturer's instructions.

## Chapter 46 Protective Coatings and Corrosion Protection (NFPA 1925)

**46.1 General.**

**46.1.1** Protective coatings and corrosion protection shall comply with *ABS Rules for Building and Classing Steel Vessels*; NFPA 302; ABYC A-28, *Galvanic Isolators*; or ABYC E-2, *Cathodic Protection*.

**46.1.2** All construction materials for the vessel and the systems shall be selected to minimize the effects of corrosion.

**46.1.3** All metal hulls for vessels normally docked afloat shall be protected below the water line with a corrosion-resistant coating system.

**46.1.3.1** Vessels normally docked afloat that are located in an environment where marine growth fouling can be expected shall be provided with anti-fouling or foul release coating, as appropriate.

**46.1.4** All steel surfaces and ferrous machinery and equipment shall be protected with a corrosion-resistant coating.

**46.1.5** All vessels normally docked afloat shall be fitted with sacrificial anodes or impressed current systems.

**46.1.6** Vessels equipped with shore power connections shall be galvanically isolated in accordance with ABYC A-28, *Galvanic Isolators*; ABYC E-2, *Cathodic Protection*; ABYC E-11, *AC and DC Electrical Systems on Boats*; or Chapters 9 and 10 of NFPA 302.

**46.2* Sacrificial Anodes.** Sacrificial anodes shall be sized and located to provide cathodic protection for the time periods between recommended dry dockings and shall be installed in accordance with ABYC E-2, *Cathodic Protection*.

**46.3 Impressed Current System.**

**46.3.1 Installation.**

**46.3.1.1** If installed, an impressed current system shall be installed in accordance with ABYC E-2, *Cathodic Protection*, and the manufacturer's recommendations.

**46.3.1.2** The type, size, and quantity of anodes and reference electrodes shall be determined by National Association of Corrosion Engineers (NACE) corrosion-certified personnel.

**46.3.2 Hull Potential Meters.** All metallic vessels and vessels with outdrives and jet drives shall be equipped with a hull potential meter appropriate to the reference cell, which is either silver/silver-chloride or zinc.

**46.4 Coating System.**

**46.4.1*** All surfaces that receive coating shall be cleaned and prepared in accordance with the coating manufacturer's instructions and with special attention to removal of salts.

**46.4.2** All coatings shall be applied in accordance with the coating manufacturer's instructions.

**46.5 Bonding.** All machinery and underwater metals shall be bonded to minimize stray electric currents.

## Chapter 47 Tests and Trials (NFPA 1925)

**47.1 General.**

**47.1.1** The vessel shall be thoroughly inspected or tested to demonstrate conformance to Chapters 32 through 48 and to regulatory body requirements, as appropriate for the complexity of the vessel.

**47.1.2** Trials shall be conducted to determine that the vessel and its equipment conform to the contract, the drawings, and the specifications.

**47.1.3** The builder shall develop a schedule for performance testing during construction of the vessel and shall submit a copy to the owner prior to any tests or trials.

**47.1.3.1** During construction, the builder shall be responsible for giving the owner advance notice of any tests or trials to be performed to allow the owner to witness the same on a noninterference basis.

**47.1.4 Test Records.**

**47.1.4.1** The builder shall provide test records for all testing activity.

**47.1.4.2** The records shall include data pertinent to the test, description of the test, and signature blanks for the builder and owner.

**47.1.5** All trial instrumentation and personnel necessary to conduct the trials in accordance with the specifications shall be furnished by the builder.

**47.1.6** Qualified personnel shall perform all tests.

**47.1.7** All instrumentation and gauges used during tests shall be calibrated to provide accurate data by which to analyze the performance of systems, machinery, and equipment.

**47.1.8** After satisfactory completion of the tests, all trial instrumentation shall be removed.

**47.2 Testing During Construction.**

**47.2.1** The builder shall inspect and test as necessary during construction all portions of the vessel and work thereon, including structure, fittings, systems, equipment, and machinery to demonstrate satisfactory workmanship, proper working order, alignment of moving parts, tightness, and compliance with the specifications.

**47.2.2** The builder shall correct any deficiencies that appear during inspection and testing and reinspect or test until proven satisfactory.

**47.3 Builder's Trials.**

**47.3.1** The tests shall be conducted in an area with sufficient water depth and maneuvering room to enable a complete and unrestricted test of all propulsion, steering, and firefighting systems.

**47.3.2** The vessel's draft and freeboard, both forward and aft, shall be measured and recorded.

**47.3.3** The maximum height of fixed structure above the water shall be determined and recorded.

**47.3.4** Deficiencies that appear during builder's trials shall be corrected by the builder, and the appropriate trials rerun to the owner's satisfaction.

**47.3.5** The builder shall provide documentation of the results of all tests performed during builder's trials.

**47.3.6** When all known deficiencies have been corrected, the vessel shall be ready for acceptance trials.

**47.3.7 Tightness Test.**

**47.3.7.1** A tightness test shall be conducted to determine that all tested components of the craft do not leak.

**47.3.7.2** All watertight closures, topside structures, windows, weathertight doors, ports, and deck penetrations shall be tested.

**47.3.7.2.1** This test shall be conducted using a hose with a ¾ in. (19 mm) minimum diameter smooth bore nozzle with at least 35 psi (2.4 bar) freshwater pressure at a distance not exceeding 10 ft (3 m).

**47.3.7.2.2** The water shall be directed in a manner to maximize the possibility of a leak.

**47.3.7.3** The opposite side of the tested area shall be inspected for leaks.

**47.3.7.4** All bilges, welds, rudders, and shafts shall be inspected for leaks or water accumulation.

**47.3.8 Main Propulsion System Test.**

**47.3.8.1** The main propulsion system shall be tested to determine that the system components and controls are functioning in accordance with manufacturer's specifications.

**47.3.8.2** Where the vessel is propelled by inboard engines using shaft drives, the shaft coupling shall be disconnected and checked to ensure alignment prior to starting the engine(s).

**47.3.9 Engine Starting System Test.**

**47.3.9.1** The engine starting system shall be tested to demonstrate that it is functioning in accordance with the engine manufacturer's specifications.

**47.3.9.2** Fluid levels such as freshwater cooling and oil shall be checked and fluids added as necessary prior to starting.

**47.3.9.3** Each engine shall be started three times from each starting location at 2-minute intervals.

**47.3.9.3.1** The starting time shall be recorded and cranking time limited to 15 seconds.

**47.3.9.3.2** During at least one of these startings, the engine shall be allowed to crank for a minimum of 15 seconds prior to being allowed to start.

**47.3.9.3.3** The starting motor shall be observed for any evidence of smoke or overheating.

**47.3.9.4** Once started, if an engine overheats or if the lubricating oil pressure does not rise to the normal operating pressure, the engine shall be shut down and no restarts attempted until the trouble has been remedied.

**47.3.10 Wire and Cable Inspection.** All wire and cable shall be tested and inspected for safe installation, grounding, chafe points, flexibility between fixed and moving equipment, and entry into junction boxes and equipment and through watertight decks and bulkheads.

**47.3.11 Engine-Driven DC Generator/Alternator Test.**

**47.3.11.1** Engine-driven DC generator/alternator shall be tested to verify satisfactory installation and performance in accordance with the generator/alternator manufacturer's instructions.

**47.3.11.2** Before starting the engine, the generator/alternator shall be inspected to ensure proper alignment.

**47.3.11.3** The engine shall be started and run at idle rpm.

**47.3.11.4** The generator/alternator shall be inspected for any noticeable vibrations or misalignments.

**47.3.11.5** The rpm, voltage, and current output shall be observed.

**47.3.11.5.1** The engine shall then be run at maximum rpm. The rpm, voltage, and current output shall be observed again.

**47.3.12 AC Generator Test.**

**47.3.12.1** AC generator tests shall be performed to verify satisfactory installation and performance of the ac generator in accordance with the generator manufacturer's instructions.

**47.3.12.2** The ac load shall be disconnected at the vessel's breaker panel, and the engine shall be started.

**47.3.12.3** The engine shall be run until all oil and water temperatures have stabilized.

**47.3.12.4** The effective operation of all instruments and switches associated with the generator being tested shall be verified.

**47.3.12.5** The rpm, voltage, current, frequency, oil pressure, and temperature at 0, 25 percent, 50 percent, 75 percent, and full rated loads shall be measured, compared with the manufacturer's specifications, and recorded, noting the presence of unusual noise and vibration.

**47.3.13 Electrical Power Distribution Test.**

**47.3.13.1** An electrical power distribution test shall be performed to verify safe installation, voltage, and phase and polarity of each ac/dc circuit and correct distribution through switchboards or power panels.

**47.3.13.1.1** The electrical power distribution tests noted in 47.3.13.2 through 47.3.13.6.2 shall be witnessed, and the results of the tests of the power source shall be certified by an independent third-party certification organization.

**47.3.13.2** Each power circuit shall be energized to verify control from the switchboard or power panel.

**47.3.13.3** Voltage shall be measured for each circuit and verified for correct phase and polarity.

**47.3.13.4** The voltage drop between the distribution panel and each significant load shall be measured and recorded.

**47.3.13.5** The secure mounting of each item of equipment shall be verified.

**47.3.13.6** The shore power feeder shall be connected, and the power transfer switch/circuit breaker shall be operated to verify safe transfer from generator to shore power.

**47.3.13.6.1** The voltage at the control panel shall be measured.

**47.3.13.6.2** The phasing shall be verified.

**47.3.14 Lighting System Test.**

**47.3.14.1*** All lighting switches, circuit breakers, and cables shall be inspected for safe installation, functioning, and labeling.

**47.3.14.2** Each lamp shall be inspected for safe size and type.

**47.3.14.3** Each light fixture shall be tested to determine safe operation and satisfactory control from the designated switch or circuit breaker.

**47.3.14.4** All portable cord-connected lighting fixtures shall be connected and operated to determine satisfactory operation.

**47.3.14.5** The arcs of coverage of the navigation lights shall be observed to ensure compliance with 33 CFR 1–124, "Navigation Rules," with respect to obstruction by the vessel's structure or other equipment.

**47.3.14.6** All lighting shall be tested in the hours of darkness, including interior lighting in the pilothouse for identification of gauges, switches, and controls.

**47.3.14.6.1** Capacity for limiting the brightness of all lighting for nighttime navigation shall be observed.

**47.3.14.6.2** Deficiencies for nighttime navigation and operations shall be corrected to the owner's satisfaction.

**47.3.15 Navigation Equipment Test.**

**47.3.15.1** All navigation equipment shall be tested to verify safe installation, operation, alignment, and calibration in accordance with the manufacturer's instructions.

**47.3.15.2** All navigational equipment shall be located for maximum efficiency, safe operation, and ease of maintenance and approved by the equipment manufacturer as to full and proper installation.

**47.3.16 Communications and Signaling System Test.**

**47.3.16.1** All communication and signaling equipment shall be tested to verify safe installation, operation, alignment, and calibration in accordance with the manufacturer's instructions.

**47.3.16.2** The location of the communication and signaling equipment shall be inspected for efficient operation and positioning.

**47.3.17 Fire Flow Test.**

**47.3.17.1** Pumps shall be tested to demonstrate that they perform in accordance with the manufacturer's specifications.

**47.3.17.2** Where indicators are installed, pump suction and discharge pressures shall be observed and recorded.

**47.3.17.3** Each system monitor and nozzle shall be operated and the pressure recorded to verify its performance in accordance with manufacturer's specifications.

**47.3.18 Instruments and Indicators Test.**

**47.3.18.1** Instruments and indicators shall be tested to determine that they are installed and functioning effectively.

**47.3.18.2** All instruments shall be verified to be of a type suitable for use in the particular vessel.

**47.3.18.3** If fitted, the fuel level indicator's accuracy shall be verified.

**47.3.19 Piping System Tests.**

**47.3.19.1** All piping systems shall be pressurized or operated and observed for leaks.

**47.3.19.2** Fire pump piping and distribution piping to discharge devices shall be hydrostatically tested in accordance with 34.3.11.1.

**47.3.19.3** Pressurization or operation shall be continued for 30 minutes during and after which all pipes, connections, tanks, and welds shall be inspected for leaks, distortion, and deformation.

**47.3.19.4** Where any leaks are detected, the test shall be stopped, the leak(s) shall be repaired, and the system shall be retested.

**47.3.19.5** All tanks, valves, pumps, and lines shall be checked for secure mounting, supports, and serviceability.

**47.3.20 Heating, Ventilation, and Air-Conditioning Tests.**

**47.3.20.1** Heating, ventilation, and air-conditioning (HVAC) systems shall be tested for safe operation in accordance with the manufacturer's instructions.

**47.3.20.2** HVAC units shall be operated until the specified temperature is reached.

**47.3.21 Fire-Extinguishing System Test.**

**47.3.21.1** The fire-extinguishing system shall be inspected, tested, and certified in accordance with manufacturers' requirements and design performance standards.

**47.3.21.2** All placards shall be inspected to verify that they are installed in effective locations.

**47.3.22 Steering Gear Test.**

**47.3.22.1** The steering gear shall be tested to verify safe installation and operation in normal and emergency modes.

**47.3.22.2** Fluid levels, fitting connections, and mountings shall be checked.

**47.3.22.3** The steering gear shall be operated from hardover to hardover to verify alignment, and the number of turns of the wheel from hardover to hardover shall be recorded.

**47.3.22.4** The steering system shall be tested to demonstrate compliance with Section 41.4.

**47.3.22.5** The rudder shall be moved hardover to port, and the diameter of the vessel's turning circle and speed shall be recorded.

**47.3.22.6** The rudder shall be moved hardover to starboard, and the diameter of the vessel's turning circle and speed shall be recorded.

**47.3.22.7** The vessel shall be operated ahead at full speed on a straight course, then the steering wheel shall be released, and any deviation from straight ahead shall be recorded in time and degrees.

**47.3.22.8** The rudder angle indicator (RAI) readout display shall be checked for accuracy with the rudder position.

**47.3.22.9*** To determine the maximum safe astern speed, the vessel shall be operated astern with rudder hardover to port and starboard, and then the wheel shall be pulled out of hardover position and returned to straight astern.

**47.3.22.9.1** During this test, the engine speed shall be increased cautiously to determine the maximum safe rpm.

**47.3.22.9.2** Once determined, the maximum safe astern rpm shall be recorded.

**47.3.22.10** Where fitted, auto pilot systems shall be calibrated and tested to manufacturers' specifications.

**47.3.23 Deck Machinery Tests.** Where provided, deck machinery, such as a crane, davit, or winches, shall be tested at maximum rated load capacity to verify that it meets specified requirements and operates without damage or distortion to the structure or vessel.

**47.3.24 Anchor Stowage and Handling Test.**

**47.3.24.1** Anchor stowage and handling and associated equipment shall be tested to ensure efficient deployment, recovery, and securing of the anchor and associated equipment.

**47.3.24.2** The anchor, rode, and line shall be inspected.

**47.3.25 Towing Fitting Test.**

**47.3.25.1** The towing tackle and fitting shall be tested to verify that they meet specified strength requirements.

**47.3.25.2** The fitting(s) shall be inspected for cracking, distortions, or any other damage due to the load.

**47.3.26 Window Wiper Test.**

**47.3.26.1** The window wipers, washers, and defog systems shall be tested to determine that the equipment is operating effectively.

**47.3.26.2** Wipers shall be operated, and wiper performance shall be tested, using a water hose to simulate foul weather conditions.

**47.3.27 Galley Equipment Test.** Where provided, the galley equipment shall be tested to determine that the equipment is operating safely.

**47.3.28 Noise Evaluation Test.**

**47.3.28.1** The mean sound levels shall be measured in all applicable areas as required by 43.4.2.

**47.3.28.2** All doors, windows, and hatches shall be tightly closed while sound levels are being measured.

**47.3.29 Propulsion System Test.**

**47.3.29.1** The propulsion system shall be tested to demonstrate satisfactory operation.

**47.3.29.2** The propulsion system shall be operated for a continuous period of 4 hours in accordance with the manufacturer's recommendations.

**47.3.29.3** During the operation as specified in 47.3.29.2, the engine oil pressure, rpm, water temperature, and gear oil pressure shall be recorded at 15-minute intervals.

**47.3.30 Propeller or Jet Pump Speed Trials.**

**47.3.30.1** Propeller or jet pump evaluation and speed trials shall be performed to demonstrate that the selected propeller or jet pump allows the engine to develop its rated shaft horsepower at its rated rpm when the vessel is in the trial condition and to determine the speed of the vessel and dynamic trim angle.

**47.3.30.2** The following information shall be recorded before beginning trial:

(1) Depth of water on measured course at time of trial
(2) Specific gravity of water (salt water or fresh water)
(3) Displacement of craft in pounds (kilograms)
(4) Static trim angle at time of trial
(5) Manufacturer and model number of installed engine
(6) Propeller manufacturer, type, number of blades, diameter, and pitch

(7) Gear manufacturer and model number and ratio
(8) Jet pump manufacturer and model number
(9) Liquids on board

**47.3.30.3** One run shall be made in each direction over the measured course.

**47.3.30.4** Engine rpm shall be within the manufacturer's specifications.

**47.3.30.5** The average speed of the two runs shall be recorded as the craft's speed, rpm, and running trim angle.

**47.3.31 Fire Pump Test.**

**47.3.31.1*** The fire pump shall be tested to demonstrate installation and operation of the fire pump system, including controls and safety devices in accordance with the specifications.

**47.3.31.2** Each fire pump shall be individually run at its rated capacity and pressure for 3 hours.

**47.3.31.3** The pump pressures taken near the pump discharge and pitot readings for capacity flows taken at the nozzle tips shall be recorded.

**47.3.31.4** All pumps shall be run together simultaneously for a period of 1 hour at their rated capacities and pressures to determine the full capacity of the vessel.

**47.3.31.5** The pump pressures shall be recorded, and flow capacities calculated and recorded.

**47.3.31.6** A vessel's capability to maneuver and keep stationary while pumping shall be demonstrated.

**47.3.31.7** An independent third-party certification organization shall witness the tests and certify the test results.

**47.3.32 Testing of Fire Protection Equipment for the Vessel.** All fire protection systems shall be tested to verify satisfactory installation and operation in accordance with the specifications.

**47.3.33 Foam Systems (if Applicable).**

**47.3.33.1** The installed foam system shall be tested in accordance with relevant NFPA standards.

**47.3.33.1.1** The test program shall include each proportioning device installed in the system and any corresponding discharge devices.

**47.3.33.1.2** The system shall demonstrate its capability to proportion and to operate at discharge design pressures.

**47.3.33.2** A representative of the foam system manufacturer shall be present for acceptance testing of the installed system.

**47.3.34 Other Devices.**

**47.3.34.1** Tests shall be performed to demonstrate satisfactory installation and operation of any other device not listed in this chapter.

**47.3.34.2** All devices shall be checked and tested in accordance with the device manufacturer's installation and operation specifications or procedures.

**47.4 Delivery Documentation.** The builder shall supply no fewer than two copies of the following documentation at the time of delivery:

(1) Copy of test and trials report
(2) Full set of original equipment manufacturer's manuals
(3) The edition of NFPA 1910 to which the vessel was constructed
(4) The original classification of the vessel in accordance with the types of marine firefighting vessels listed in Chapter 33
(5) A list of basic equipment and related items required by the classification as found in Table 38.1.1(a) [or Table 38.1.1(b)] and Table 38.3.1(a) [or Table 38.3.1(b)]

## Chapter 48 Vessel Maintenance (NFPA 1925)

**48.1 Haul-Out for Maintenance and Inspection.**

**48.1.1*** A vessel docking or haul-out plan shall be provided by the builder.

**48.1.2*** A recommended time interval for haul-out shall be provided by the builder.

**48.2 Maintenance Schedules.**

**48.2.1** The owner/operator shall develop a schedule for care, maintenance, and inspection utilizing information from the builder, equipment/machinery manufacturers, and owner's maintenance personnel.

**48.2.2** The schedule shall specify the maintenance, or inspection interval and what must be done to maintain each piece of equipment, including the types and amounts of grease, oil, and other fluids recommended for use.

**48.2.3** A daily, weekly, monthly, and annual check-off sheet shall be kept in an accessible location.

**48.3 Docking and Access.**

**48.3.1*** The vessel's normal berth shall meet the requirements of NFPA 303.

**48.3.2** Where the vessel is kept on a trailer and is towed to a launch area, the launch area shall be a safe and accessible area where the vessel can be launched during any stage of the tide.

**48.4 Trailers.**

**48.4.1*** Where a trailer is used for storage and launching the vessel, the trailer shall be designed for the intended purpose of the vessel and accommodate the total weight, including a full complement of tools and equipment.

**48.4.2** The trailer shall have at a minimum a biannual maintenance schedule to include, but not be limited to, inspection of brakes, bearings, winch and cable, bunks, tire pressure, and lubrication.

**48.5 Maintenance Tests.**

**48.5.1*** Tests shall be conducted at least annually on all equipment, or after major repairs, after overhaul, or when there is reason to believe that usage has exceeded the manufacturer's instructions for safe operating procedures.

**48.5.2** The inspection and tests specified herein shall be used to supplement, not to replace or modify, any instructions or recommendations of the manufacturer's maintenance manual.

**48.5.3*** Full operational tests shall be performed at least monthly to ensure that all equipment is functioning safely and that all safety equipment is in place and in working order.

**48.5.4** The fire pump shall be tested to the manufacturer's specifications and include routine testing of the pump and accessories.

**48.5.4.1** These tests shall include a vacuum test, if appropriate, a pressure test, and a running test.

**48.5.4.2** An annual test shall be conducted to determine whether the pump is meeting the requirements established for a vessel of its particular rating.

## Chapter 49 Emergency Vehicle Technician I (NFPA 1071)

### 49.1 Administration.

**49.1.1* Scope.** Chapters 49 through 51 identify the minimum job performance requirements (JPRs) for emergency vehicle technicians.

**49.1.2* Purpose.** The purpose of Chapters 49 through 51 are to specify the minimum JPRs for service as an emergency vehicle technician.

**49.1.2.1** Chapters 49 through 51 shall define Emergency Vehicle Technician I (EVT I), Emergency Vehicle Technician II (EVT II), and Emergency Vehicle Technician III (EVT III).

**49.1.2.2** The intent of Chapters 49 through 51 shall be to ensure that personnel serving as EVT I, EVT II, and EVT III are qualified.

**49.1.2.3*** Chapters 49 through 51 shall not address organization or management responsibility.

**49.1.2.4** It shall not be the intent of this standard to restrict any authority having jurisdiction from exceeding or combining these minimum requirements.

**49.1.2.5** JPRs for each level and position are the tasks personnel shall be able to perform to carry out the job duties.

**49.1.2.6*** EVTs who perform or support duties and responsibilities relating to emergency vehicle maintenance and repair shall remain current with required knowledge, required skills, and individual JPRs addressed for each level or position of qualification in order to maintain proficiency and competency with the JPRs covered in this standard.

**49.1.2.7*** To obtain and maintain qualification as an EVT, persons shall furnish documentation showing that they have completed 20 hours of initial or continuing education for EVT I, 25 hours for EVT II, and 30 hours for EVT III on an annual basis.

**49.1.3 Application.** The application of Chapters 49 through 51 is to specify which requirements within the document shall apply to EVT I, EVT II, and EVT III.

**49.1.3.1** The JPRs shall be accomplished in accordance with the requirements of the authority having jurisdiction (AHJ) and all applicable NFPA standards.

**49.1.3.2** JPRs shall not be required to be mastered in the order in which they appear.

**49.1.3.3** The AHJ shall establish instructional priority and the training program content to prepare personnel to meet the JPRs of Chapters 49 through 51.

**49.1.3.4*** Performance of each requirement in Chapters 49 through 51 shall be evaluated by personnel approved by the AHJ.

**49.1.3.5** The JPRs for each level or position shall be completed in accordance with recognized practices and procedures or as defined by law or by the AHJ.

**49.1.3.6** Personnel assigned the duties of EVT I shall meet all the requirements defined in Chapter 49 prior to being qualified.

**49.1.3.7** Personnel assigned the duties of EVT II shall meet all the requirements defined in Chapter 50 prior to being qualified.

**49.1.3.8** Personnel assigned the duties of EVT III shall meet all the requirements defined in Chapter 51 prior to being qualified.

**49.1.3.9** An EVT I meeting the requirements of Chapter 49 shall be able to perform inspections and maintenance duties as required by Chapters 1 through 28.

**49.1.3.10** An EVT II meeting the requirements of Chapters 49 and 50 shall be able to perform inspections, maintenance, repairs, diagnoses, and performance testing duties as required by Chapters 1 through 28.

**49.1.3.11** An EVT III meeting the requirements of Chapters 49 through 51 shall be able to perform inspections, maintenance, repairs, diagnoses, performance testing, and first-level supervisor duties as required by Chapters 1 through 28.

**49.1.3.12** The AHJ shall provide personal protective clothing and the equipment necessary to conduct assignments.

**49.1.3.13*** JPRs involving exposure to products of combustion shall be performed in approved PPE.

**49.1.3.14** Prior to training to meet the requirements of Chapters 49 through 51, personnel shall meet the following requirements:

(1) Educational requirements established by the AHJ
(2) Age requirements established by the AHJ
(3) Medical requirements established by the AHJ
(4) Job-related physical performance requirements established by the AHJ

**49.1.3.15** The EVT shall apply the best practices of NFPA 1581 to reduce exposure to blood-borne pathogens.

**49.1.3.16** Wherever in this standard the terms *rules*, *regulations*, *policies*, *procedures*, *supplies*, *apparatus*, or *equipment* are referred to, it shall be implied that they are those of the AHJ.

**49.1.4 Units.** In this standard, equivalent values in SI units shall not be considered as the requirement, as these values can be approximate. *(See Table 49.1.4.)*

**Table 49.1.4 US-to-SI Conversions**

| Quantity | US Unit/Symbol | SI Unit/Symbol | Conversion Factor |
|---|---|---|---|
| Length | inch (in.) | millimeter (mm) | 1 in. = 25.4 mm |
| | foot (ft) | meter (m) | 1 ft = 0.305 m |
| Area | square foot ($ft^2$) | square meter ($m^2$) | 1 $ft^2$ = 0.0929 $m^2$ |

**49.2 General.** To be considered qualified as an Emergency Vehicle Technician I, the individual shall meet the following criteria:

(1) Have the general knowledge defined in 49.2.1 and the general skills defined in 49.2.2
(2) Meet the job performance requirements of Sections 49.3 through 49.5 and at least one specialty area as defined in Section 49.6, Section 49.7, or Section 49.10

**49.2.1* General Knowledge Requirements.** The organization of the fire department and the maintenance facility; the role of the EVT in the organization; the mission of the fire service; the fire department's standard operating procedures (SOPs) and rules and regulations as they apply to the EVT; the critical aspects of NFPA 1500, NFPA 1900, and Chapters 1 through 28, as they apply to the EVT; federal motor carrier safety regulations; applicable federal, state, and local regulations; interpretation and use of manufacturer's specifications, inspection checklists, maintenance schedules, maintenance checklists, and department SOPs; selection of tools; fastener types and their usage; maintenance equipment and its usage; workplace safety practices; selection and use of cleaning products and procedures; housekeeping; and identification and handling of hazardous materials.

**49.2.2 General Skill Requirements.** The ability to use tools in a recognized safe manner; operate emergency response vehicles in compliance with applicable federal, state, and local regulations; and locate information in departmental documents and in standards and reference materials.

**49.3* Chassis.** This duty involves the inspection and preventive maintenance practices involved with an emergency response vehicle chassis and inter-related systems such as axles, engines, transmissions, drivelines, brakes, steering and suspension systems, and wheels and tires.

**49.3.1** Inspect the chassis systems, given an emergency response vehicle, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the structural integrity, the operation, and the condition of the auxiliary drive systems, axles, driveline, steering and suspension system, wheels, and tires are verified to be within manufacturer's specifications; the mounting security is verified; the chassis components are operational and within manufacturer's specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; inspections and services are documented; and any deficiencies found during the inspection and diagnostic check process are documented.

**(A) Requisite Knowledge.** Function, operation, and construction of chassis and vehicle systems; type of defects, deficiencies, and potential problems associated with chassis systems; use of a checklist; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions of the chassis and vehicle systems; determine defects, deficiencies, and potential problems; perform operational checks; and complete checklist and inspection documentation.

**49.3.2** Perform maintenance on the chassis system, given an emergency response vehicle, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; components are lubricated; fluid levels are maintained; calibrations and adjustment are performed; the system's operational condition is preserved or restored; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of chassis and vehicle systems; types of defects, deficiencies, and potential problems associated with chassis and vehicle systems; troubleshooting procedures; adjustment methods and procedures; selection of test and calibration equipment; role of a maintenance schedule and a maintenance checklist; record-keeping requirements; and inspection and maintenance procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; evaluate reported conditions; recognize and correct deficiencies; use test and calibration equipment; perform all required maintenance, including all items on a maintenance checklist; and complete required documentation.

**49.3.3** Inspect chassis systems and components unique to emergency response vehicles, given an emergency response vehicle, SOPs, manufacturer's specifications, tools, test and calibration equipment, an assignment, and an inspection checklist, so that the structural integrity of the frame is verified; the operation and condition of independent suspension systems, all-wheel steering systems, secondary braking systems, and auxiliary cooling systems are verified to be within manufacturer's specifications; multiplexing, interface electronics, and load management systems are operationally checked; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and operational checks are documented.

**(A) Requisite Knowledge.** Function, operation, construction, and interface of frames, independent suspension systems, all-wheel steering systems, secondary braking systems, and auxiliary cooling systems; the principles of electricity and operational theory of electronics; selection of test and calibration equipment; types of defects, deficiencies, and potential problems associated with chassis systems and components unique to emergency response vehicles; use of checklists; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions; use test and calibration equipment; determine defects, deficiencies, and potential problems; perform operational checks; and complete checklist and inspection documentation.

**49.3.4** Perform maintenance on chassis systems and components unique to emergency response vehicles, given an emergency response vehicle, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance check-

list, SOPs, test and calibration equipment, and tools and diagnostic equipment, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; components are lubricated; fluid levels are maintained; calibrations and adjustment are performed; the system's operational condition is preserved or restored; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of chassis and vehicle systems; types of defects, deficiencies, and potential problems associated with chassis and vehicle systems; the theory of electronics; selection of test, calibration, and diagnostic equipment; role of a maintenance schedule and a maintenance checklist; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and inspection and maintenance procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; evaluate reported conditions; recognize and correct deficiencies; use test, calibration, and diagnostic equipment; perform all required maintenance, including all items on a maintenance checklist; and complete required documentation.

**49.4 Cab and Body Components.** This duty involves the inspection and maintenance of cabs (fixed and tilt) and the vehicle body, including compartments, warning systems, mounting racks, brackets, latches, and steps and ladders.

**49.4.1** Inspect the cab, given an emergency response vehicle, applicable SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation of the cab and components is verified; the condition of finishes, signs, labels, and paint is determined; the operation and condition of the doors, latches, trays, glass, and associated hardware are verified to be within manufacturer's specifications; climate control systems are tested for proper operation; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented.

**(A) Requisite Knowledge.** Function, construction, and operation of doors and latches, seats, self-contained breathing apparatus (SCBA) mounting, safety restraints, instrumentation, window glass and mirrors, steps, handrails, and skid-resistant walking surfaces; types of defects, deficiencies, and potential problems associated with cabs; types of lubricants; failures of finishes, signs, labels, and paint; use of checklists; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; recognize and identify symptoms and conditions; determine defects, deficiencies, and potential problems; and complete checklist and inspection documentation.

**49.4.2** Perform maintenance on the cab, given an emergency response vehicle, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, and tools and test equipment, so that the operational condition is preserved or restored; deformed, broken, loose, worn, or missing parts are repaired or replaced; components are lubricated; skid-resistant walking surfaces are intact; finishes and surfaces are clean and preserved; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function and construction of cab and components, including steps, handrails, skid-resistant walking surfaces, and storage areas; types of defects or deficiencies associated with cabs; role of a maintenance schedule and a maintenance checklist; troubleshooting procedures; adjustment methods and procedures; types of lubricants; operation of doors; common problems and failures of finishes, paint, signs, and labels; record-keeping requirements; and inspection and maintenance procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; evaluate reported conditions; perform all required maintenance, including all items on a maintenance checklist; and complete required documentation.

**49.4.3** Inspect equipment mounting systems and mounting racks, brackets, and latches, given an emergency response vehicle and its assigned equipment, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the mounting system and mounting racks are verified to be within manufacturer's specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and operational checks are documented.

**(A) Requisite Knowledge.** Function, operation, and construction of assigned equipment mounting systems, warning systems, and mounting racks, brackets, and latches; types of defects, deficiencies, and potential problems associated with equipment mounting systems, warning systems, and mounting racks, brackets, and latches; use of checklists; selection of test and calibration equipment; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions of equipment mounting systems and mounting racks, brackets, and locks; use test and calibration equipment; perform operational checks; determine defects, deficiencies, and potential problems; and complete checklist and inspection documentation.

**49.4.4** Perform maintenance on equipment mounting systems and mounting racks, brackets, and latches, given an emergency response vehicle, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, and tools and test equipment, so that warning system components function; all hoses are tight; leaks are stopped; latches are aligned and adjusted to operational condition; fluids are checked and filled; lubricants are applied; any electrical connections are clean and tight; worn pads are replaced; deformed, broken, loose, worn, or missing parts are repaired or replaced; operational condition is preserved or restored; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of equipment mounting systems and mounting racks, brackets, and latches; components of warning systems; common requirements of maintenance; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with equipment mounting systems, warning systems, and mounting racks, brackets, and latches; adjustment methods and procedures; methods to stop leaks; types of fluids and lubricants; adjustment and calibration procedures; electri-

cal connection theory and maintenance; record-keeping requirements; troubleshooting procedures; and inspection and maintenance procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; evaluate reported conditions; perform all required maintenance, including all items on a maintenance checklist; correct deficiencies; and complete required documentation.

**49.4.5** Inspect the operation of the cab tilt system and components, given an emergency response vehicle with a cab tilt system, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the tilt mechanism is readied safe; the structural integrity is assessed; the operation and condition of all cab tilt components and warning systems are verified to be within manufacturer's specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspections and checks are documented.

**(A) Requisite Knowledge.** Function, operation, and construction of the cab tilt system, safety and latch systems, and warning systems; types of defects, deficiencies, and potential problems associated with cab tilt systems; use of checklist; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; recognize and identify symptoms and conditions of the cab tilt systems; determine defects, deficiencies, and potential problems; and complete checklist and inspection documentation.

**49.4.6** Inspect body, compartments, and storage areas, given an emergency response vehicle, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the body, compartments, doors, latches, trays, and associated hardware are verified to be within manufacturer's specifications; the condition of finishes, signs, labels, and paint is determined and documented; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of body, compartments, shelves and dividers, steps, ladders, platforms, handrails, and skid-resistant walking surfaces; operation of doors, latches, trays, and associated hardware; types of defects, deficiencies, and potential problems associated with the body, compartments, shelves and dividers, steps, ladders, platforms, handrails, and skid-resistant walking surfaces; use of checklists; common problems and failures of finishes and paint, signs, and labels; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; recognize and identify symptoms and conditions; determine defects, deficiencies, and potential problems; and complete checklist and inspection documentation.

**49.4.7** Perform maintenance on body, compartments, and storage areas, given an emergency response vehicle, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, and tools and test equipment, so that operational condition is preserved or restored; deformed, broken, loose, worn, or missing parts are repaired or replaced; components are lubricated; skid-resistant walking surfaces are intact; finishes and surfaces are clean and preserved; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function and construction of body, compartments, shelves and dividers, steps, ladders, platforms, handrails, skid-resistant walking surfaces, and storage areas; types of defects or deficiencies; troubleshooting procedures; role of a maintenance schedule and a maintenance checklist; adjustment methods and procedures; types of lubricants; operation of doors and trays; common problems and failures of finishes, paint, signs, and labels; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational checks; evaluate reported conditions; perform all required maintenance, including all items on a maintenance checklist; correct deficiencies; and complete required documentation.

**49.5 Electronic and Electrical Systems (Low Voltage).** This duty involves the operational checks of the vehicle's charging systems, starting systems, lighting system, electronic pump controls, and other low-voltage electronic and electrical systems and devices.

**49.5.1*** Inspect the low-voltage electrical system, given an emergency response vehicle; SOPs; manufacturer's specifications; tools and test equipment, including a belt tension gauge and a multimeter; an assignment; and an inspection checklist, so that the mounting security is verified; operation and condition of the low-voltage electrical system is verified to be within manufacturer's specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, operation, and requirements of starting and charging systems, chassis lighting and electrical components, emergency lighting, and accessory lighting; selection of test and calibration equipment; principles of electricity (Ohm's law), magnetism, and voltage drop; types of defects, deficiencies, and potential problems associated with low-voltage electrical systems; mounting and adjustment requirements; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions of low-voltage electrical systems, determine defects and deficiencies, use test and calibration equipment, perform operational checks, and complete checklist and inspection documentation.

**49.5.2*** Perform maintenance on the low-voltage electrical system, given an emergency response vehicle, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; the operational condition is preserved or restored; calibration and adjustments are

performed; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, operation, and requirements of starting and charging systems, chassis lighting and electrical components, emergency lighting, and accessory lighting; types of defects or deficiencies associated with low-voltage electrical systems; role of a maintenance schedule and a maintenance checklist; troubleshooting procedures; adjustment methods and procedures; selection of test and calibration equipment; principles of electricity (Ohm's law), magnetism, and voltage drop; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform operational checks; perform all required maintenance, including all items on a maintenance checklist; correct deficiencies; use test and calibration equipment; and complete required documentation.

**49.6 Fire Pump, Auxiliary Pump, and Tank Systems.** This duty involves inspection, maintenance, and operational checking of the fire pump wildland pump, ultra-high-pressure pump or industrial pump system, and onboard water/foam tank.

**49.6.1** Inspect fire pumps or auxiliary pump and related components, given an emergency response vehicle with a fire pump or an auxiliary pump, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the security of the mounting of all system components (e.g., primer pump, plumbing and valves, pressure control devices, gauges) is verified; operation and condition of the system components, warning system, and interlocks are verified to be within manufacturer's specifications; adjustments are made where required; recommended fluid levels are verified; leaks and fluid contamination are identified and reported; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of fire pumps, auxiliary pumps, primer pumps, and related components; pressure control devices; plumbing and valves; packing and seals; types, grades, and viscosity of lubricating oils; pump packing adjustment methods and procedures; pump operational procedures; types of defects, deficiencies, and potential problems associated with fire pumps, auxiliary pumps, primer pumps, and related components; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions of pumps and components, determine defects and deficiencies, recognize characteristics of fluid contamination, perform operational checks, and complete checklist and inspection documentation.

**49.6.2** Inspect water/foam agent tanks, given an emergency response vehicle with a water or foam tank, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the mounting and condition of the water/foam agent tank is verified; all coated and noncoated surfaces are free of corrosion; sacrificial anodes are evaluated for life-cycle condition and replaced if necessary; the tank is flushed; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspections and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, operation, and construction of water/foam tanks and related components; flushing procedures; sacrificial anode replacement procedures and schedules; types of defects, deficiencies, and potential problems associated with water/foam agent tanks; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify the effects of corrosion by different types of water and foam agents on selected tank materials, determine defects and deficiencies, perform operational checks, and complete checklist and inspection documentation.

**49.6.3*** Perform maintenance on a fire pump or auxiliary pump and related components, given an emergency response vehicle with a fire pump or an auxiliary pump, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; all packing and seals are adjusted to specification; hoses, valves, and fittings are in good condition and are leak-free; fluids are at recommended levels; recommended lubricants are applied; indicator lights are operational and electrical connections are clean and tight; instrumentation is operational; controls are adjusted, lubricated, and operational; the system's operational condition is preserved or restored; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of a fire pump, auxiliary pump-priming device, and related components; packing and seal adjustment procedures; instrumentation and controls; sacrificial anode replacement procedure and schedules; types of defects or deficiencies associated with fire pumps, auxiliary pumps, priming devices, and related components; role of a maintenance schedule and a maintenance checklist; troubleshooting procedures; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform operational tests; use test and calibration equipment; perform all required maintenance, including all items on a maintenance checklist; correct deficiencies; and complete required documentation.

**49.7 Aerial Systems.** This duty involves inspection, maintenance, and operational checks of aerial ladder, elevating platform, and water tower systems.

**49.7.1** Inspect the ladder sections of an aerial ladder, given an emergency response vehicle with an aerial ladder, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the ladder sections and extension systems are verified to be within manufacturer's specification; the mounting security is verified; the alignment of the sections is checked for twists and bows; rails and rungs are checked for corrosion and dents; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identi-

fied and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, operation, construction, and inspection practices of aerial ladders; types of defects, deficiencies, and potential problems associated with aerial ladders; use of checklists; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Recognize and identify physical and operational conditions of ladder sections, components, and systems; determine defects and deficiencies; perform operational checks; and complete checklist and inspection documentation.

**49.7.2** Inspect the sections of an elevating platform or water tower, given an emergency response vehicle with an elevating platform or water tower, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the boom sections are verified to be within manufacturer's specifications; the mounting security of all components is verified; the alignment of the booms is checked for twists and bows; booms are checked for corrosion, dents, wear, and discontinuities; extension, elevation, and leveling systems are checked for damage; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, operation, and construction of elevating platforms or water towers; types of defects, deficiencies, and potential problems associated with elevating platforms; use of checklists; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Recognize and identify physical and operational conditions of elevating platforms or water towers and components, perform operational checks, determine defects and deficiencies, and complete checklist and inspection documentation.

**49.7.3** Perform maintenance on aerial sections, booms, platforms and waterways, given an emergency response vehicle with an aerial device and waterway, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that the aerial sections, booms, platforms, and waterways are maintained in accordance with specifications, and are cleaned, lubricated, and adjusted; deformed, broken, loose, worn, or missing parts are repaired or replaced; the operational condition is preserved or restored; the aerial device is tested for proper operation; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of aerial device, components, and systems; fluid types and lubricants; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with aerial devices; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and apparatus inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform operational checks; perform all required maintenance, including all items on a maintenance checklist; use test and calibration equipment; correct deficiencies; and complete required documentation.

**49.7.4** Inspect the hydraulic system components of an aerial device, given an emergency response vehicle with an aerial device, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the hydraulic system components, warning systems, and gauges are verified to be within manufacturer's specifications; the security of the mounting of components is verified; recommended fluid levels are verified; visible leakage or contamination is identified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, operation, and inspection procedures of stabilizers, rotation motors, extension cylinders, elevation cylinders, leveling cylinders, gauges, and parts of an aerial device hydraulic system; normal operating condition; fluid requirements; types of defects, deficiencies, and potential problems associated with hydraulic systems; sources of contamination; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify the condition of the aerial device hydraulic system, recognize and identify recommended fluid levels and sources of contamination, determine defects and deficiencies, read and interpret gauges, perform operational checks, and complete checklist and inspection documentation.

**49.7.5** Inspect all mechanical components of the stabilization system, given an emergency response vehicle with an aerial device stabilization system, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the security of the mounting is verified; operation and condition of the mechanical components of the stabilization system are verified to be within manufacturer's specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of an aerial device stabilization system, including wheels, tires, axles, frame, torque box, turntable, and related components; normal operating condition; types of defects, deficiencies, and potential problems associated with stabilization systems; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify the condition of an aerial device stabilization system, determine defects and deficiencies, perform operational checks, and complete checklist and inspection documentation.

**49.7.6** Perform maintenance on the aerial device stabilization system, given an emergency response vehicle with an aerial

device stabilization system, a maintenance schedule or an assignment, manufacturer's specifications, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; the stabilization system is maintained in accordance with manufacturer's specifications; the operational condition is preserved or restored; the stabilization system is tested for proper operation; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device stabilization system; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with stabilization systems; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; selection of test and calibration equipment; and aerial device inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform operational tests; perform all required maintenance, including all items on a maintenance checklist; use test and calibration equipment; correct deficiencies; and complete required documentation.

**49.7.7** Inspect all components of aerial device lifting, rotating, and extension systems, given an emergency response vehicle with an aerial device, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the aerial device lifting, rotating, and extension systems, including the rotation motor and cables, and warning systems are verified to be within manufacturer's specifications; the security of mounting of the components is verified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of components of lifting, rotating, and extension systems of an aerial device; normal condition; types of defects, deficiencies, and potential problems associated with aerial device lifting, rotating, and extension systems; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify conditions of components of lifting, rotating, and extension systems of an aerial device that are abnormal or operating outside manufacturer's requirements; determine defects and deficiencies; perform operational checks; and complete checklist and inspection documentation.

**49.7.8** Inspect the components of the aerial device electrical system, given an emergency response vehicle with an aerial device, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the security of mounting is verified; operation and condition of the electrical system, interlocks, and warning systems are verified to be within manufacturer's specifications; the operation and the legibility of the gauges are verified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, operation, and inspection of components of the aerial device electrical and warning systems; normal condition; types of defects, deficiencies, and potential problems of aerial device electrical systems; selection of test gauges and meters; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify conditions of components of aerial device electrical systems that are deficient or operating outside manufacturer's requirements, read and interpret test gauges and meters, perform operational checks, and complete checklist and inspection documentation.

**49.7.9** Inspect all components of an aerial device waterway system, given an emergency response vehicle with an aerial device and waterway system, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the security of mounting is verified; the operation and condition of the aerial device waterway system are verified to be within manufacturer's specifications; the operation and the legibility of the gauges are verified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of components of the waterway system; selection of test and calibration equipment; lubrication requirements; types of defects, deficiencies, and potential problems associated with aerial device waterway systems; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify symptoms and the condition of components of aerial device waterway systems that are deficient or operating outside manufacturer's requirements, use test and calibration equipment, read and interpret test gauges and flowmeters, perform operational checks, and complete checklist and inspection documentation.

**49.8 Trailers.**

**49.8.1** Inspect trailers and components unique to emergency response trailers, given an emergency response trailer, appropriate SOPs, manufacturer's specifications, appropriate tools, test and calibration equipment, an assignment, and an inspection checklist, so that the structural integrity of the frame is verified; the operation and condition of independent suspension systems, the condition of the wheels and tires, braking systems, safety equipment, and lighting systems, is verified to be within manufacturer's specifications; interface electronics and load management systems are operationally tested; all checklist items are inspected; defects and deficiencies including broken, loose, worn, or missing parts are identified and reported; and inspections are documented.

**(A) Requisite Knowledge.** Function, operation, construction, and interface of frames, suspension systems, braking systems, safety equipment and lighting systems; the principles of electricity and operational theory of electronics; selection of test and calibration equipment; types of defects, deficiencies, and potential problems associated with trailer systems and compo-

nents unique to emergency response trailers; use of checklists; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions; use test and calibration equipment; determine defects, deficiencies, and potential problems; perform operational checks; and complete checklist and inspection documentation.

**49.8.2** Perform maintenance on chassis systems and components unique to emergency response vehicles, given an emergency response trailer, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, appropriate SOPs, test and calibration equipment, and appropriate tools and diagnostic equipment, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; components are lubricated; fluid levels are maintained; calibrations and adjustment are performed; the system's operational condition is preserved or restored; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of trailer systems; types of defects, deficiencies, and potential problems associated with trailer systems; the theory of electronics; selection of test, calibration, and diagnostic equipment; the role of a maintenance schedule and a maintenance checklist; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and inspection and maintenance procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational verification tests; evaluate reported conditions; recognize and correct deficiencies; use test, calibration, and diagnostic equipment; perform all required maintenance including all items on a maintenance checklist; and complete required documentation.

**49.9 Ambulance Patient Module.**

**49.9.1** Inspect patient module and components unique to ambulances, given an ambulance, appropriate SOPs, manufacturer's specifications, appropriate tools, test and calibration equipment, an assignment, and an inspection checklist, so that the structural integrity of the patient module frame is verified; the operation and condition of patient module structure, patient module entry doors, compartment doors, patient module interior systems, components, safety equipment, oxygen system, line voltage system, electrical and lighting systems, is verified to be within manufacturer's specifications; interface electronics and load management systems are operationally tested; all checklist items are inspected; defects and deficiencies including broken, loose, worn, or missing parts are identified and reported; and inspections are documented.

**(A) Requisite Knowledge.** Function, operation, construction, and interface of patient module structure, compartments, doors, patient module interior systems, line voltage systems, electrical systems, safety equipment, oxygen systems and lighting systems; the principles of electricity and operational theory of electronics; selection of test and calibration equipment; types of defects, deficiencies, and potential problems associated with patient module systems and components unique to ambulances; use of checklists; record-keeping requirements; and inspection procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions; use test and calibration equipment; determine defects, deficiencies, and potential problems; perform operational tests; and complete checklist and inspection documentation.

**49.9.2** Perform maintenance on a patient module and components unique to ambulances, given an ambulance, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, appropriate SOPs, test and calibration equipment, and appropriate tools and diagnostic equipment, so that deformed, broken, loose, worn, or missing parts are repaired or replaced; components are lubricated; calibrations and adjustments are performed; the system's operational condition is preserved or restored; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of ambulance systems; types of defects, deficiencies, and potential problems associated with patient module systems; the theory of electronics; selection of test, calibration, and diagnostic equipment; the role of a maintenance schedule and a maintenance checklist; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and inspection and maintenance procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Perform operational verification tests; evaluate reported conditions; recognize and correct deficiencies; use test, calibration, and diagnostic equipment; perform all required maintenance including all items on a maintenance checklist; and complete required documentation.

**49.10 Specialized Systems.** This duty involves inspection, operational checking, and maintenance of foam systems, line voltage electrical systems, breathing-air systems, and auxiliary air systems.

**49.10.1*** Inspect the foam-proportioning system, given an emergency response vehicle with a foam-proportioning system, SOPs, manufacturer's specifications, tools, test and calibration equipment, an assignment, and an inspection checklist, so that the mounting security and structural integrity are verified; operation and condition of the system are verified to be within manufacturer's specifications; recommended fluid levels are verified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of foam-proportioning systems, including construction and operation of eduction, injection, and venturi proportioning systems and related components; characteristics of system design, including foam concentrate agents; characteristics of water flow and pressure; flushing procedures; backflow prevention; the use of filters and strainers; basic principles of operating controls, metering devices, and indicators; selection of test and calibration equipment; types of defects, deficiencies, and potential problems associated with foam-proportioning systems; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Interpret manufacturer's operational and maintenance guidelines, identify and operate proportioning

systems, recognize symptoms and conditions, determine defects and deficiencies, use test and calibration equipment, perform operational checks, and complete checklist and inspection documentation.

**49.10.2** Perform maintenance on a foam-proportioning system, given an emergency response vehicle with a foam-proportioning system, a maintenance schedule or an assignment, a maintenance checklist, manufacturer's specifications, SOPs, test and calibration equipment, and tools so that deformed, broken, loose, worn, or missing parts are repaired or replaced; the system operates within manufacturer's guidelines; fluid levels are maintained; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of a foam-proportioning system; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with foam-proportioning systems; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform all required maintenance, including all items on a maintenance checklist; use test and calibration equipment; correct deficiencies; perform operational checks on the foam-proportioning system; and complete required documentation.

**49.10.3** Inspect the compressed air foam system (CAFS) and associated components, given an emergency response vehicle with a CAFS, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the security of mounting of the system is verified; the operation and condition of the system and its associated components, including air tank, hoses, valves and fittings, warning and interlock systems, linkage, and drive shafts, are verified to be within manufacturer's specifications; recommended fluid levels are verified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of CAFSs; warning and interlock systems; common failure symptoms associated with component interfaces of related equipment; types of defects, deficiencies, and potential problems associated with CAFSs; pressure-control devices; packing and seals; types, grades, and viscosity of lubricants; use of checklists; record-keeping requirements; operational testing requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify normal operating conditions of CAFSs; identify components that are damaged, worn, or missing; determine defects and deficiencies; use test and calibration equipment; perform operational checks; and complete checklists and inspection documentation.

**49.10.4** Perform maintenance on a CAFS and its components, given an emergency response vehicle with a compressed air foam system, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, and tools and test equipment, so that the operational condition of the CAFS is preserved or restored; CAFS compressor and system components function to the recommended specifications; all hoses are tight; adjustments are made to stop all fluid leaks; lubricants are applied; all electrical connections are clean and tight; system operation is verified; deformed, broken, loose, worn, or missing parts, including component mounts, drive system, pump, plumbing, and valves, are repaired or replaced; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of CAFSs, including foam types, drive systems, flowmeters, proportioners, valves, eductors, and nozzles; the use of test and calibration equipment; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with CAFSs; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Ability to evaluate the reported condition of a CAFS; perform all required maintenance, including all items on a maintenance checklist; recognize and correct deficiencies; interpret and follow operational check procedures; use test and calibration equipment; and complete required documentation.

**49.10.5*** Inspect all components and accessories of the electrical line voltage generation system, controls, and instrumentation, given an emergency response vehicle with a line voltage electrical system, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the security of mounting is verified; the operation and condition of the system and drive units, cord reels, lighting, accessories and equipment, safety and protection devices, and instrumentation are verified to be within manufacturer's specifications; the condition and correct placement of information and warning signs and labels are verified; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Electricity safety and inspection procedures; function, construction, operation, and inspection of components of electrical line voltage generation, controls, and instrumentation; types of defects, deficiencies, and potential problems associated with electrical line voltage generation systems; required labels, plates, and signs; use of checklists; record-keeping requirements; and inspection procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify the symptoms and conditions of components of electrical line voltage generation, including controls and instrumentation; determine defects and deficiencies; perform operational checks; and complete checklist and inspection documentation.

**49.10.6** Perform maintenance on electrical line voltage generation system, controls, and instrumentation, given an emergency response vehicle with a line voltage electrical system, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that the operational condition of generators, system components, instrumentation, controls, safety and load protection devices, and the drive unit is preserved or restored; lubrication and fluid levels are checked;

deformed, broken, loose, worn, or missing parts are repaired or replaced; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Knowledge of local, state, and federal regulation regarding inspection and maintenance of line voltage installations; function, construction, and operation of generators, instrumentation, controls, and drive units; lubrication requirements and types; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with line voltage electrical systems; troubleshooting procedures; adjustment methods and procedures; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform operational checks; perform all required maintenance, including all items on a maintenance checklist; use test and calibration equipment, correct deficiencies, and complete required documentation.

**49.10.7** Inspect all components of a breathing-air and purification system, given an emergency response vehicle with a breathing-air and purification system, SOPs, manufacturer's specifications, tools and test equipment, quality sample kits, an assignment, and an inspection checklist, so that the security of mounting is verified; operation and condition of the breathing-air and purification system, including the drive unit and compressors, electrical protection devices, safety devices, interlocks, and instrumentation, are verified to be within manufacturer's specifications; the condition of the separator filters is verified; recommended fluid levels of drive units and compressors are verified; the condition and adjustment of drive belts are verified to be within manufacturer's specifications; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of a breathing-air purification system; understanding of cascading operations, high-pressure air regulation, and purification testing; types of defects, deficiencies, and potential problems associated with breathing-air and purification systems; use of checklists; record-keeping requirements; system inspection and maintenance procedures of the authority having jurisdiction and manufacturer; selection of test and calibration equipment; and test methods and troubleshooting procedures.

**(B) Requisite Skills.** Evaluate reported conditions, recognize symptoms and conditions, determine defects and deficiencies, perform operational checks, use test and calibration equipment, and complete checklist and inspection documentation.

**49.10.8** Perform maintenance on a breathing-air and purification system, given an emergency response vehicle with a breathing-air and purification system, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that drive units and compressors are maintained; breathing air is within purification standards; deformed, broken, loose, worn, or missing parts are repaired or replaced; the operational condition is preserved or restored; the system is operationally checked; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of drive units and compressors; selection of test and calibration equipment; lubricants and lubrication systems; role of a maintenance schedule and a maintenance checklist; types of defects or deficiencies associated with breathing-air and purification systems; troubleshooting procedures; adjustment methods and procedures; inspection and repair or replacement of system components; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions of the compressor and drive unit; perform all required maintenance, including all items on a maintenance checklist; recognize and correct deficiencies; interpret and follow operational checking methods and procedures; use test and calibration equipment; and complete required documentation.

**49.10.9** Inspect an auxiliary air compressor, given an emergency response vehicle with an auxiliary air compressor, SOPs, manufacturer's specifications, tools and test equipment, an assignment, and an inspection checklist, so that the operation and condition of the auxiliary air compressor, warning systems, instrumentation, and interlock systems are verified to be within manufacturer's specifications; the security of mounting of the system and its associated components is verified; linkage and drive shafts are inspected for wear and alignment; the condition of air tank, dryer, reels, hoses, piping, valves, and fittings is assessed; recommended fluid levels are verified and fluids are inspected for any visible contamination; all checklist items are inspected; defects and deficiencies, including broken, loose, worn, or missing parts, are identified and reported; and inspection and checks are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of auxiliary air compressors, drive units, and related components; warning and interlock systems; common failure symptoms associated with component interfaces of related equipment; purpose for and use of checklists; types of defects, deficiencies, and potential problems associated with auxiliary air compressors, drive units, and related components; types of instrumentation; selection of test and calibration equipment; pressure control and safety devices, packing, and seals; types, grades, and viscosity of lubricants; use of checklists; record-keeping requirements; and inspection and operational checking requirements and procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize and identify symptoms and conditions of compressors, drive units, and related components that are damaged, worn, or missing; determine defects and deficiencies; use test and calibration equipment; perform operational checks; and complete checklists and inspection documentation.

**49.10.10** Perform maintenance on auxiliary air compressors, drive units, and related components, given an emergency response vehicle with an auxiliary air compressor, manufacturer's specifications, a maintenance schedule or an assignment, a maintenance checklist, SOPs, and tools and test equipment, so that the compressor, drive unit, and related components are operational and functioning within the manufacturer's specifications; filters are replaced; any leaks in hoses, piping, valves, and fittings are repaired; lubricants are applied; all electrical connections are clean and tight; deformed, broken, loose,

worn, or missing parts are repaired or replaced; system operation is verified; activities are documented; and additional repair needs are reported.

**(A) Requisite Knowledge.** Function, construction, and operation of a drive unit, compressor, and related components; selection of test and calibration equipment; role of a maintenance schedule and a maintenance checklist; lubricants and lubrication systems; types of defects or deficiencies associated with auxiliary air compressors, drive units, and related components; troubleshooting procedures; adjustment methods and procedures; inspection and repair or replacement of system components; record-keeping requirements; and inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate the reported condition of compressors, drive units, and related components; perform operational checks; perform all required maintenance, including all items on a maintenance checklist; determine and correct defects and deficiencies; use test and calibration equipment; and complete checklists and required documentation.

## Chapter 50 Emergency Vehicle Technician II (NFPA 1071)

### 50.1 General.

**50.1.1** To be considered qualified as an Emergency Vehicle Technician II, the individual shall meet the following criteria:

(1) Meet the requirements of an Emergency Vehicle Technician I
(2) Meet the job performance requirements of Sections 50.2 through 50.4 and at least one specialty area as defined in Section 50.5, Section 50.6, or Section 50.7

**50.1.2** The Emergency Vehicle Technician II shall not be considered qualified in a specialty area as defined in Section 50.5, Section 50.6, or Section 50.7 unless he or she is first qualified in the equivalent specialty as defined in Section 49.6, Section 49.7, or Section 49.10 as an Emergency Vehicle Technician I.

**50.2 Chassis.** This duty involves the repair, diagnostic checking, performance testing, and weight verification on an emergency response vehicle of chassis and interdependent systems such as engines, transmissions, auxiliary drive systems, drivelines, brakes, steering and suspension, fuel, electrical, exhaust, and climate control.

**50.2.1** Perform repairs on chassis systems and components, given an emergency response vehicle with an identified defective component(s), manufacturer's specifications, SOPs, an assignment or inspection report detailing a deficiency or deformation, and test and calibration equipment and tools, so that the identified defective component is diagnosed; deformed, broken, loose, worn, or missing parts of a chassis system or its components are repaired, rebuilt, or replaced to manufacturer's specifications; diagnostic checks are conducted and performance is verified; and the repairs are documented in accordance with the procedures of the jurisdiction.

**(A) Requisite Knowledge.** Function, operation, and construction of chassis and vehicle systems; types of defects, deficiencies, and potential problems; selection of test and calibration equipment; repair and overhaul procedures; theory of electricity and electronics; types of cooling systems; types of suspension and steering systems; basic principles of suspension and steering geometry; types of brake systems, including secondary braking systems; principles of hydraulics; diagnostic checks and performance tests; adjustment and calibration procedures; selection of test and calibration equipment; common defects; electrical troubleshooting procedures; record-keeping requirements; and diagnostic and repair procedures of the authority having jurisdiction and the manufacturer.

**(B) Requisite Skills.** Identify and evaluate conditions; recognize deficiencies; perform required repairs to resolve deficiencies; conduct required testing; use test and calibration equipment; and complete required documentation.

**50.2.2** Complete axle weight performance test on apparatus in accordance with Chapters 1 through 28, given an emergency response vehicle, an applicable driving license (if required), and a commercial certified scale, so that the apparatus weight is determined to ensure that the weight on the vehicle does not exceed the gross axle weight rating (GAWR) and the gross vehicle weight rating (GVWR) or gross combination weight rating (GCWR) as shown on the rating label on the fire apparatus; and all testing is documented in accordance with the requirements of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Legal operation of fire apparatus; familiarity with location of certified scale; and record-keeping requirements of Chapters 1 through 28 and the AHJ.

**(B) Requisite Skills.** Operation of fire apparatus; and complete required documentation.

**50.2.3** Complete braking performance test on apparatus in accordance with Chapters 1 through 28, given an emergency response vehicle, an applicable driving license (if required), and a calibrated driving course, so that the apparatus braking system performance is verified to ensure that the braking ability of the apparatus complies with the requirements of Chapters 1 through 28 and federal and state regulations; and all testing is documented in accordance with the requirements of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Legal operation of fire apparatus; familiarity with brake testing course; requirements of Chapters 1 through 28 and federal and state regulations; and record-keeping requirements of Chapters 1 through 28 and the AHJ.

**(B) Requisite Skills.** Operation of fire apparatus; recognize and perform braking test; and complete required documentation.

**50.2.4** Complete parking brake performance test on apparatus in accordance with Chapters 1 through 28, given an emergency response vehicle, an applicable driving license (if required), and an appropriate road grade, so that the apparatus parking brake system performance is verified to ensure that the park braking ability of the apparatus complies with the requirements of Chapters 1 through 28 and federal and state regulations; and all testing is documented in accordance with the procedures of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Legal operation of fire apparatus; familiarity with park brake testing course; requirements of Chapters 1 through 28 and federal and state regulations; and record-keeping requirements of Chapters 1 through 28 and the AHJ.

**(B) Requisite Skills.** Operation of fire apparatus; recognize and perform park braking test; and complete required documentation.

**50.2.5** Complete road performance test on apparatus in accordance with Chapters 1 through 28, given an emergency response vehicle, an applicable driving license (if required), and an approved driving course, so that apparatus system performance is verified to ensure that the drivability of the apparatus complies with requirements of Chapters 1 through 28 and federal and state regulations; and all testing is documented in accordance with the requirements of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Legal operation of fire apparatus; familiarity with apparatus drivability; requirements of Chapters 1 through 28 and federal and state regulations; and record-keeping requirements of Chapters 1 through 28 and the AHJ.

**(B) Requisite Skills.** Operation of fire apparatus, ability to recognize and perform road test; and complete required documentation.

**50.3 Cab and Body Components.** This duty involves the repair of cabs (fixed and tilt) and the vehicle body, including compartments, mounting brackets, steps, and ladders.

**50.3.1** Perform repairs on equipment-mounting systems and racks, given an emergency response vehicle, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, and test and calibration equipment and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an equipment-mounting system or rack are repaired, rebuilt, or replaced to manufacturer's specifications; diagnostic checks are conducted and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of equipment-mounting systems, mounting racks, brackets, and locks; selection of test and calibration equipment; principles of welding and fabrication; principles of pneumatic, hydraulic, and electric operation; troubleshooting procedures; repairing, rebuilding, and replacement procedures; diagnostic checks; types of fluids; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; use test and calibration equipment; measure voltage, amperage, and resistance; recognize metals; perform welding and fabrication; perform required repairs to resolve deficiencies; perform diagnostic checks; and complete required documentation.

**50.3.2** Perform repairs on cab tilt systems, given an emergency response vehicle with a cab tilt system, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, and test and calibration equipment and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of a cab tilt system are repaired, replaced, or rebuilt to manufacturer's specifications; diagnostic checks are conducted and performance is verified; hazards are avoided; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of cab tilt systems and safety locks; selection of test and calibration equipment; principles of welding and fabrication; principles of pneumatic, hydraulic, and electric operation; troubleshooting procedures; repairing, rebuilding, and replacement procedures; diagnostic checks; types of fluids; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; use testing and calibration equipment; measure voltage, amperage, and resistance; recognize metals; perform welding and fabrication; perform required repairs to resolve deficiencies; perform diagnostic checks; and complete required documentation.

**50.3.3** Perform repairs on body, compartments, and storage areas, given an emergency response vehicle, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of a body, compartment, or storage area are repaired, replaced, or rebuilt to manufacturer's specifications; components are fabricated, adjusted, aligned, and lubricated; hazardous conditions are resolved; diagnostic checks are conducted and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of doors, compartment shelves, trays, and dividers, steps, ladders, platforms, handrails, skid-resistant walking surfaces, and storage areas; types of lubricants; failures and restoration of finishes, signs, labels, and paint; welding and fabrication procedures; selection of test and calibration equipment; adjustment and alignment procedures; troubleshooting procedures; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; use test and calibration equipment; recognize metals; apply paint and finish materials; perform welding and fabrication; perform required repairs to resolve deficiencies; perform diagnostic checks; and complete required documentation.

**50.3.4** Perform repairs on a cab, given an emergency response vehicle, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of a cab are repaired, replaced, or rebuilt to manufacturer's specifications; diagnostic checks are conducted and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of doors and latches, seats, self-contained breathing apparatus (SCBA) mounting and safety restraints, instrumentation, window glass and mirrors, steps, handrails, and skid-resistant walking surfaces; types of lubricants; failures and restoration of finishes, signs, labels, and paint; welding and fabrication procedures; selection of test and calibration equipment; adjustment

and alignment procedures; troubleshooting procedures; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; use test and calibration equipment; recognize metals; apply paint and finish materials; perform welding and fabrication; perform required repairs to resolve deficiencies; perform diagnostic checks; and complete required documentation.

**50.4 Electronic and Electrical Systems (Low Voltage).** This duty involves the repair, diagnostic checks, and performance testing of the charging systems, starting systems, lighting systems, electronic pump controls, and other low-voltage electronic and electrical devices.

**50.4.1** Perform repairs on low-voltage electrical system components, given an emergency response vehicle, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of low-voltage electrical system components are repaired, replaced, or rebuilt to manufacturer's specifications; charging systems, starting systems, lighting systems, electrical accessories, and other electrical systems are returned to operation; correct test equipment is used; hazards are avoided; correct parts are used; diagnostic checks are conducted and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of starting motors, alternators, and accessory electric motors, relays, solenoids, and regulators; repair and overhaul procedures; theory of electricity; operation, diagnostic checks, and performance tests; adjustment and calibration procedures; selection of test and calibration equipment; common defects; electrical troubleshooting procedures; record-keeping requirements; and diagnostic and repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; perform required repairs to resolve deficiencies; use test and calibration equipment; measure voltage, amperage, and resistance; distinguish defects and deficiencies; operate and test system; perform electrical calculations; and complete required documentation.

**50.4.2** Perform repairs on electronic controls and instrumentation, given an emergency response vehicle, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an electronic control or instrumentation are repaired, replaced, or rebuilt to manufacturer's specifications; engine, transmission, and brake electronic control units or electronic control modules, pump throttles and pressure control devices, and instrumentation are returned to operation; programming is correct; load control devices, sequencer, interfaces, and interlocks are operational; correct test equipment is used; correct parts are used; correct tests and programming procedures are followed; diagnostic checks are conducted and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, operation, and requirements of electronic engine, transmission, and brake controls, instrumentation, load control devices, onboard chargers, sequencers, interfaces, and interlocks; selection of test and calibration equipment; digital volt-ohmmeter, electronic readers, and fault code interpretation; safety procedures; common deficiencies; correct repair procedures; record-keeping requirements; diagnostic and repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and analyze reported conditions, defects, and deficiencies; perform required repairs to resolve deficiencies; use test and calibration equipment; operate and test system(s); perform calculations; use correct parts; and complete required documentation.

**50.4.3** Complete performance testing on low-voltage electrical system components including batteries, charging systems, starting systems, onboard chargers, electrical loads, solenoids, and relay devices in accordance with Chapters 1 through 28, given an emergency response vehicle, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that components are performance tested to assure they are operating in accordance with manufacturer's specifications and NFPA standards; performance tests are conducted to verify that repairs are completed; and all testing is documented in accordance with the procedures of the manufacturer and the AHJ.

**(A) Requisite Knowledge.** Function, construction, and operation of starting motors, alternators, relays, solenoids, and regulators; repair and overhaul procedures; theory of electricity; diagnostic checks and performance tests; adjustment and calibration procedures; selection of test and calibration equipment; common defects; electrical troubleshooting procedures; record-keeping requirements; diagnostic and repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; perform required repairs to resolve deficiencies; use test and calibration equipment; measure voltage, amperage, and resistance; distinguish defects and deficiencies; diagnostically check and performance test system; perform electrical calculations; complete required documentation in accordance with SOPs and NFPA standards.

**50.5 Pump and Tank Systems.** This duty involves the maintenance, repair, diagnostic checking, and performance testing of pump systems and water/foam tanks.

**50.5.1** Perform repairs on fire pumps or auxiliary pumps and related components, given an emergency response vehicle with a fire pump, wildland pump, ultra-high-pressure or industrial pump, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts on a fire pump, auxiliary pumps, or related components are repaired, replaced, or rebuilt to manufacturer's specifications; diagnostic checks and service tests are conducted and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of a pump and its related components; overhaul procedures; principles of pressure control devices; packing and seal replacement and adjustment procedures; diagnostic checks and performance testing procedure and requirements; selection of test and calibration equipment; safety procedures; troubleshooting procedures; record-keeping requirements; and diagnostic and repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; perform required repairs to resolve deficiencies; use test and calibration equipment; identify defects and deficiencies; diagnostically check and performance test systems; perform fire flow hydraulic calculations; and complete required documentation.

**50.5.2** Perform repairs on water/foam tanks, given an emergency response vehicle with a water or foam tank, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, and tools, so that leaks are repaired; interior and exterior surfaces are free of corrosion; coatings are renewed; deformed, broken, loose, worn, or missing parts are repaired, replaced, or rebuilt to manufacturer's specifications; service flow test of the tank(s) is conducted; and the repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of water/tanks; flow requirements; cleaning and coating procedures; principles of welding and fabrication; recognition of materials; selection of test and calibration equipment; performance testing procedures; troubleshooting; record-keeping requirements; and diagnostic and repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and identify reported conditions; recognize tank materials; perform welding and fabrication; perform required repairs to resolve deficiencies; use test and calibration equipment; perform service flow tests; and complete required documentation.

**50.5.3** Complete performance testing on apparatus fire pumps and related components in accordance with Chapters 1 through 28, given an emergency response vehicle with a fire pump, wildland pump, ultra-high-pressure pump or industrial pump, manufacturer's specifications, SOPs, test and calibration equipment, facilities, and tools, so that the pumping systems are capable of meeting the performance requirements without exceeding 110 percent of the original certification test rpm; and all testing is documented in accordance with the procedures of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Function, construction, and operation of a pump and its related components; principles of pressure control devices; diagnostic checking and performance testing procedure and requirements; selection of test and calibration equipment; safety procedures; diagnostic procedures; fire flow hydraulic calculations; and record-keeping requirements.

**(B) Requisite Skills.** Conduct fire pump performance tests; use test and calibration equipment; identify defects and deficiencies; perform fire flow hydraulic calculations; and complete required documentation.

**50.6 Aerial Systems.** This duty involves inspection, maintenance, repair, diagnostic checking, and performance testing of an aerial system.

**50.6.1** Perform repair on aerial sections, booms, and platforms, given an emergency response vehicle with an aerial device, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an aerial section, boom, or platform are repaired, replaced, or rebuilt to manufacturer's specifications; the aerial device is diagnostically checked for proper operation and performance is verified; and the repairs are documented in accordance with the procedures of the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of aerial devices, components, and systems; selection of test and calibration equipment; fluid types and lubricants; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; interpret the manufacturer's specifications; perform required repairs to resolve deficiencies; use test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.6.2** Perform repairs on the aerial device stabilization system, given an emergency response vehicle with an aerial device stabilization system, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an aerial device stabilization system are repaired, replaced, or rebuilt to manufacturer's specifications; the stabilization system is diagnostically checked for proper operation and performance is verified; and the repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device stabilization system; record-keeping requirements; selection of test and calibration equipment; and aerial device repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; interpret the manufacturer's specifications; perform required repairs to resolve deficiencies; use required test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.6.3** Perform maintenance on an aerial device lifting, rotating, and extension system, given an emergency response vehicle with an aerial device, a maintenance schedule or an assignment, manufacturer's specifications, a maintenance checklist, SOPs, test and calibration equipment, and tools, so that the lifting, rotating, and extension systems are maintained in accordance with manufacturer's specifications; electrical connections are clean and tight; hoses, valves, and fittings are leak-free and in good condition; instrumentation is operational; controls are operational; lubricants are applied; fluids are at recommended levels; the operational condition is preserved or restored; deformed, broken, loose, worn, or miss-

ing parts are repaired or replaced; the aerial system is diagnostically checked for proper operation and the performance is verified; additional repair needs are reported; and the maintenance is documented.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device lifting, rotating, and extension systems; role of a maintenance schedule and a maintenance checklist; lubrication and fluid types; adjustment methods and procedures; troubleshooting procedures; types of defects and deficiencies; principles of hydraulics; selection of test and calibration equipment; record-keeping requirements; and aerial device inspection and maintenance procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Evaluate reported conditions; perform all required maintenance, including all items on a maintenance checklist; correct deficiencies; use required test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.6.4** Perform repairs on an aerial device lifting, rotating, and extension system, given an emergency response vehicle with an aerial device, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an aerial device lifting, rotating, and extension system are repaired, replaced, or rebuilt to manufacturer's specifications; the aerial device is diagnostically checked for proper operation and the performance is verified; and the repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device lifting, rotating, and extension systems; troubleshooting procedures; selection of test and calibration equipment; record-keeping requirements; and aerial device repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; interpret manufacturer's specifications; perform required repairs to resolve deficiencies; use required test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.6.5** Perform repairs on an aerial hydraulic system, given an emergency response vehicle with an aerial device, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, and tools, test, and calibration equipment, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an aerial hydraulic system are repaired, rebuilt, or replaced according to manufacturer's specifications; fluids are restored to recommended levels; the aerial device is diagnostically checked for proper operation and the performance is verified; and the repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device hydraulic system and components; principles of hydraulics; lubricants and fluid types; troubleshooting procedures; selection of test and calibration equipment; adjustment methods and procedures; record-keeping requirements; and aerial device repair procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; perform required repairs to resolve deficiencies; use required test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.6.6** Perform repairs on aerial device electrical and electronic systems, given an emergency response vehicle with an aerial device, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an aerial device electrical or electronic system are repaired, rebuilt, or replaced to manufacturer's specifications; the aerial device is diagnostically checked for proper operation and the performance is verified; and the repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device electrical or electronic system; principles of electricity; electronic theory; selection of test, calibration, and diagnostic equipment; record-keeping requirements; and diagnostic, repair, and performance testing procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; interpret manufacturer's specifications; perform required diagnosis; perform required repairs to resolve deficiencies; use required test, calibration, and diagnostic equipment; perform diagnostic checks; and complete required documentation.

**50.6.7** Perform repairs on an aerial device waterway system, given an emergency response vehicle with an aerial device and a prepiped waterway system, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an aerial device waterway system are repaired, rebuilt, or replaced and tested according to manufacturer's specifications; the aerial device and the waterway is diagnostically checked for proper operation and the performance is verified; and the repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the aerial device waterway system; principles of hydraulics; selection of test and calibration equipment; adjustment and alignment procedures; record-keeping requirements; and aerial device waterway diagnostic, repair, and performance testing procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; interpret manufacturer specifications; perform required repairs to resolve deficiencies; use required test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.6.8** Complete annual performance testing on fire department aerial devices, systems, and related components in accordance with Chapters 1 through 28 and SOPs, given test and calibration equipment, tools, facilities, records, and forms,

so that aerial device performance can be evaluated; defects and deficiencies are identified; operation of aerial device systems is verified; and performance test results are documented.

**(A) Requisite Knowledge.** Function, construction, and operation of aerial devices, controls, and instrumentation; selection of test and calibration equipment; test equipment calibration requirements; aerial device performance testing procedures; fire flow hydraulic calculations; and record-keeping requirements.

**(B) Requisite Skills.** Evaluate conditions; recognize deficiencies; interpret and follow performance test procedures; conduct required performance tests; use test and calibration equipment; and complete performance testing forms and required documentation.

**50.7 Specialized Systems.** This duty involves the repair, diagnostic checks, and performance testing of foam systems, line voltage electrical systems, breathing-air systems, and auxiliary air systems.

**50.7.1** Repair foam-proportioning system components, given an emergency response vehicle with a foam-proportioning system, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of a foam-proportioning system, including component mounts, drive systems, pumps, plumbing, and valves, are repaired, replaced, or rebuilt to manufacturer's specifications; the foam system is diagnostically checked for proper operation and performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of foam-proportioning systems, including foam types, drive systems, foam concentrate pumps, flowmeters, proportioners, valves, eductors, and nozzles; the selection of testing and calibration equipment; methods and procedures; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; interpret manufacturer's specifications; use required test and calibration equipment; perform diagnostic procedures; perform required repairs to resolve deficiencies; perform diagnostic checks; and complete required documentation of the manufacturer and the authority having jurisdiction.

**50.7.2** Complete performance testing on apparatus foam system and related components in accordance with Chapters 1 through 28, given an emergency response vehicle with a foam system, manufacturer's specifications, SOPs, test and calibration equipment, and facilities and tools, so that the foam system is capable of meeting the performance testing requirements; and all testing is documented in accordance with the requirements of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Function, construction, and operation of a foam system and its related components; principles of foam proportioning; diagnostic checks and performance testing procedure and requirements; selection of test and calibration equipment; safety procedures; diagnostic procedures; foam flow calculations; and record-keeping requirements.

**(B) Requisite Skills.** Conduct foam system performance tests; use test and calibration equipment; identify defects and deficiencies; perform foam flow calculations; and complete required documentation.

**50.7.3** Repair compressed air foam system (CAFS), given an emergency response vehicle with a CAFS, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, department SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of a CAFS, including component mounts, drive systems, pumps, plumbing, and valves, are repaired, replaced, or rebuilt to manufacturer's specifications; fluid levels are restored; the CAFS is diagnostically checked for proper operation and its performance is verified; and repairs are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of CAFS, including foam types, drive systems, air compressors, flowmeters, proportioners, valves, eductors, and nozzles; the selection of test and calibration equipment; adjustment methods and procedures; lubrication and fluid types; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and analyze reported conditions; perform required repairs to resolve deficiencies; interpret manufacturer's specifications; use test and calibration equipment; perform diagnostic checks; and complete required documentation of the manufacturer and the authority having jurisdiction.

**50.7.4** Complete performance testing on apparatus compressed air foam system (CAFS) and related components in accordance with Chapters 1 through 28, given an emergency response vehicle with a CAFS, manufacturer's specifications, SOPs, test and calibration equipment, and facilities and tools, so that the CAFS is capable of meeting the performance testing requirements; and all performance testing is documented in accordance with the requirements of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Function, construction, and operation of a CAFS and its related components; principles of compressed air systems; foam-proportioning systems; diagnostic checks and performance testing procedure and requirements; selection of test and calibration equipment; safety procedures; diagnostic procedures; foam and compressed air flow calculations; and record-keeping requirements.

**(B) Requisite Skills.** Conduct CAFS performance tests; use test and calibration equipment; identify defects and deficiencies; perform foam and compressed air flow calculations; and complete required documentation.

**50.7.5*** Repair all components of an electrical line voltage generation system, its controls, and its instrumentation, given an emergency response vehicle with an electrical line voltage system, manufacturer's specifications, an assignment or an inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an electrical line voltage generation system are repaired, replaced, or rebuilt to manufacturer's specifications; fluids and lubricants are restored; the system is diagnostically

checked for proper operation and performance is verified; and the repair and diagnostic check results are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, operation, and requirements of generators, drive units, controls and instrumentation, interfaces, and interlocks; selection of test and calibration equipment; defects and deficiencies; repair procedures; troubleshooting procedures; line voltage wiring procedures and requirements; safety protection devices; fluid and lubricant types; required calibrations; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, evaluate, and analyze conditions; perform required diagnostic checks and repairs to resolve deficiencies; use test and calibration equipment; perform system diagnostic checks; perform calculations; and complete required documentation.

**50.7.6** Complete performance testing on apparatus line voltage electrical system and related components in accordance with Chapters 1 through 28, given an emergency response vehicle with a line voltage electrical system, manufacturer's specifications, SOPs, test equipment, and facilities and tools, so that the line voltage electrical system is capable of meeting the performance testing and safety requirements; and all performance testing is documented in accordance with the procedures of NFPA standards and the AHJ.

**(A) Requisite Knowledge.** Function, construction, and operation of a line voltage electrical system and its related components; principles of electricity; generating systems; wiring and grounding standards; diagnostic checks and performance testing procedure and requirements; selection of test equipment; safety procedures; diagnostic procedures; electrical load, grounding and insulation calculations; and record-keeping requirements.

**(B) Requisite Skills.** Conduct line voltage electrical performance tests; use test equipment; identify defects and deficiencies; perform GFCI operational check and load bank testing; perform calculations; and complete required documentation.

**50.7.7*** Repair all hardwired line voltage appliances and controls, given an emergency response vehicle with hardwired line voltage appliances and controls, manufacturer's specifications, an assignment or inspection report detailing a deficiency or deformation, SOPs, test and calibration equipment, and tools, so that defective components and accessories are diagnosed; deformed, broken, loose, worn, or missing parts of a hardwired line voltage appliance or control are repaired, replaced, or rebuilt to manufacturer's specifications; systems are diagnostically checked for proper operation and performance verified; and repairs and test results are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, operation, and requirements of hardwired line voltage appliances and controls, accessories, and equipment; selection of test and calibration equipment; types of defects and deficiencies; troubleshooting procedures; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Recognize, identify, and evaluate reported conditions of line voltage components and accessories; perform repairs to resolve deficiencies; use test and calibration equipment; perform diagnostic checks; and complete required documentation.

**50.7.8** Repair a breathing-air and air purification system, given an emergency response vehicle with a breathing-air and air purification system, an assignment or inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that all defective components are diagnosed; deformed, broken, loose, worn, or missing parts of a breathing-air and air purification system, including mounts, drive systems, pumps, piping, valves, fittings, tanks, and other components, are repaired, replaced, or rebuilt to manufacturer's specifications; the system is diagnostically checked for proper operation and performance is verified; and the repairs and test results are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the complete breathing-air system and high-pressure air regulation; purification testing; record-keeping requirements; system diagnostic and repair procedures of the authority having jurisdiction and the manufacturer; selection of test and calibration equipment; troubleshooting procedures; and performance test procedures.

**(B) Requisite Skills.** Identify and evaluate reported conditions; use test and calibration equipment; perform diagnostic procedures; perform required repairs to resolve deficiencies; calibrate equipment; perform diagnostic checks; and complete required documentation.

**50.7.9** Complete performance testing on breathing-air compressor system and related components in accordance with Chapters 1 through 28 and NFPA 1989, given an emergency response vehicle with a breathing-air compressor system, manufacturer's specifications, and SOPs, so that the breathing-air compressor system is tested to ensure that the compressor performs to the compressor manufacturer’s original requirements; compressed breathing air is tested to ensure breathing-air quality standards are met; and all results are documented in accordance with the requirements of NFPA standards, the compressor manufacturer, and the AHJ.

**(A) Requisite Knowledge.** Function, construction, and operation of a breathing-air compressor system and its related components; familiarity with compressor manufacturers or manufacturer representative; familiarity with compressed breathing-air quality standards and air quality testing agencies; and record-keeping requirements.

**(B) Requisite Skills.** Schedule and verify completion of breathing-air compressor testing; schedule and verify compressed breathing-air quality testing; and complete required documentation.

**50.7.10** Repair an auxiliary air system and its components, given an emergency response vehicle with an auxiliary air system, an assignment, or an inspection report detailing a deficiency or deformation, manufacturer's specifications, SOPs, test and calibration equipment, and tools, so that defective components are diagnosed; deformed, broken, loose, worn, or missing parts of an auxiliary air system, including mounts, drive systems, pumps, piping, valves, fittings, tanks, and other compo-

nents, are repaired, replaced, or rebuilt to manufacturer's specifications; the auxiliary air system is diagnostically checked for proper operation and its performance is verified; and the repair and test results are documented in accordance with the procedures of the manufacturer and the authority having jurisdiction.

**(A) Requisite Knowledge.** Function, construction, and operation of the auxiliary air system, low-pressure regulation, valves, and controls; testing procedures; the selection of test and calibration equipment; adjustment and calibration methods and procedures; record-keeping requirements; and repair and diagnostic procedures of the manufacturer and the authority having jurisdiction.

**(B) Requisite Skills.** Identify and evaluate reported conditions; use test and calibration equipment; perform diagnostic procedures; perform tests and calibrations; perform required repairs to resolve deficiencies; perform diagnostic checks; and complete required documentation.

## Chapter 51 Emergency Vehicle Technician III (NFPA 1071)

**51.1* Emergency Vehicle Technician (EVT) III.** To be considered qualified as an Emergency Vehicle Technician III, the individual shall meet the following criteria:

(1) Meet the requirements of an Emergency Vehicle Technician II
(2) Meet the job performance requirements of Sections 51.2 through 51.6

**51.2 Human Resource Management.** This duty involves utilizing human resources to accomplish assignments in accordance with safety plans and in an efficient manner, as well as evaluating member performance and supervising personnel during work periods, according to the job performance requirements given in 51.2.1 through 51.2.3.4.

**51.2.1** Assign tasks or responsibilities to technicians, given a work order, an emergency vehicle, work space, and required tools, equipment, and parts, so that the instructions are complete, clear, and concise; safety considerations are addressed; and the work is completed and within the scheduled time.

**(A) Requisite Knowledge.** Function, construction, and operation of vehicles and systems; required testing; required record-keeping and documentation; common deficiencies; repair procedures; testing procedures; vehicle safety requirements; skill levels of assigned technicians; agency priorities; and available resources.

**(B) Requisite Skills.** Verbal and written communication and performance evaluation.

**51.2.2** Conduct individual training for technicians, given an assignment, a workspace, and all necessary tools, so that the technician understands the procedure and is able to demonstrate proficiency at the given task.

**(A) Requisite Knowledge.** Function, operation, and construction of component; applicable standards; manufacturer's specifications; recommended procedures; and the technician's capability.

**(B) Requisite Skills.** Research, communicate, and deliver training material based on methods and practices; and evaluate the results.

**51.2.3* Evaluation.**

**51.2.3.1** Provide input on the performance level of the technician, given a time record, pertinent work orders, and evaluation forms, so that the abilities and weaknesses of a technician can be determined; required counseling and training can be scheduled to maintain or improve a technician's proficiency; or an issue can be referred to the next level of supervision.

**(A) Requisite Knowledge.** Allowable repair times, failure analysis, agency policies and procedures, human behavior, job descriptions, and goals of the evaluation program.

**(B) Requisite Skills.** Verbal and written communication and performance evaluation.

**51.2.3.2** Recommend, specify, and enforce discipline, given employee history and department SOPs, so that the employee is given the guidance necessary to improve or resolve issues.

**(A) Requisite Knowledge.** Agency policies and procedures, and awareness of the situation and the individual involved.

**(B) Requisite Skills.** Verbal and written communication, assessment of employee abilities and attitude, and implementation of the most effective alternative.

**51.2.3.3** Recommend and enforce safety policies and procedures, given agency safety policies and procedures; federal, state, local, and industry standards for workplace safety; and safety hazards, so that workplace safety is monitored and recommendations for deficiencies are documented.

**(A) Requisite Knowledge.** Agency safety policies and procedures; federal, state, local, and industry standards for workplace safety; safety hazards; safe practices; equipment limitations; and personal protection devices.

**(B) Requisite Skills.** Verbal and written communication.

**51.2.3.4** Monitor compliance of applicable environmental regulations, given agency policies and procedures; federal, state, and local environmental regulations; and material safety data sheets (MSDS), so that the workplace is in compliance with all required regulations; and all deficiencies are identified and corrected.

**(A) Requisite Knowledge.** Agency policies and procedures; federal, state, and local environmental regulations; and MSDS.

**(B) Requisite Skills.** Verbal and written communication.

**51.3 Quality Control.** This duty involves the inspection of completed vehicle maintenance and repairs both in-house and outsourced.

**51.3.1 Inspection.**

**51.3.1.1** Inspect a completed vehicle, given a vehicle, a deficiency list, completed tasks, and required license, so that all deficiencies are repaired; documentation is completed; and the vehicle is diagnostically checked to manufacturer's specifications.

**(A) Requisite Knowledge.** Function, construction, and operation of vehicles and systems; required diagnostic checks and performance testing; required record-keeping and documenta-

tion; common deficiencies; repair procedures; performance testing procedures; and vehicle safety requirements.

**(B) Requisite Skills.** Operation of vehicles, performance of required tests and checks, use of diagnostic equipment and tools, and verbal and written communication.

**51.3.1.2** Monitor outsourced repairs, given a completed vehicle, a deficiency list, and a list of completed tasks, so that all repairs are verified; and diagnostic checks are completed and documented.

**(A) Requisite Knowledge.** Function, construction, and operation of vehicles and systems; qualifications and limitations of vendors; required diagnostic checks or performance tests; required record-keeping and documentation; common deficiencies; repair procedures; diagnostic checks and performance testing procedures; and vehicle safety requirements.

**(B) Requisite Skills.** Operation of vehicles, diagnostic checks and performance tests, use of diagnostic equipment and tools, and verbal and written communication.

**51.4 Equipment and Parts Management.** This duty involves the administration, creation, and tracking of purchase orders, determination of correct parts, the maintenance of required levels of parts and tools inventory, and the validation of records.

**51.4.1** Monitor inventory levels within the relevant level of responsibility, given current inventory, agency equipment lists, and manufacturer's specifications, a maintenance schedule and a previous repair history, and manufacturer's parts manuals, so that the inventory is maintained at the required levels.

**(A) Requisite Knowledge.** Current suppliers, previous repair history, transportation systems, and agency and purchase policies.

**(B) Requisite Skills.** Determine current needs and use previous repair history to predict future needs.

**51.4.2** Order appropriate parts, given a part number or specification and application of part required, purchase order form and procedure, and vendor list, so that the correct part is ordered from the vendor; purchase orders are tracked; and purchase is recorded.

**(A) Requisite Knowledge.** Function, operation, and construction of component; applicable standards; manufacturer's specifications; recommended part substitutions; and parts locations.

**(B) Requisite Skills.** Written and electronic sources and manuals research; and verbal and written communication.

**51.5 Documentation.** This duty involves the documentation of estimates, warranties, work orders, repair requests, diagnostic checks, and performance test results.

**51.5.1** Prepare an estimate of deficiencies or upgrades to be completed on an emergency vehicle, given an emergency vehicle, repair history, estimate forms, parts lists, required repair or upgrade hours, and a calculator, so that the costs are calculated, documented, and communicated.

**(A) Requisite Knowledge.** Function, construction, and operation of emergency response vehicles; repair times; parts and component costs; and applicable vehicle standards.

**(B) Requisite Skills.** Estimation and calculation of costs and repair times, record-keeping, and verbal and written communication.

**51.5.2** Adhere to a schedule for maintenance or repair of an emergency vehicle, given an emergency vehicle, a schedule, forms, a repair or maintenance request, current staffing and workload, work estimate, and work space availability, so that required repairs or maintenance can be assigned and completed in accordance with the projected times.

**(A) Requisite Knowledge.** Resource availability; agency requirements; and the function, construction, and operation of emergency response vehicles.

**(B) Requisite Skills.** Utilize resources, evaluate requests, and project results.

**51.5.3** Document warranty repairs, given a repaired vehicle, applicable warranties, a deficiency list, technical service bulletins, and a list of completed tasks, so that all repairs are completed, and diagnostically checked and performance tested if required; and the warranty claim is processed.

**(A) Requisite Knowledge.** Current warranties; technical service bulletins; required diagnostic checks or performance tests; required record-keeping and documentation; diagnostic checks or performance testing procedures; vehicle safety requirements; function, construction, and operation of emergency response vehicles; manufacturer's specifications; and department policies and procedures.

**(B) Requisite Skills.** Verbal and written communication, compliance with agency and manufacturers' record-keeping requirements.

**51.5.4** Create work orders, given an emergency response vehicle, an assignment, and agency work order forms, so that all work to be performed is documented; all required information is recorded; all necessary information is communicated to the technician(s); and the emergency response vehicle is prepared for repair or maintenance.

**(A) Requisite Knowledge.** Required record-keeping; agency record-keeping system; previous repair history; and function, construction, and operation of emergency response vehicles.

**(B) Requisite Skills.** Application of agency record-keeping system; verbal and written communication, and diagnostic skill.

**51.5.5** Validate maintenance records, given completed documentation of maintenance records and agency record-keeping policies, so that accurate records are maintained.

**(A) Requisite Knowledge.** Record-keeping, accounting, and statistical analysis; and agency policy and procedure.

**(B) Requisite Skills.** Recognize, evaluate, analyze, and calculate statistical information, accounting reports, and cost and performance reports.

**51.6 Apparatus Specifications.** This duty involves development of apparatus specifications.

**51.6.1** Develop a specification through review and research of existing fire apparatus, given recommendations of departmental committees, department policies and procedures, and applicable NFPA standards, so that technical criteria are presented as a completed specification.

**(A) Requisite Knowledge.** Current standards of quality and the requirements of the department, American Society of Mechanical Engineers (ASME), Society of Automotive Engineers (SAE), Occupational Safety and Health Administration (OSHA), and NFPA standards for the construction of a fire apparatus.

**(B) Requisite Skills.** Recognition of department guidelines, organization and identification of apparatus components based on the needs of the applicable divisions, and verbal and written communication.

## 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.1.3** Any AHJs incorporating NFPA 1911, NFPA 1912, NFPA 1925, NFPA 1071 or any combination of the four, can replace those references with chapters and still reference similar content. For example, if an AHJ incorporated the 2017 edition of NFPA 1911 (i.e. in accordance with the 2017 edition of NFPA 1911), and they wish to update to the latest information, they can do so by incorporating Chapters 1 through 3, Chapters 4 through 28, and Annexes A through D of the 2024 edition of NFPA 1910 (i.e. in accordance with Chapters 1 through 3, Chapters 4 through 28, and Annexes A through D of the 2024 edition of NFPA 1910).

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

**A.3.2.4 Listed.** The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

**A.3.3.21 Anode.** This metal tends to corrode or dissolve in an electrolyte.

**A.3.3.25 Auxiliary Pump.** An auxiliary pump can be a pump that is secondary to a fire pump to achieve pump and roll capability or to provide high-pressure hose reel operations. It could also be the only pump on a special service or wildland fire apparatus for which the desired performance is different than that of a fire pump, an industrial supply pump, or a transfer pump.

**A.3.3.30 Bitter End.** An example of a bitter end is the onboard end of the anchor rode, which is usually permanently attached to the vessel.

**A.3.3.32 Boom.** The term *boom* is used to refer either to a single straight structure or two or more pieces connected by knuckle(s). The boom construction can be of stressed-skin-box-beam-type, tube-type, trussed-lattice-type, or open "U" truss-type design. [**1900,** 2024]

**A.3.3.37 Bridge.** The bridge is also called the pilothouse.

**A.3.3.50 Compound Gauge.** On most gauges, zero equals atmospheric pressure. Gauges typically measure pressure above atmospheric pressure in pounds per square inch (psi) [kilopascals (kPa)] and below atmospheric pressure in inches of mercury (in. Hg) [kilopascals (kPa)].

**A.3.3.52 Contractor.** The contractor might not necessarily refurbish the vehicle or any portion of the vehicle but is responsible for the completion, delivery, acceptance, and warranty of the entire unit. Since fire apparatus are frequently refurbished in-house by the local fire department or city garage, the term *contractor* would include that department and its personnel if the project were to be done by the local fire department, fire brigade, or other municipal agency.

**A.3.3.71 Eductor.** Typical uses include foam mixing, dewatering, bilge pumping, and so forth. The pressure at the throat is below atmospheric pressure, allowing liquid at atmospheric pressure to flow into the water stream.

**A.3.3.72 Electrolyte.** Salt or brackish water are examples of electrolytes.

**A.3.3.73 Electronic Battery Conductance Tester.** A conductivity tester displays a battery's cold cranking amps (CCA) value based on the amount of battery plate surface area available upon which electrochemical activity can occur.

**A.3.3.80 Emergency Vehicle.** A motor vehicle is defined, in part, by 49 CFR 301, "Motor Vehicle Safety," as a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways.

**A.3.3.81.3 Emergency Vehicle Technician (EVT) III.** This individual can also perform inspection, diagnosis, maintenance, repair, diagnostic checking, and performance testing activities on emergency response vehicles and has, by possession of a recognized certificate, professional standing, or skill, acquired the knowledge, training, and experience and demonstrated the ability to deal with issues related to the subject matter, the work, or the project.

**A.3.3.98 Foam.** Air foam is made by mixing air into a water solution containing a foam concentrate, by means of suitably

designed equipment. It flows freely over a burning liquid surface and forms a tough, air-excluding, continuous blanket that seals volatile combustible vapors from access to air. It resists disruption from wind and draft or heat and flame attack and is capable of resealing in case of mechanical rupture. Firefighting foams retain these properties for relatively long periods of time. Foams also are defined by expansion and are arbitrarily subdivided into three ranges of expansion. These ranges correspond broadly to certain types of usage described below. The three ranges are as follows:

(1) Low-expansion foam — expansion up to 20
(2) Medium-expansion foam — expansion from 20 to 200
(3) High-expansion foam — expansion from 200 to approximately 1000

[**11,** 2021]

**A.3.3.108 GAWR (Gross Axle Weight Rating).** It is a requirement of the National Highway Traffic Safety Administration that the GAWR be posted in the vehicle on a permanently affixed label. The axle system includes, but is not limited to, the axle, tires, suspension, wheels, frame, brakes, and applied engine torque.

The final-stage manufacturer might have to de-rate the GAWR for the purpose of preventing vehicle instability as a result of changes made during the refurbishing. In addition, if an apparatus received a Level I refurbishing, it might have new axles, tires, suspension, and so forth, that allow a higher GAWR than the original rating. The final-stage manufacturer is the one who will know this.

**A.3.3.109 GCWR (Gross Combination Weight Rating).** A combination vehicle is the combination of a towing vehicle and one or more towed units (trailers). When a trailer is detachable, the GCWR limits the maximum loaded weight for any replacement trailer. The in-service weight or gross combination weight, including any connected trailer, should always be equal to or less than the GCWR.

**A.3.3.111 Grade.** A 45-degree slope is equal to a 100 percent grade.

**A.3.3.116 GVWR (Gross Vehicle Weight Rating).** It is a requirement of the National Highway Traffic Safety Administration that the GVWR of a vehicle be posted in the vehicle on a permanently affixed label. The GVWR can be equal to or less than the sum of the front GAWR and the rear GAWR. The in-service weight or gross vehicle weight should always be equal to or less than the GVWR.

**A.3.3.118 Helm.** The primary helm can be independent or located on the bridge. Secondary helms can be located for improved visibility for operations such as docking and towing.

**A.3.3.122 Impressed Current System.** Typical power sources are batteries, alternators, and rectified output from alternating current generators.

**A.3.3.127 Instability.** The lifting of a tire or stabilizer on the opposite side of the vehicle from the load does not necessarily indicate a condition of instability. Instability occurs when an aerial device can no longer support a given load and overturning is imminent.

**A.3.3.131 Jet Drive.** Water jet is an example of jet drive.

**A.3.3.163 Net Pump Pressure.** When operating from a hydrant, the net pump pressure typically is less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psi (1034 kPa) and the intake (suction) gauge reads 20 psi (138 kPa), the net pump pressure equals 130 psi (896 kPa). When operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge reads 145 psi (1000 kPa) and the intake (suction) gauge reads 10 in. Hg (34 kPa) vacuum, the net pump pressure will be 150 psi (1034 kPa) (1 in. Hg = 0.5 psi = 3.4 kPa).

**A.3.3.169 Optical Source.** An optical source can consist of a single optical element or a fixed array of any number of optical elements where their geometric positioning relative to each other is fixed by the manufacturer of the optical source and cannot be easily modified.

**A.3.3.186 Purchaser.** In the case of refurbished apparatus, the purchaser can be the original owner of the vehicle scheduled for refurbishing, or it may be a person, organization, or jurisdiction considering the purchase of a refurbished fire apparatus.

**A.3.3.189 Quint.** The primary purpose of this type of fire apparatus is to combat structural and associated fires and to support firefighting and rescue operations by positioning personnel-handling materials, providing continuous egress, or discharging water at positions elevated from the ground.

**A.3.3.192 Rated Vertical Height.** For an aerial ladder, rated vertical height is measured from the outermost rung of the outermost fly section, with the ladder at maximum elevation and extension. For an elevating platform, rated vertical height is measured from the top of the platform handrails with the platform raised to its position of maximum elevation and extension, and for a water tower, rated vertical height is measured from the discharge end of the nozzle with the boom raised to its position of maximum elevation and extension.

**A.3.3.194.1 Level I Refurbishing.** A vehicle that has undergone Level I refurbishing receives a new make and model designation and a new Certificate of Origin for the current calendar year.

**A.3.3.194.2 Level II Refurbishing.** A vehicle that has undergone Level II refurbishing retains its original make and model identification as well as its original title and year of manufacture designation.

**A.3.3.214 Special Services Fire Apparatus.** These services could be rescue, command, hazardous material containment, air supply, electrical generation and floodlighting, or transportation of support equipment and personnel.

**A.3.3.243 Upgrade.** It is recommended that consideration be given to using upgraded components or systems that meet current standards to the maximum extent possible, to ensure that the refurbished apparatus will approach the performance and safety requirements of newly manufactured apparatus.

**A.3.3.244 Vacuum.** Typically, vacuum is expressed in inches of mercury (in. Hg) [kilopascals (kPa)].

**A.3.3.245 Ventilation.** Ventilation can be achieved by introduction of fresh air to dilute contaminated air or by local exhaust of contaminated air. [**302,** 2020]

**A.4.1.5** Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter, a unit that is

outside of but recognized by SI, is commonly used in international fire protection. Table A.4.1.5(a), Table A.4.1.5(b), and Table A.4.1.5(c) provide conversion factors as an aid to the user. Table A.4.1.5(d) provides a list of the abbreviations used in this standard and their meaning.

**A.4.2** The intent is to include reserve emergency vehicle that are fully equipped as well as reserve emergency vehicle that might need to be equipped with hose, tools, and equipment before being ready to respond.

**Table A.4.1.5(a) Conversion Factors: US Units to SI Units**

| US Units | | SI Units |
|---|---|---|
| 1 gallon per minute (gpm) | = | 3.785 liters per minute (L/min) |
| 1 imperial gallon per minute (igpm) | = | 4.546 liters per minute (L/min) |
| 1 pound per square inch (psi) | = | 6.895 kilopascals (kPa) |
| 1 inch of mercury (in. Hg) at 60°F (15.6°C) | = | 3.376 kilopascals (kPa) |
| 1 inch (in.) | = | 25.40 millimeters (mm) |
| 1 foot (ft) | = | 0.3048 meter (m) |
| 1 cubic foot ($ft^3$) | = | 0.02832 cubic meter ($m^3$) |
| 1 square inch ($in.^2$) | = | 645.2 square millimeters ($mm^2$) |
| 1 mile per hour (mph) | = | 1.609 kilometer per hour (km/hr) |
| 1 pound (lb) | = | 0.4536 kilogram (kg) |

**Table A.4.1.5(b) Conversion Factors: SI Units to US Units**

| S.I. Units | | US Units |
|---|---|---|
| 1 liter per minute (L/min) | = | 0.2642 gallon per minute (gpm) |
| 1 liter per minute (L/min) | = | 0.2200 imperial gallon per minute (igpm) |
| 1 kilopascal (kPa) | = | 0.1450 pound per square inch (psi) |
| 1 kilopascal (kPa) | = | 0.2962 inch of mercury (in. Hg) at 60°F (15.6°C) |
| 1 millimeter (mm) | = | 0.03937 inch (in.) |
| 1 meter (m) | = | 3.281 feet (ft) |
| 1 cubic meter ($m^3$) | = | 35.31 cubic feet ($ft^3$) |
| 1 kilometer per hour (km/hr) | = | 0.6214 mile per hour (mph) |
| 1 kilogram (kg) | = | 2.205 pounds (lb) |
| 1 lux (lx) | = | 0.09290 footcandle (fc) |

**Table A.4.1.5(c) Useful Conversion Factors**

| | | |
|---|---|---|
| 1 gallon per minute (gpm) | = | 0.833 imperial gallon per minute (igpm) |
| 1 imperial gallon per minute (igpm) | = | 1.2 gallons per minute (gpm) |
| 1 foot (ft) of water | = | 0.433 pound per square inch (psi) |
| 1 pound per square inch (psi) | = | 2.31 feet (ft) of water |
| 1 metric ton (mton) | = | 1000 kilograms (kg) |
| 1 kilopascal (kPa) | = | 0.01 bar |
| 1 bar | = | 100 kilopascals (kPa) |

**Table A.4.1.5(d) Abbreviations Used in This Standard**

| Abbreviation | Term |
|---|---|
| Ac | alternating current |
| AHJ | authority having jurisdiction |
| C | centigrade |
| CAFS | compressed air–foam system |
| CCA | cold cranking amperage |
| dc | direct current |
| F | Fahrenheit |
| ft | feet |
| gpm | gallons per minute |
| in. | inch |
| in. Hg | inches of mercury |
| kg | kilogram |
| km/hr | kilometers per hour |
| kPa | kilopascal |
| L | liter |
| L/min | liters per minute |
| lb | pound |
| m | meter |
| mm | millimeter |
| mph | miles per hour |
| psi | pounds per square inch |
| V | volts |

**A.4.4.1.1** Additional qualifications can be identified by schooling, training, experience, and recognized certification programs, such as those administered by Automotive Service Excellence (ASE), Emergency Vehicle Technician Certification Commission, Inc., or other equivalent certifying agencies.

**A.4.4.2** Persons performing daily/weekly inspections and operational checks of emergency vehicles should be qualified to be drivers/operators for the type of vehicle being checked.

**A.4.5.1** Emergency vehicles are complex machines that involve all kinds of mechanical, electrical, and chemical hazards. Failure to consult the appropriate manuals might result in serious injury to the person performing the inspection or maintenance or to other persons in the area.

**A.4.5.3** One area in which there are regulations in the United States is the area of tire and wheel service, which is covered under the Occupational Safety and Health Administration (OSHA) regulations specified in 29 CFR 1910.177.

**A.4.6.2** If the emergency vehicle manufacturer is no longer in business, or the servicing and maintenance criteria or recommendations are no longer available from the manufacturer, the fire department should establish the criteria that are necessary to inspect and maintain the specific emergency vehicle. These criteria can be established by discussing inspection and maintenance procedures for similar types or styles of emergency vehicles or components with persons experienced with such maintenance and by reviewing the industry standards that were in effect at the time the emergency vehicle or component was built. The criteria should be developed in writing.

The *Passenger Vehicles & Light Trucks Vehicle Inspection Handbook* and the *Trucks, Buses, & Trailers Vehicle Inspection Handbook*, prepared by the American Association of Motor Vehicle Administrators, provide a valuable resource in developing an inspection program.

**A.4.6.3** The frequency of use (for example, hours, miles, and time) of emergency vehicles (duty cycle) might require that diagnostic checking, inspection, and maintenance be completed on a monthly, quarterly, or semiannual basis.

**A.4.6.5** During an inspection, the technician should conduct a diagnostic check of the entire emergency vehicle to detect abnormal vibrations that could indicate a component defect or possible failure.

**A.4.8** The AHJ should identify the state, provincial, and local regulations that pertain to record retention and follow them as a minimum.

**A.5.1** Unsafe emergency vehicles pose severe safety risks to emergency responders and the general public. These risks result in death, severe injury, and property loss. These risks are particularly prevalent in older emergency vehicles. See Annex D for safety criteria on older emergency vehicles.

**A.6.1.6** When a component on the emergency vehicle is taken out of service, a determination needs to be made as to whether the emergency vehicle is suitable for continued use. If any component that affects the operation of the chassis, the other components used during response, or the operational safety of the emergency vehicle is taken out of service, the entire emergency vehicle should be taken out of service.

**A.6.2.3** Deficiencies or problems might or might not make the emergency vehicle unsafe but will render it unusable for some operations. The AHJ should provide a list of limitations to be imposed or a list of enforced conditions under which the emergency vehicle *cannot* continue to be used, pending repair of the deficiency. That list should include, but is not limited to, the following:

(1) Compartment doors will not stay closed.
(2) Running boards are not secure.
(3) Tailboard is not secure.
(4) Accessory step (folding step) is broken or missing.

Although this standard identifies that cracked or broken windshields and mirrors should be consideration for taking the emergency vehicle out of service, consideration should also be given to state, provincial, or local regulations. The AHJ should identify and follow the pertinent state, provincial, and local regulations.

**A.6.3.1(4)** Tread depth should be checked with a tread depth gauge. When inserted into the tire tread, the amount of tread left is indicated in $\frac{1}{32}$ in. (1 mm) increments.

**A.6.4.1** Loss of power can be the result of numerous items related to the engine, fuel system, and air intake system. Loss of power can be associated with loud or unusual noises. Loud or unusual noises can be the result of worn, damaged, or defective internal engine components, such as main and connecting rod bearings, connecting rods, piston pins, pistons, valve trains, and fuel systems. Loss of power can be the result of something as simple as clogged fuel or air filters. Inspection of the air intake restriction gauge will allow determination of the condition of the air intake system.

Many vehicles, especially those with water-fuel separators, have both audible and visual indicators to show failure of fuel system filters or the presence of excessive water. Another indicator of factors resulting in loss of power is engine exhaust smoke. As a rule, white smoke indicates a cooling system leak into the combustion area; blue smoke indicates excessive oil consumption, normally engine oil but in some applications transmission fluid; and black smoke indicates excessive unburned fuel. In any case, any one of the aforementioned items can deter from proper and safe operation of the vehicle and should therefore be remedied as soon as possible.

See also A.8.4.5 and A.8.6.

**A.6.7.1(4)** Burned-out lamps and other deficiencies should be corrected immediately. While all systems have a degree of redundancy, they are not designed to operate with multiple deficiencies. When more than one optical source in the warning light system is inoperative and the emergency vehicle must be used, it should be driven as a nonemergency vehicle.

**A.6.7.3(1)** When the audible warning system is inoperative and the emergency vehicle must be used, it should be driven as a nonemergency vehicle.

**A.6.8.1.1** Paragraph 6.8.1.1(1) refers to the leak-down rate of the supply side of the air system. Paragraph 6.8.1.1(2) refers to the leak-down rate of the applied side of the air system. Paragraph 6.8.1.1(8) refers to the air compressor's ability to supply ample air for correct and safe operation of the vehicle.

Although this standard identifies out-of-service criteria for air brake systems, consideration should also be given to state or local regulations. The authority having jurisdiction should identify and follow the pertinent state and local regulations to ensure the vehicle is safe to operate.

Lining thickness of less than $\frac{3}{16}$ in. (4.8 mm) for a brake shoe with a continuous strip of lining, $\frac{1}{4}$ in. (6.4 mm) to the wear indicator for a shoe with two pads for drum brakes, or less than $\frac{1}{8}$ in. (3.2 mm) of lining for disc pads should be considered worn out, and the lining should be replaced.

**A.6.8.2.1** Although this standard identifies out-of-service criteria for hydraulic brake systems, consideration should also be given to state or local regulations. The AHJ should identify and follow the pertinent state and local regulations to ensure the vehicle is safe to operate.

Lining thickness of less than $\frac{1}{16}$ in. (1.6 mm) for a brake shoe or disk should be considered worn out and should be replaced.

**A.6.9.1(6)** Beginning with the 1991 edition of NFPA 1901 (which is now consolidated in NFPA 1900), fire apparatus equipped with electronic or electric engine throttle controls are required to include an interlock system to prevent engine speed advancement, unless the chassis transmission is in neutral with the parking brake engaged; unless the parking brake is engaged, the fire pump is engaged, and the chassis transmission is in pumping gear; or unless the apparatus is in the "okay to pump" mode.

**A.6.11.1(7)** Tread depth should be checked with a tread depth gauge. When inserted into the tire tread, the amount of tread left is indicated in $\frac{1}{32}$ in. (1 mm) increments.

**A.6.13.2.4** Refer to the latest tire information for the make, model, and load rating of the tire. This information can be found online from each tire manufacturer. When checking the load rating, keep in mind that a commercial truck tire will typically have a different rating when it is used in a single-tire configuration than when it is used in a dual-tire application. Add up the load ratings for all tires on the axle and compare to the GAWR for might axle. The sum of the tire load ratings

should equal or exceed the GAWR. Note that some fire apparatus may be taking advantage of special fire service ratings allowed by the tire OEM. The fire service rating will also have some impact on the allowable top speed and the allowable driving time between cooldowns. These ratings are also available from the tire OEM online or from the apparatus manufacturer.

**A.7.1** The importance of the daily / weekly checks cannot be stressed enough. For a preventive maintenance plan to succeed the daily/weekly visual and operational checks must be done correctly. Properly done daily/weekly checks quickly locate problems that can be corrected before they become worse. The AHJ should work with the maintenance department to develop a plan to complete the daily/weekly checks within the allotted time, complete the checks thoroughly, and document the results properly. The driver/ operators assigned to perform the daily/weekly checks should be trained with the help of the maintenance department and technicians regarding the expected outcome of each item on the check sheet. Other groups, such as state mechanics associations, apparatus manufacturers, and independent trainers offer some training for driver operators. NFPA 1002 has requirements for what a driver operator should know to perform the daily/weekly checks.

**A.8.3.3** It is important that the cold tire inflation be maintained to the emergency vehicle manufacturer's recommended tire pressure, which is based on the weight of the completed vehicle, and not to the maximum pressure shown on the sidewall of the tire. If the information from the emergency vehicle manufacturer is not available for the tires on the vehicle, each axle should be weighed with the vehicle fully loaded and the tires inflated to the tire manufacturer's inflation specification for the tire model, size, and axle load.

**A.8.3.4** Some apparatus may use tires based on an intermittent duty (fire service) load rating. This information is available from the tire manufacturer or the apparatus manufacturer. Fire service ratings are based on the assumption that the truck will never drive with this load for more than 50 miles (80 km) (1 hour for some manufacturers) without stopping to cool the tires. The AHJ must understand this limitation.

**A.8.3.6** Tire age can be determined by checking the DOT code on the sidewall of each tire. The code begins with "DOT" and ends with a 3-digit (through 1999) or 4-digit (2000 and beyond) date code. The first 2 digits of the date code are the week of the year the tire was manufactured, and the last 1 or 2 digits indicate the year. For example, "DOT GJ HU234 319" was manufactured in week 31 of 1999. "DOT BT FR87 2501" was manufactured in week 25 of 2001. The code may be on the inside or outside sidewall.

**A.8.3.7** Wheel-attaching hardware should be torqued to the manufacturer's recommendation at the time of wheel installation. The wheel- or rim-attaching hardware should be retorqued at 50 mi to 100 mi (80 km to 160 km) after installation and periodically thereafter. Wheel covers or nut covers might have to be removed for proper inspection.

**A.8.4.5** To ensure efficient engine performance and extended valve and injector service life, a scheduled valve lash and injector height measurement and adjustment schedule should be maintained. Certain engines might also require nozzle and pump calibration, timing, replacement of spark plugs, ignition system tests, or other adjustments.

It is imperative that all engine components and accessories that can affect engine performance be inspected, adjusted, and maintained. Visual inspections along with air restriction tests performed on a regularly scheduled basis will ensure proper operation of components. Examples of engine performance concerns are abnormal black, blue, or white exhaust smoke and abnormal engine noises.

Other pertinent tests might be required for the engine to perform at maximum efficiency on an emergency scene. All recommended tests and adjustments should be performed to ensure proper operation.

Failure to perform factory-recommended engine adjustments or inspections that are required initially and at regular intervals thereafter, or failure to make necessary adjustments or part replacements (for example, spark plugs on gas engines), might result in gradual degradation of engine performance and reduced fuel combustion efficiency.

Increasing the engine performance through any means, such as reprogramming, might cause the engine to produce more power, torque, or both than other components on the chassis are rated to handle. This situation can have serious safety implications.

**A.8.6** Fuel systems are essential components of the engine. To ensure that the engine is capable of proper performance and operation, the fuel system should be inspected and tested to the manufacturer's specifications. Quality fuel must be utilized. The fuel filters (primary and secondary, if equipped) should be replaced or serviced on a regular basis, normally at 6-month intervals or at every oil change is recommended. Fuel pressure should be tested utilizing factory-recommended procedures. Fuel spill-back (return) should also be included in fuel system checks. Some manufacturers recommend that a fuel suction test be performed to test the suction capabilities of the fuel pump and suction side of the fuel system.

**A.8.6.5** All linkage should be inspected for freedom of movement, adjustment, full throttle position, idle position, and smooth operation.

**A.8.12.1** Severe duty (conditions) scheduling applies to brake system maintenance due to the normal hard braking encountered with the emergency vehicle.

A brake maintenance schedule for each emergency vehicle should be set after the brakes have been inspected several times. This schedule should include both minor inspections and major inspections as follows:

(1) For minor inspections, the brakes, brake linings or pads, and slack adjusters should be inspected for freedom of movement, security of mounting, and deformation and should be tested for proper operation.
(2) The slack adjuster should be lubricated according to a schedule that provides the most frequent inspection and lubrication based on one of the following:
    (a) Schedule for chassis lubrication used by the department
    (b) Schedule for chassis lubrication recommended by the manufacturer of the chassis
    (c) At least four times during the life of the linings

(3) Major inspections should be performed whenever the brakes are relined, or at least once a year, whichever comes first, and should include the following:
   (a) All procedures, inspections, and measurements recommended by the manufacturer for relining the brakes
   (b) Lubrication of the slack adjuster and caliper, if equipped
   (c) Adjustment of the brakes as described in the manufacturer's literature

**A.8.14.6** For the safety of personnel riding in the driving or crew area, the equipment specified in 8.14.6 should be mounted in accordance with the requirements of NFPA 1900.

**A.8.14.7.1** If the cab has a powered tilting system that does not have an interlock system, consideration should be given to providing an interlock to allow operation only when the parking brake is engaged.

**A.8.15.4** If the emergency vehicle does not have the reflective striping, consideration should be given to adding the reflective striping in accordance with the applicable sections of NFPA 1900 or other applicable documents.

**A.8.15.5** If the emergency vehicle does not have the warning signs, consideration should be given to adding the warning signs in accordance with the applicable sections of NFPA 1900 or other applicable documents.

**A.9.5.2** Alternators are required to be performance tested at least annually and after certain repairs *(see Section 21.5)*. The purpose of the diagnostic check specified in Chapter 9 is not to duplicate the tests required in the annual performance test but to ensure the component is working properly. If the alternator is working, the voltage should increase after starting the engine, and the ammeter (if equipped) should read positive.

**A.10.2.1** Fire pumps and industrial supply pumps are required to be performance tested at least annually and after certain repairs *(see Chapter 22)*. The purpose of the diagnostic check specified in Chapter 10 is not to duplicate the tests required in the annual performance test but to ensure that the component is working properly.

**A.10.2.4.1** Components of the pump drive system could include, but are not limited to, the following:

(1) Split-shaft power takeoff (PTO)
(2) Pump transmission
(3) Pump transfer case
(4) PTO
(5) Pump clutch
(6) Pump drive shafts
(7) Hydraulic drive systems
(8) Auxiliary drive engine

**A.10.2.4.2** Pump shift controls can include electrical, pneumatic, or mechanical components working individually or in combination to shift the pump drive system into and out of pump mode. Some pumps have manual backup shift controls. Pump shift indicators in-cab and on the operator's panel on split-shaft PTO pump drive systems typically require an electromechanical device, such as a switch mounted on the pump transmission, to sense pump shift status. The controls need to be inspected, diagnostically checked, and lubricated as part of a preventive maintenance program.

Beginning with the 1991 edition of NFPA 1901 (which is now consolidated in NFPA 1900), fire apparatus equipped with electronic or electric engine throttle controls are required to include an interlock system to prevent engine speed advancement, unless the chassis transmission is in neutral with the parking brake engaged; unless the parking brake is engaged, the fire pump is engaged, and the chassis transmission is in pumping gear; or unless the apparatus is in the "okay to pump" mode.

**A.12.1** It is important for the operator, maintenance personnel, and fire apparatus technician to understand the types and properties of mechanical foam and its application to maintain a foam proportioner system. Specific information regarding foam concentrates and their corrosive characteristics, biodegradability, and application is available in NFPA 11. Information on foam concentrates for Class A fires is available in NFPA 1150. A thorough knowledge of foam and foam systems will enhance the ability to maintain systems in peak operating conditions at all times.

There are many designs for foam proportioning systems. These systems include, but are not limited to, the following:

(1) Eductor systems
(2) Self-educting master stream nozzles
(3) Intake-side foam proportioning systems
(4) Around-the-pump foam proportioning systems
(5) Balanced pressure foam proportioning systems
(6) Direct injection foam proportioning systems

Annex A of NFPA 1900 describes these systems and variations thereof. A review of that material will assist with the understanding of foam proportioning systems.

**A.12.3** Most foam system manufacturers differentiate between the materials they recommend for foam proportioning system components that are designed to be flushed with water after operation and those components that are intended to be wetted continuously with foam concentrate (that is, some positive displacement pumps are designed to be completely full of foam concentrate).

**A.13.3.3.1** Special attention should be paid to the cleanliness and security of engine covers, cooling fins, and fans on air-cooled engines, as they are critical to the proper operation of the engine.

**A.14.7.1.1** It is important to check the cleanliness and security of engine covers, cooling fins, and fans on air-cooled engines, as these factors are critical to the proper operation of the engine.

**A.15.8** There are refill stations currently on emergency vehicles that were never designed to the requirements of NFPA 1900 and whose design has never been certified by an independent third-party certification organization. These include open-top fragmentation tubes and closed systems that have never been tested to determine if they will contain all fragments of a failed cylinder to protect the operator. If a commercial refill station is on the emergency vehicle, it might be possible to confirm with the manufacturer whether the design of the unit meets current standards. Older refill stations should be considered for replacement with refill stations that meet the requirements of NFPA 1900.

**A.15.9.1.1** Special attention should be paid to the cleanliness and security of engine covers, cooling fins, and fans on air-

cooled engines, as they are critical to the proper operation of the engine.

**A.16.2.8** It is important that the cold tire inflation be maintained to the fire apparatus manufacturer's recommended tire pressure, which is based on the weight of the completed apparatus, and not to the maximum pressure shown on the sidewall of the tire. If the information from the fire apparatus manufacturer is not available for the tires on the vehicle, each axle should be weighed with the vehicle fully loaded and the tires inflated to the tire manufacturer's inflation specification for the tire model, size, and axle load.

**A.16.2.9** Tire age can be determined by checking the DOT code on the sidewall of each tire. The code begins with DOT and ends with a 3-digit (through 1999) or 4-digit (2000 and beyond) date code. The first two digits of the date code indicate the week of the year the tire was manufactured, and the last one or two digits indicate the year. For example, DOT GJ HU234 319 was manufactured in week 31 of 1999. DOT BT FR87 2501 was manufactured in week 25 of 2001. The code may be on the inside or outside sidewall.

**A.20.2.3** If the scales allow, the right side and the left side of the emergency vehicle should also be weighed. The side-to-side tire load variation should be no more than 7 percent of the total tire load for a given tire's axle.

**A.20.2.4(3)** In some chassis designs, the personnel weight is centered over the front axle and the entire personnel weight can be entered in the front axle column. If not, the weight allocation for each seating position can be calculated as follows:

**[A.20.2.4(3)a]**

$$\text{front weight} = \frac{200 \text{ lb } (90 \text{ kg}) \times \left(\begin{matrix}\text{wheel base } - \text{ distance aft} \\ \text{of front axle to seat}\end{matrix}\right)}{\text{wheel base}}$$

If the seat is forward of the front axle, the distance is negative or the value should be added to the wheel base in the numerator formula (wheel base + seat distance forward of front axle).

The weight on the rear axle attributed to each seating position equals 200 lb (90 kg) minus the weight attributed to that seating position on the front axle.

**[A.20.2.4(3)b]**

$$\text{rear weight} = 200 \text{ lb } (90 \text{ kg}) - \text{front weight}$$

If the seat is not between the front and rear axle, one of the weights will be negative.

Figure A.20.2.4(3) is an example that shows four potential seating areas along the length of an emergency vehicle with a 240 in. wheelbase. Each seating area could have more than one seating position (e.g., the driver's seat and officer's seat at the front of the vehicle).

Table A.20.2.4(3) shows the net effect of a seating position on the axle loadings at each of the four seating locations along the vehicle as shown in Figure A.20.2.4(3).

**A.20.2.4(4)** The reference to "additional equipment" is intended to account for equipment added to an emergency vehicle for specific calls. This equipment could include, but is not limited to, ice rescue sleds, water rescue crafts, wildland firefighter supplies, hose bridges, and portable water tanks added to the vehicle for particular responses. The purpose of such additions is to honestly assess the fully loaded weight of an emergency vehicle responding to any emergency or any service offered by the department. For this reason, where the equipment added to the apparatus is as important as standard equipment, the added equipment's weight should be recorded on line D of Figure 20.2.4 to represent where the additional weight impacts the apparatus.

**Table A.20.2.4(3) Effect of Seat Location on Axle Loading**

| Seating Location on Figure | Distance from Front Axle (in.) | Wheelbase (in.) | Weight on Front Axle (lb) | Weight on Rear Axle (lb) | Total Value (lb) |
|---|---|---|---|---|---|
| A | –24 | 240 | 220* | –20* | 200 |
| B | 48 | 240 | 160* | 40* | 200 |
| C | 150 | 240 | 75* | 125* | 200 |
| D | 300 | 240 | –50* | 250* | 200 |

*Final weight entered on Figure 20.2.4 needs to reflect this weight times the number of seating positions at this location.

If the emergency vehicle is to be used for extended operations away from the community where it is normally housed, such that the emergency responders will be taking personal clothing and equipment with them, an additional allowance of 70 lb (32 kg) per seating position should be included.

**A.20.3.3** Figure A.20.3.3 shows the layout of the brake test area.

**A.20.4.1** The parking brake should be tested to the chassis manufacturer's recommendations. NFPA 1901 (which is now consolidated in NFPA 1900) has required a parking brake system to hold a fully loaded emergency vehicle on at least a 20 percent grade since 1991. If the emergency vehicle parking brake system was not designed to perform up to these or applicable federal standards, or if the AHJ operates the emergency vehicle beyond these standards, the AHJ should develop a standard operating guideline to supplement the emergency vehicle parking brake system.

**A.20.4.2** If grades of over 20 percent are present in the normal response area of the emergency vehicle, the emergency vehicle parking brake system should be tested on the steeper grade. If the vehicle fails to hold, the AHJ should develop a standard operating guideline to supplement the emergency vehicle parking brake system.

**A.21.2** "Major repairs" does not necessarily refer to the length of time that a repair takes but rather whether or not a repair potentially affects the operation or safety of any aspect of the low-voltage electrical system. This might include repairs unrelated to the low-voltage electrical system, such as body repairs, that might disturb wiring or other parts of the system. Testing should be performed to verify that, after the repair, the system is operating properly and safely.

**A.21.3.2.1** Conductivity testing is preferred to load testing because it does not stress the battery, it is a more accurate indication of the state of health of the battery, and it provides values that can be recorded and tracked for trend analysis.

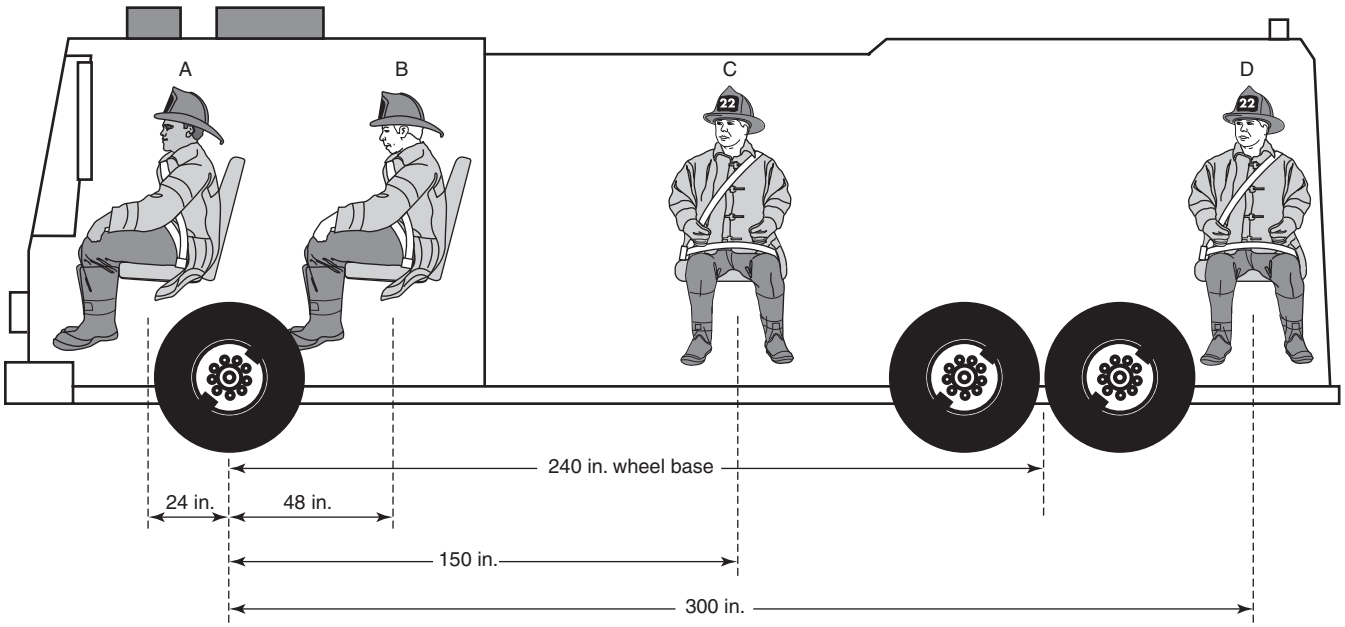



**FIGURE A.20.2.4(3) Diagram of an Emergency Vehicle Showing Potential Seating Locations.**

**A.21.4** This test verifies that the wiring to the starter is in good condition and the connections are tight and free of internal corrosion.

**A.21.5** This test verifies the output of the alternator and the alternator wiring.

**A.21.5.5** If any portion of this test fails, it might indicate a problem with the alternator, or the problem might be with some other component of the electrical system. If the test fails, a qualified technician should do further investigation to determine the exact problem.

**A.21.5.5(7)** If the system includes a battery isolator, the voltage drop is the sum of the drop between the alternator and the battery isolator and the drop between the battery isolator and the battery.

**A.21.6.6** If any portion of this test fails, it might indicate a problem with the regulator, or the problem might be with some other component of the electrical system. If the test fails, a qualified technician should do further investigation to determine the exact problem.

**A.21.8** This test is designed to verify that the charging system, with the load management system, if supplied, is sufficient to supply the total connected load.

**A.21.8.3(3)** The total continuous electrical load includes all continuous electrical equipment on the apparatus, including heating and air-conditioning, warning and scene lights, marker and head lights, step and ground lights, compartment lights, and other low-voltage equipment. It excludes intermittent loads, such as starters, primers, reel rewind motors, sirens, and horns.

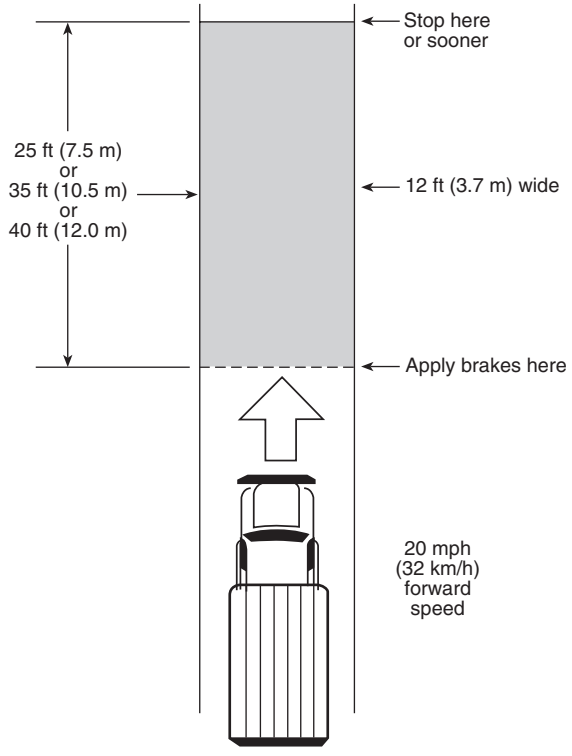



**FIGURE A.20.3.3 Layout of a Brake Test Area.**

**A.21.8.4** The alternator is supposed to be able to supply the total continuous electrical load, as adjusted by the load management system. If the electrical system is working properly and can sustain the electrical load, no current should be drawn from the batteries during this test. The voltage at the battery terminals should remain constant if the batteries are fully charged or go up if the batteries are not fully charged. The allowance for a drop of 0.05 volts allows for normal voltage variation and instrument errors.

**A.21.9.3** An excessive voltage drop across a power relay or solenoid indicates a problem with the component and, if not repaired, will often lead to a failure of the device by which it is controlled.

**A.22.1** Some fire apparatus is equipped with an auxiliary pump or a transfer pump. Any water pump used in firefighting operations not classified as a fire pump or industrial supply pump should be tested on an annual basis and the test results examined year-to-year for unexplained changes that could indicate developing problems with the pump or the engine driving the pump.

If there are no test results and no test procedure from previous testing of the pump, the procedure that follows is recommended on an annual basis.

Determine the pump shutoff pressure as follows:

(1) Engage the pump and, while taking suction from the water tank, close the discharge valve and advance the engine speed until the discharge pressure ceases to increase, taking care not to run the pump in this condition for more than 1 minute.
(2) Record the pump shutoff pressure.

Determine the discharge pressure and volume operating from the water tank on the apparatus as follows:

(1) Open the discharge valve and advance the engine speed until the pump is operating at the highest discharge rate possible for the normal pump discharge pressure, recognizing that the maximum discharge rate might be governed by the capacity of the pump or might be governed by the size and arrangement of the piping between the water tank and the pump.
(2) Measure the discharge rate using a flowmeter, a hoseline with a smoothbore nozzle of sufficient size, or another method.
(3) Continue to discharge water for 10 minutes or until the pressure begins to drop, whichever comes first, measuring the discharge rate and discharge pressure at 5-minute intervals.
(4) Average the discharge rates measured and the discharge pressure readings and record the results.

Determine the discharge pressure and volume operating from draft as follows:

(1) If the pump has other than an exhaust gas primer, cap the pump intake and close any discharge valves or cap any discharge outlets, operate the priming pump to develop at least 17 in. Hg (57.4 kPa) vacuum, and record the vacuum at the beginning and end of 5 minutes.
(2) Operate the pump at the maximum discharge rate that can be obtained at the normal pump discharge pressure when drafting using the suction hose carried on the fire apparatus for that pump at a lift of up to 10 ft (3 m).
(3) Measure the discharge rate using a flowmeter, a hoseline with a smoothbore nozzle of sufficient size, or another method.
(4) Continue to discharge water for 10 minutes, measuring the discharge rate and discharge pressure at 5-minute intervals.
(5) Average the discharge rates measured and the discharge pressure readings and record the results.
(6) Record the pump site conditions (suction hose size and length, lift, atmospheric pressure) and the pump test results, so the test can be repeated under similar conditions in future years.

**A.22.2** "Major repairs" does not necessarily refer to the length of time that a repair takes but rather whether or not a repair affects a major component of the pump assembly so as to require assurance after the repair that the pump is still operating properly.

**A.22.3.1** It is preferable to test apparatus at draft. It is important that a proper site be selected for the testing. Clean freshwater is desirable, but, where saltwater is drafted, the pump, piping, fittings, and pressure-regulating governors should be thoroughly flushed out after testing.

The apparatus should be parked as close as possible to the water's edge. It is usually more convenient to have the pump control panel side face away from the water. The intake(s) with shortest distance to the pump impeller should be used. Front or rear intakes on midship pumps should be avoided, as the piping between the pump and inlet is usually more restrictive than the side intakes.

The size and number of the suction hose(s) to be used will depend on the altitude and the lift as well as the rated capacity of the pump to be tested. Chafing pads should be provided to prevent damage to the suction hose when the hose is in contact with sharp edges of docks, manholes, walls, and rocks.

**A.22.3.2** Testing the pump at draft is preferable to testing from a hydrant. The true performance of the pump is easier to evaluate while pumping from draft. If no suitable drafting site is available, testing the pump from a hydrant is acceptable. Care must be taken to ensure that the discharge gauge readings reflect the pressure necessary for the pump to be performing at the needed net pump pressure. For example, if the intake pressure gauge reads 30 psi (207 kPa) and the test requires a 150 psi (1034 kPa) net pump pressure, the discharge test gauge should read 180 psi (1241 kPa). Because of the amount of treated water that will be discharged from the water system during the course of a fire pump test, as a courtesy, the local water authority should be notified prior to the test being conducted.

**A.22.4** If conditions are not within the specified limits, the test should be delayed until they are satisfactory; otherwise, the results will need to be confirmed by another test at a later date. It is particularly important that the water supply be nonaerated and not over 90°F (32°C). If these criteria are not met, the pump performance could be seriously affected.

An attempt should be made to duplicate the environmental conditions and test setup as closely as possible from year to year, so that differences in test results can be attributed to changes in the engine or pump, and not to environmental or test conditions.

The suction lift capability of a fire pump is certified by the pump manufacturer for specific conditions of altitude above sea level, atmospheric pressure, water temperature, and friction and entrance loss caused by the flow of water through intake strainers and hose. The AHJ should be aware that as the temperature of the water increases and barometric pressure decreases, the suction lift capability of the fire pump is reduced. The test site configuration must not provide a vertical lift that exceeds the suction lift capability of the pump as a result of elevated water temperatures and reduced barometric pressure. See Table A.22.4.

**A.22.5.1.1** For elevations greater than 2000 ft (600 m), suction hose size and quantity might have to be increased to maintain the desired pump performance.

**A.22.5.1.2** The intake hose should always be connected to an intake on the opposite side of the apparatus from the pump operator's position.

**A.22.5.2.1** A maximum flow velocity of 35 ft/sec (10.7 m/sec) is desirable and is equal to approximately 500 gpm (2000 L/min) flowing through 2½ in. (65 mm) hose.

Where two or more lines are indicated for use with one nozzle, they are to be siamesed into a heavy-stream appliance. The purpose of the hose is to convey water from the discharge side of the pump to the nozzle, monitor, or flow-measuring device where the volume will be measured and the water will be discharged to the atmosphere. Single or multiple larger diameter hoselines can be used for this purpose as well. The length and size of the hose are not factors, unless the length and size together create excessive friction loss that requires the pump to operate above the net pump pressure that is required for the test to achieve the rated flow. If relatively short lengths of hose are used, the total friction loss that is necessary to reduce the pump discharge pressure to the required nozzle pressure can be increased by partially closing the discharge valves on the apparatus.

For the protection of the operator, hoselines should not be connected to the pump at the operator's position. The hose that is used should be "attack hose," as defined by NFPA 1961, and should have been recently tested in accordance with NFPA 1962.

**A.22.5.3.2** Nozzles that are suitable for testing usually can be found in the regular equipment of a fire department. However, the actual coefficient of discharge of each nozzle should be known; otherwise, test results could be erroneous. The actual coefficient of discharge needs to be determined by tests conducted by competent persons who are using equipment such as weigh tanks or calibrated flowmeters. Nozzles should be used with portable or mounted monitors. Handheld nozzles should not be used.

**Table A.22.4 Effect of Water Temperature and Barometric Pressure on Suction Lift**

| Water Temperature Effect | | Barometric Pressure Effect | |
|---|---|---|---|
| 60°F (16°C) | 0 ft | 29.9 in. Hg | 0 ft |
| 90°F (32°C) | –1 ft | 29.0 in. Hg | –1 ft |
| 110°F (43°C) | –2.3 ft | | |
| 120°F (49°C) | –3.3 ft | | |

The size of the nozzle that is used usually is chosen to give the desired discharge at a nozzle pressure between 60 psi and 70 psi (410 kPa and 480 kPa). This pressure is neither so high that the pitot is difficult to handle in the stream nor so low that the normal inaccuracies of a gauge that is used at low pressure would come into play. Nozzle (pitot) pressures less than 50 psi (350 kPa) or higher than 100 psi (690 kPa) should be avoided. The nozzle should always be used in conjunction with a securely placed monitor; a test should never be conducted while any person holds the nozzle. Failure to abide by this recommendation can cause serious injuries.

Only smoothbore nozzles should be used. Care should be taken that washers or gaskets do not protrude into the nozzle, because a perfectly smooth waterway is essential. Nozzle tips of ¾ in. to 2¼ in. (19 mm to 57 mm) inside diameter are desirable for use during various capacity and pressure tests. They should be free of nicks and scratches to ensure a smooth stream. Tips should be measured, preferably after being attached and made ready for the test, to ensure that there is no mistake about the size of the tip being used.

**A.22.5.3.2.2** A pitot tube with an air chamber and pressure gauge is necessary for determining the velocity pressure of the water at the nozzle. The pitot tube should be kept free of dirt and the air chamber free of water. Any water that accumulates in the air chamber should be removed after each test. The knife edges will get battered in service and need to be kept sharp to reduce as much spray as possible caused by inserting the pitot into the stream.

To ensure accurate and consistent readings, pitot tubes should be fixed in the center of the stream, with the end of the tube located away from the end of the nozzle by a distance that is equal to half of the nozzle diameter.

See Annex B, Table B.3(a), Table B.3(b), Table B.3(c), and Table B.3(d) for information on determination of flow rates with nozzles.

**A.22.5.3.3** Square-edged round orifice and pressure gauge is a very accurate method of measuring low pump flows found on wildland fire apparatus. Flow through a square-edged round orifice shall be determined using the following equation:

**[A.22.5.3.3]**

$$Q = 29.8 \cdot C \cdot d^2 \cdot \sqrt{P}$$

where:
$Q$ = flow (gpm)
$C$ = orifice discharge coefficient (0.62 recommended)
$d$ = orifice diameter (in.)
$P$ = pressure (psi)

For best accuracy, the line to the square-edged round orifice should be three times the diameter of the orifice.

If the nozzle diameter is measured in millimeters, the diameter should be divided by 25.4 to convert the measurement to inches. If the pressure is measured in kilopascals (kPa), the pressure should be divided by 6.895 to convert the measurement to pounds per square inch (psi). The resulting flow can be converted from gallons per minute (gpm) to liters per minute (L/min) by multiplying by 3.785.

**A.22.5.4.1** It is important that the gauge be sufficiently accurate to ensure that test results are reliable. Grade A gauges in

accordance with ASME B40.100 must be accurate within 2 percent of the span over the entire scale, and within 1 percent over the middle half of the scale. This means that a gauge of 0–400 psi (0–2800 kPa) will be accurate within 4 psi (28 kPa) from 100 psi to 300 psi (700 kPa to 2100 kPa). Grade 3A or Grade 4A gauges, which are used for calibrating other gauges, must be accurate within 0.25 percent or 0.10 percent, respectively, over the entire span.

While a 0–400 psi (0–2800 kPa) range is not preferred per ASME B40.100, such gauges are readily available. Graduation increments should be no greater than twice the allowable error in the middle of the scale [8 psi maximum on a 0–400 psi Grade A gauge (56 kPa maximum on a 0–2800 kPa Grade A gauge)], and smaller increments are recommended. Many variations and special constructions are available, and gauge manufacturers can be contacted for their recommendations.

**A.22.5.6** If a counter speed shaft is not provided, the engine speed can be read with a photo tachometer or strobe light off a rotating element.

**A.22.6** It is recommended that the fire department duplicate the test conditions to the extent possible from year to year to allow more accurate comparison of data over a period of time. These conditions should include the following:

(1) Lift
(2) Air and water temperature
(3) Suction hose size, length, and style
(4) Strainer type
(5) Intake and discharge hose layout

**A.22.6.2** The engine compartment should remain closed during the pumping test, unless the apparatus was designed to an older standard that permitted testing with the compartment open.

**A.22.6.2.2.1** The 1996 edition of NFPA 1901 (which is now consolidated in NFPA 1900) added a requirement stipulating that an engine driving both a pump and a fixed power source needs to be able to power the fixed power source at a minimum of 50 percent of its rated capacity while the pump is operating at rated capacity. Older fire apparatus might not have the engine horsepower to run both simultaneously. Where the same engine drives both the pump and the fixed power source, it is recommended that the capability to run both should be investigated so the operator will know the capability of the apparatus.

**A.22.7.1** Other data that should be obtained are indicated on the test form shown in Figure C.3(c). The layout of the hose and nozzle and data about the pump and engine should be recorded.

**A.22.7.4** Pump shift controls might include electrical, pneumatic, or mechanical components working individually or in combination to shift the pump drive system into and out of pump mode. Some pumps have manual backup shift controls. Pump shift indicators in-cab and on the operator's panel on split-shaft PTO pump drive systems typically require an electromechanical device, such as a switch mounted on the pump transmission, to sense pump shift status.

**A.22.7.5** Since the 1991 edition of NFPA 1901, fire apparatus equipped with electronic or electric engine throttle controls have been required to include an interlock system to prevent engine speed advancement unless the chassis transmission is in neutral with the parking brake engaged; unless the parking brake is engaged, the fire pump is engaged, and the chassis transmission is in pumping gear; or unless the apparatus is in the "okay to pump" mode.

**A.22.7.7** At the time of purchase, a pump must be able to develop a vacuum of 22 in. Hg (75 kPa) with a capped suction hose and must hold the vacuum with a drop not in excess of 10 in. Hg (34 kPa) in 5 minutes. This is basically a test of the priming system and the tightness of the pump and fittings, not a test of the ability to maintain a vacuum while pumping water.

The number, length, and condition of suction hose, as well as altitude, water temperature, atmospheric pressure, and lift, are all factors that affect pumping from draft.

**A.22.7.7(7)** By conducting a second vacuum test with the valves closed on the intakes so equipped and the caps or plugs removed on those intakes, a leaking intake valve would be detected.

**A.22.7.8.2.3** If the pump is a two-stage, parallel/series-type unit, then operation of the transfer (that is, changeover) valve should be checked thoroughly. Conducting the pumping test with the transfer valve positioned as specified in 22.7.8.2.3 will ensure that the valve is exercised. If a comparison with the original engine speeds shows a significant difference for any of the tests, one of the problems could be with the transfer valve.

**A.22.7.9** Care should be taken to perform the pressure control tests using net pump pressure and net pressure rise readings. Some pressure control systems might not operate correctly if the hydrant pressure is too high; the system manufacturer's manual should be consulted for information.

**A.22.7.9.2.1(3)** Closing all discharges in less than 3 seconds could cause instantaneous pressure rises that the pressure control device might not be able to respond to rapidly enough to avoid damage to the pumping system. Taking more than 10 seconds to close the discharges is not a reasonable test of the pressure control device response capability. Controlling closure of the discharges can be done manually or otherwise.

**A.22.7.9.3.1(3)** See A.22.7.9.2.1(3).

**A.22.7.9.4** Positive displacement UHP pumps equipped with trap pressure unloaders trap pressure between a check valve in the outlet of the unloader and the discharge nozzle when the spray nozzle is closed while bypassing pump output back to the pump intake or back to a tank. The pump recirculates water without building any more pressure than is required to overcome the friction loss of pushing the water through the unloader and through whatever passageway (internal passageway or external hose, pipe, etc.) back to intake or tank. UHP systems on which the discharge pressure gauge is installed on the pump head will indicate a significant drop in the observed gauge pressure when the discharge is closed. If the observed final discharge pressure reading during the pressure control test increases from one year to the next or over time, this might indicate that the setting of the unloader has changed, the check valve has become damaged or fails to fully close, or the bypass passageway has become restricted. Such changes indicate that the unloader should be investigated and repaired.

**A.22.7.10** One method of conducting this test is to use a second pumping apparatus to supply water to the pump being tested. Pressure from the supply pump should be increased until the receiving pump relief system opens a dump valve. The

pressure at which the system opens, dumps, or otherwise starts to operate should be recorded. The pressure at which the system starts to operate should be reviewed against current operating procedures and the system adjusted accordingly.

**A.22.7.11.1** The pressure gauge can be checked quickly against the test gauge for accuracy. Individual discharge lines with a gauge should be capped and the discharge valve opened slightly. The test gauge, the master discharge gauge, and the discharge gauge should all indicate the same readings.

**A.22.7.12.1** Flowmeters need to be checked individually using a hose stream with a smoothbore tip and a pitot tube to measure the actual flow.

**A.22.7.13(9)** Rates less than the rate established when the apparatus was new, or than established in previous testing, indicate problems in the tank-to-pump line or tank.

**A.22.8** Test data forms for recording the test readings and other necessary data should be provided. An example of a suitable form is shown in Figure C.3(c). The use of such a form will help to ensure that all needed data are obtained.

**A.22.8.1** When fire apparatus is operating at or near full engine power while stationary, the generated heat can raise the temperature of certain chassis components, pumping system components, or both above the level that can be touched without extreme discomfort or injury. However, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions and the engine coolant temperature is within normal range, the rise in temperature should be considered acceptable.

**A.22.8.3** If the test conditions are equal to those at the time of delivery of the apparatus and the speed of the engine increases by more than 10 percent of the original engine speed, the reason for the decrease in performance should be determined and the deficiency corrected. Where test conditions are significantly different from the original test conditions at the time of delivery, results should be compared with previous years' tests. The test conditions should be maintained as consistently as possible from test period to test period.

**A.22.8.7** There are two conditions under which rerating a pump on a fire apparatus should be considered. The first is when the apparatus is delivered or repowered with an engine that is capable of supplying additional power beyond that which is needed by the pump to meet its required rating when new, and where the pump is designed to permit a larger capacity rating. This condition might require the addition of suction intakes or pump discharges to take advantage of that capacity. The fire apparatus manufacturer or pump manufacturer should be consulted as necessary to ensure that all components of the pumping system are adequate for the potential rerating.

The second condition is when the environment in which the engine/pump was initially delivered has changed and the engine can no longer achieve its original performance. This situation can occur when an engine/pump passed the original pump rating test with little or no reserve and the apparatus has been relocated to a higher elevation, or natural wear within the engine has reduced the power output.

The pump should not be considered for rerating if the engine is seriously worn or should have major restorative work. The pump also should not be considered for rerating if the results of testing show the pump has signs of wear or other problems. In these cases, there is a good chance the pump will not pass the complete pump test, thus wasting time and money to get an accredited third-party testing organization to witness and certify the tests. Problems with engine wear, pump wear, pump blockages, or other issues with the pump will worsen at an accelerated rate if they are not corrected, potentially resulting in catastrophic failure during an emergency.

It might be necessary, for various reasons, to continue to use the pump on an apparatus that does not meet its original rating until the pump can be repaired. This is an operational decision that needs to be made on a case-by-case basis, depending on the deficiency of the pump and the apparatus that is available to replace the deficient apparatus while repairs are being made. Rerating the pump downward where such deficiencies are present only creates a false sense of vehicle capability.

**A.23.1.2** Full nondestructive testing (NDT) can be desirable on a more frequent basis than every 5 years, depending on the service to which the aerial device is subjected. Extensive use of the aerial device in urban environments would be a reason for more frequent testing. Many departments have found aerial devices damaged not by use but by transport over rough roads that wrack the device in its bed.

**A.23.1.3.1** If possible, the manufacturer of the aerial device should be consulted when structural defects are revealed by the performance test in this standard. The recommendations for repair that are made by the manufacturer should be followed strictly. However, if the manufacturer is no longer in business, the AHJ must choose a repair facility to conduct the repair work. Choosing a repair facility to perform structural repair on an aerial apparatus is a process that requires a great deal of research and careful thought. Some of the items that should be considered include the following:

(1) Does the facility have experience with the same structural repair needed by the aerial device, and can the facility provide a reference list?
(2) Does the facility have the original design, construction, and operation specifications for the make and model of the aerial device?
(3) Does the facility have in its possession written procedures for structural repair that were developed previously by the manufacturer of the aerial device?
(4) Does the facility employ an engineering staff to analyze structures and recommend structural repair methods?
(5) Will the facility provide an engineering analysis that substantiates the structural repair method recommended?
(6) Will the facility provide an independent certification by a professional engineer of the analysis that substantiates the recommended structural repair method?
(7) Will the facility warrant the work performed?

**A.23.1.4** Specific, written checklists, which combine the manufacturer's recommended checks with the inspection procedures of this standard and any other checks found desirable by the department, should be developed by each fire department for its style and brand of apparatus to ensure a systematic and complete inspection.

**A.23.1.5** Qualified vehicle operators are either those who have been schooled in the operation of the vehicle by the manufacturer or fire department instructors who have received special

training in all phases of vehicle operations. Operators of fire department apparatus should complete a course in driver training and aerial ladder or elevating platform operational procedures, including positioning on the fireground. Specific training should be given in procedures to be followed if the hydraulic system fails. A thorough understanding of safe load capacity, stabilizing procedures, and operational limits is paramount. Safety procedures, proper shutdown, and boom-lowering procedures are also critical. Operators should be tested upon completion of training. Periodic retraining and retesting should also be required.

**A.23.8.4.16.2** If the aerial device is operated for a considerable time period prior to the drift test, the hydraulic fluid temperature will be elevated. During the 1 hour test, the hydraulic fluid will cool to ambient temperature, and it can change in volume by 3 percent to 4 percent, leading to erroneous test results.

**A.23.8.5.8.2** See A.23.8.4.16.2.

**A.23.8.6.6(2)(b)** If heat sensors are provided, they are normally located on the last 10 ft (3 m) of each top rail section. If heat sensors are not installed by the manufacturer, the manufacturer should be consulted for installation recommendations.

**A.23.8.6.8(2)** Some hollow I-beam aerial ladder base rails have an additional layer of sheet metal spot welded to the bottom of the base rail on the bed ladder section. This additional metal is commonly known as a *glove*. Base rails constructed in this manner are susceptible to corrosion between the inside of the glove and the outside of the base rail when water is trapped in this area. This corrosion is not detected easily, as the area inside the glove cannot be inspected visually unless the glove is removed. If any corrosion or rust can be seen bleeding from the glove, the manufacturer should be contacted and the glove removed to determine whether corrosion has weakened the base rail.

**A.23.8.6.8(3)(b)** If heat sensors are not installed by the manufacturer, the manufacturer should be consulted for installation recommendations.

**A.23.8.6.28.2** See A.23.8.4.16.2.

**A.23.8.7.1** A strong wind on the long cable and test load will introduce a pendulum action that will potentially add load to the ladder far beyond the test weight.

**A.23.8.7.4.2** Figure A.23.8.7.4.2 illustrates such a hanger.

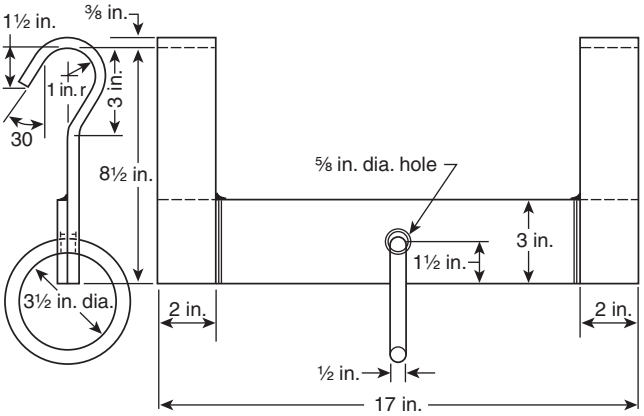
**A.23.8.7.4.8** Figure A.23.8.7.4.8 shows an example of a test weight container.

**A.23.8.7.5.2** See Figure A.23.8.7.4.2.

**A.23.8.8.2** The time within which an aerial device is required to be raised from the bedded position to maximum elevation and extension and rotated 90 degrees after the stabilizers are set is shown in Table A.23.8.8.2. Two or more of these functions are permitted to be performed simultaneously.

**A.23.8.9.4.1** The purpose of this test is primarily to detect water leaks in the turntable center swivel area. However, leaks in other areas also could be detected during this test.

**A.23.8.9.4.1.2** It is recommended that a valve or restricting orifice plate be placed in the hoseline where it connects to the ladder pipe intake to throttle the water entering the system. This precaution allows only a controlled flow if a component breaks during the test.




For SI units, 1 in. = 25.4 mm.

**FIGURE A.23.8.7.4.2 Hanger for Test Cable.**

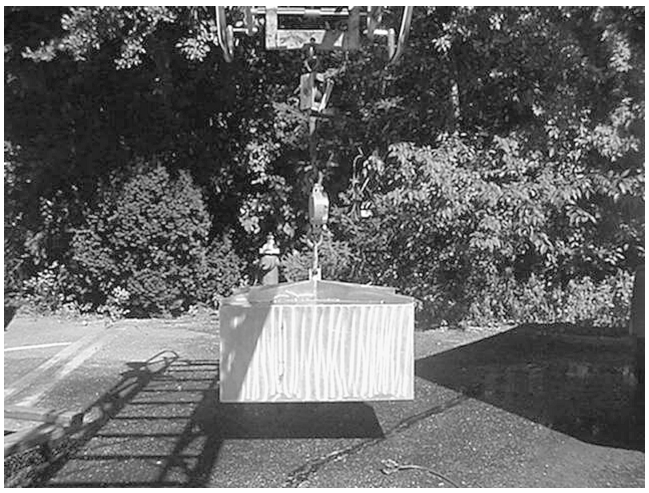


**FIGURE A.23.8.7.4.8 Test Weight Container.**

**A.23.8.9.4.2** The purpose of this test is primarily to detect water leaks in the seals between the telescoping water pipes. However, leaks in other areas could also be detected during this test.

**A.23.8.9.4.3** It is recognized that fittings could drip slightly during the test, and such dripping is acceptable. However, any steady leak is a sign of a developing problem that should be corrected.

**A.23.8.11** Spectrochemical analysis of the hydraulic fluid is intended to identify contaminants in the hydraulic system. Typically, the analysis will identify contaminants in parts per million (ppm) or by percent. Many laboratories that perform the analysis will provide service recommendations with their hydraulic fluid analysis report. In most cases, recommendations are limited, unless a reference analysis has been performed. The reference analysis is an analysis of new hydraulic fluid from the fluid manufacturer/supplier prior to the fluid being put into the aerial hydraulic system. Subsequent hydraulic fluid analyses are then compared to the reference analysis. By comparing the contaminant levels, trends can be identified and can give the analyzing laboratory specific service recommendations.

**Table A.23.8.8.2 Maximum Time to Elevate, Rotate, and Extend an Aerial Device**

| Edition of NFPA 1900/1901 | Aerial Ladder | Elevating Platform | Water Tower |
|---|---|---|---|
| 2024 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 2016 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 2009 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 2003 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 1999 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 1996 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 1991 | 120 seconds for rated vertical height of 110 ft (34 m) or less<br>180 seconds for rated vertical height over 110 ft (34 m) | 150 seconds for rated vertical height of 110 ft (34 m) or less<br>No time limit for rated vertical height over 110 ft (34 m) | 105 seconds |
| 1985* | 60 seconds | 150 seconds | 105 seconds |
| 1979 | 60 seconds | 150 seconds | 105 seconds |
| 1975 | 60 seconds | 150 seconds | 150 seconds |
| 1973 | 60 seconds | 150 seconds | 120 seconds |
| 1971 | 60 seconds | 150 seconds | 120 seconds |

*Prior to 1991, there was no differentiation in time related to the length of the aerial device.

**A.23.8.12** Figure C.3(d) shows a form that can be used to record the results of the inspection and test. This form can be supplemented with other data specific to the aerial device being inspected and tested.

**A.23.9.7.3.2** If the aerial device is operated for a considerable time period prior to the drift test, the hydraulic fluid temperature will be elevated. During the 1-hour test, the hydraulic fluid will cool to ambient temperature, and it can change in volume by 3 percent to 4 percent, leading to erroneous test results.

**A.23.9.7.5(4)(b)** If heat sensors are not installed by the manufacturer, the manufacturer should be consulted for installation recommendations.

**A.23.9.8.6(4)(b)** See A.23.9.7.5(4)(b).

**A.23.9.8.13.2** See A.23.9.7.3.2.

**A.23.9.9.1(4)(b)** See A.23.9.7.5(4)(b).

**A.23.9.9.5** The proper tensioning of extension and retraction cables of an aerial device is very important to ensure the smooth and safe operation of the aerial. When cable tension is too loose, the cable can jump the sheave wheel causing damage. When tension is too tight, the cable can cause damage to the sheave groove and bearings, which can damage the pulley and the cable. The manufacturers of aerial devices have different methods to determine that proper cable tensions are achieved. It is important that the manufacturer's guidelines are strictly followed for establishing cable tension. Cable tension is best measured using a tensiometer. The manufacturers of aerial devices are encouraged to provide the user with acceptable tensiometer readings for each cable. Determining cable tension with finger pressure should be avoided, as it is a less than accurate practice.

**A.23.9.9.12.2** See A.23.9.7.3.2.

**A.23.9.13.3** See A.23.8.8.2.

**A.23.9.14.3.2** It is recommended that a valve or restricting orifice plate be placed in the hoseline where it connects to the elevating platform intake to throttle the water entering the system. This precaution allows only a controlled flow if a component breaks during the test.

**A.23.9.14.3.4** It is recognized that fittings could drip slightly during the test, and such dripping is acceptable. However, any steady leak is a sign of a developing problem that should be corrected.

**A.23.9.14.6.2** The AHJ can elect to set the waterway relief pressure less than the recommended manufacturer's settings based on their standard operating procedures (SOP), in which case the relief valve test can be conducted at that operating pressure. It should be noted that the most complete test for the relief valve is based on the manufacturer's recommended settings because SOPs can change.

**A.23.9.16** See A.23.8.11.

**A.23.9.17** See A.23.8.12.

**A.23.10.10.2** See A.23.8.8.2.

**A.23.10.11.3.4** It is recognized that fittings could drip slightly during the test, and such dripping is acceptable. However, any steady leak is a sign of a developing problem that should be corrected.

**A.23.10.13** See A.23.8.11.

**A.23.10.14** See A.23.8.12.

**A.24.3** The four methods for testing a foam proportioning system for calibration accuracy are detailed below.

***Test Method 1: Substituting Water for Foam Concentrate.*** The foam system is operated at the water flow rates at which the system is to be tested. Water is used as a substitute for foam concentrate. The substitute water for the foam concentrate is drawn from a calibrated tank instead of foam concentrate from the foam concentrate tank. The volume of water drawn from the calibrated tank divided by the volume of water pumped over the same time period multiplied by 100 represents the percentage of foam the foam proportioner is producing.

***Test Method 2: Measuring Foam Concentrate Pump Output Directly.*** With some direct-injection systems, it is possible to directly measure the foam concentrate pump output. With the foam system operating at a given water flow rate, and using either foam concentrate or water as a substitute for foam concentrate, the output of the foam concentrate pump is measured by diverting that output into a calibrated container for direct measurement over a measured period of time. An alternative is to measure the foam concentrate flow or water substitute with a calibrated meter.

***Test Method 3: Determining Foam Percentage by Use of a Refractometer.*** A refractometer is used to measure the refractive index of a foam solution sample.

First, a base calibration curve is prepared using the same water and foam concentrate that will be used with the system to be tested. Three known foam solution samples are needed and should include the following:

(1) The nominal intended percentage
(2) The nominal intended percentage plus 1 percent
(3) The nominal intended percentage minus 1 percent

If the nominal intended percent is 1 percent or less, the three samples should be as follows:

(1) The nominal intended percentage
(2) The nominal intended percentage plus 0.3 percent
(3) The nominal intended percentage minus 0.3 percent

The required amount of water is placed in a 100 ml or larger graduated cylinder, leaving space for the foam concentrate. A 10 ml pipette or 10 cc syringe is used to carefully add the required amount of foam concentrate to the water. Each measured foam solution is then poured from the graduated cylinder into a 100 ml or larger plastic bottle, and the bottle is marked to indicate the percentage of solution it contains. The bottle is capped and thoroughly shaken to mix the foam solution.

An alternative method for making the three foam solution samples is to use a very accurate scale. The density of the foam concentrate needs to be known and can be found on the product data sheet or the Material Safety Data Sheet (MSDS) for the foam concentrate. For example, to make a 100 ml sample of a 3 percent foam solution using a foam concentrate with a density of 1.04, 97 g of water is measured into a beaker and 3.12 g of foam concentrate is added to the beaker ($1.04 \times 3$ g = 3.12 g).

After the foam solution samples are thoroughly mixed, a refractive index reading is taken of each foam solution sample. This is done by placing a few drops of the solution on the

refractometer prism, closing the cover plate, and observing the scale reading at the dark field intersection. Because the refractometer is temperature compensated, it could take 10 seconds to 20 seconds for the sample to be read properly. It is important to take all refractometer readings at an ambient temperature of 50°F (10°C) or above.

Using standard graph paper, the refractive index readings are plotted on one axis and the percentage of concentration on the other. This plotted curve serves as the known baseline for the test series. The solution samples should be set aside in the event the measurements need to be checked.

Foam solution samples are then collected from the proportioner system, making certain that the samples are taken at an adequate distance downstream from the foam proportioner being tested to allow for complete mixing of the water and the foam concentrate. Refractive index readings of the samples are taken and compared to the plotted curve to determine the percentage of foam.

This method might not be accurate for AFFF, alcohol-resistant foam, or certain other types of foam that typically exhibit very low refractive index readings. Also, the refractometer method should not be used when testing foam percentages of 1 percent or lower because the accuracy for determining the percentage of foam concentrate in a solution when using a refractometer is ±0.1 percent, at best. For this reason, test method 4, the conductivity method, might be preferable where AFFF, alcohol-resistant foam, or 1 percent or less foam is to be tested.

***Test Method 4: Determining Foam Percentage by Use of a Conductivity Meter.*** The conductivity test method is based on changes in electrical conductivity as foam concentrate is added to water. Conductivity is a very accurate method, provided there are substantial changes in conductivity as foam concentrate is added to the water in relatively low percentages. Because saltwater and brackish water are very conductive, this method might not be suitable where these waters are used because of the small conductivity changes as foam concentrate is added. If saltwater or brackish water is used, it is necessary to make foam solutions in advance to determine if adequate changes in conductivity can be detected. This method cannot be used if the water has more total solids than the foam concentrate.

The following three variations of this test method can be used to determine the foam percentage by the conductivity method:

(1) *Direct Reading Conductivity Method.* A sample of the water to be used in the test is put in a 100 ml or larger container. The conductivity meter head is immersed in the water sample, and the meter display is set at zero. If the direct reading foam solution conductivity meter is mounted in a discharge line, the meter should be set at zero with plain water flowing.

If the conductivity meter manufacturer does not indicate that the percentage of foam solution can be read directly for the foam concentrate being used, a calibration curve needs to be developed. The calibration curve might show that the direct meter readings are correct for the foam concentrate being used, or it might indicate that the calibration curve needs to be used when that foam concentrate is used in the test.

The foam proportioner system is operated, and a sample of the foam solution produced by the system is collected using a 100 ml or larger container. The conductivity meter head is immersed in the foam solution sample, and the percentage of the foam solution is read on the meter display. If the conductivity meter is mounted in a discharge line, the percentage of the foam solution is read on the meter display while foam solution is being discharged.

(2) *Conductivity Comparison Method.* A sample of the water to be used in the test is put in a 100 ml or larger container. Using a conductivity meter reading in microsiemens per centimeter (μS/cm), the conductivity value of the water sample is determined. The foam proportioning system is operated, and a sample of the foam solution produced by the system is collected in a 100 ml or larger container. Using the conductivity meter, the conductivity value of the foam solution sample is determined.

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

**[A.24.3]**

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

Note that the divisor is 500 only if the conductivity meter units are microsiemens per centimeter (μS/cm). Other units of conductivity can be used, but the value of the divisor (500) will need to be adjusted.

(3) *Conductivity Calibration Curve Method.* A base calibration curve is prepared using the water and foam concentrate from the system to be tested. Three known foam solution samples are made using the procedure in test method 3. After the foam solution samples are thoroughly mixed, the conductivity of each solution is measured using a conductivity meter. Care should be taken to ensure that the proper procedures are used for taking readings and that the meter is switched to the correct conductivity range. Most synthetic-based foams used with freshwater result in foam solution conductivity readings of less than 2000 μS/cm. Protein-based foams used with freshwater generally produce conductivity readings in excess of 2000 μS/cm. Because of the temperature-compensation feature of the conductivity meter, it could take a short time to obtain a consistent reading.

Once the solution samples have been measured and recorded, the bottles should be set aside as control sample references. The conductivity readings then should be plotted on standard graph paper. It is more convenient to place the foam solution percentage on the horizontal axis and the conductivity readings on the vertical axis.

A straight line should be drawn that approximates the connection of all three points. While it might not be possible to connect all three points with a straight line, they should be very close to the line. If not, the conductivity measurements should be repeated, and, if necessary, new control sample solutions should be prepared and used until all three points plot in a nearly straight line. This plot serves as the known base (calibration) curve to be used for the test series.

Once a base curve has been plotted, foam solution samples are collected from the proportioner system. The conductivity of the test samples is measured, and the percentage of foam solution is determined from the base curve. Foam solution

samples that have been allowed to drain from expanded foam should not be used, because they can produce misleading conductivity readings.

**A.26.2** "Major repairs" does not necessarily refer to the length of time that a repair takes but rather whether or not a repair potentially affects the operation or safety of any aspect of the line voltage electrical system. This might include repairs unrelated to the line voltage electrical system, such as body repairs, that might disturb wiring or other parts of the system. Testing should be performed to verify that, after the repair, the system is operating properly and safely.

**A.26.4.1** All loads must be disconnected while doing continuity testing.

**A.26.4.1.1** Inexpensive receptacle testers with lights to indicate correct or problem wiring are available from any hardware store or home center. Many also include a button for testing GFCIs as needed for the testing in 26.5.2. Testing can also be done with the power off using a continuity tester to the hot and neutral busses in the circuit breaker panel for the hot and neutral wires and to the body for the protective ground wire. Testing of twist lock or other special receptacles may require the use of an adapter.

**A.26.4.1.2** With an isolated system, the three light testers will, and should, indicate an open ground. To maintain the safety of the isolated system, it is important to verify the isolation between the current-carrying conductors and the body. This test detects faults that do not cause other indications.

**A.26.4.2** Receptacles supplied from a shore line should always have a bonded neutral when being powered from the shore line, and should have an isolated neutral when powered from the on-board source if the on-board system is isolated. If the transfer switch operation is powered from the on-board power source, the testing must be done with a three-light tester, which should indicate an open ground.

**A.26.5** With an isolated neutral electrical system, this test is not needed and probably will not work. The leakage path to protective ground created by a tester will not create any current leakage, and thus the GFCI will not trip. Inexpensive receptacle testers with a GFCI test button and lights to indicate correct or problem wiring are available from any hardware store or home center. This same tester can be used for the receptacle testing in 26.4.1.1. Testing of twist lock or other special outlets may require the use of an adapter.

**A.26.5.2(3)** If the neutral is not bonded to the vehicle frame, an external tester will not create a fault current, so it will not cause the GFCI to trip.

**A.26.6** At least every 5 years and after a vehicle accident or body repair, a dielectric test should be performed on the line voltage electrical system. The wiring and permanently connected devices and equipment should be subjected to a dielectric voltage withstand test of 900 volts for 1 minute.

The test should be conducted as follows:

(1) If the system has a neutral conductor bonded to the vehicle chassis, isolate the power source from the panel board.
(2) Disconnect any solid-state low-voltage components.
(3) Connect one lead of the dielectric tester to all the hot and neutral busses tied together.
(4) Connect the other lead to the fire vehicle frame or body.
(5) Close any switches and circuit breakers in the circuit(s).
(6) Apply the dielectric voltage for 1 minute in accordance with the testing equipment manufacturer's instructions.

**A.26.6.1** This testing may be performed at the same time as the power source testing required in Section 26.3 or Section 26.7.

**A.26.6.3** Heating of plugs, receptacles, and other points of connection are indications of loose connections. All points should be checked after at least 5 minutes of time under load. Any devices with hot connectors should be removed from service until repaired.

**A.26.7.2** Some large power sources have the capability to produce more power than can be used by all available appliances in the fire station. Load banks can be rented from local rental agencies. Caution should be used when testing generators with motor loads to avoid damage due to starting current requirements.

**A.29.1.1** This document is designed to aid in developing specifications for the refurbishing of fire apparatus. It is the intent of this standard to ensure that refurbished fire apparatus meet all applicable federal motor vehicle regulations as well as the applicable portions of NFPA 1900.

This standard will do the following:

(1) Identify minimum levels of refurbishing
(2) Establish minimum requirements for inspection and/or replacement of all vehicle components
(3) Create informational checklists that will identify areas on the vehicle that should be addressed when considering refurbishing
(4) Create a guideline for any personnel engaged in preparing specifications for fire department or municipal agency emergency vehicle refurbishing

**A.29.1.5** Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter, a unit that is outside of, but recognized by, SI is commonly used in international fire protection. Table A.29.1.5(a) and Table A.29.1.5(b) provide conversion factors as an aid to the user. Table A.29.1.5(c) provides other conversion factors that could be useful to the reader. Table A.29.1.5(d) provides a list of the abbreviations used in this standard and their meaning.

**Table A.29.1.5(a) Conversion Factors: US Units to SI Units**

| US | SI |
|---|---|
| 1 gallon per minute (gpm) | 3.785 liters per minute (L/min) |
| 1 imperial gallon per minute (igpm) | 4.546 liters per minute (L/min) |
| 1 pound per square inch (psi) | 6.895 kilopascals (kPa) |
| 1 inch of mercury (in. Hg) at 60°F (15.6°C) | 3.376 kilopascals (kPa) |
| 1 inch (in.) | 25.40 millimeters (mm) |
| 1 foot (ft) | 0.3048 meter (m) |
| 1 cubic foot ($ft^3$) | 0.02832 cubic meter ($m^3$) |
| 1 mile per hour (mph) | 1.609 kilometer per hour (km/hr) |
| 1 pound (lb) | 0.4536 kilogram (kg) |
| 1 footcandle (fc) | 10.76 lux (lx) |

**A.29.2** It is recommended that upgraded components or systems meeting current NFPA standards be installed whenever possible for enhanced safety and serviceability. Replacement parts, components, or systems should meet the requirements of the applicable chapters of NFPA 1900 to make the fire apparatus as safe as possible and to allow for easier availability of parts for maintenance and repair.

Where local operating conditions necessitate apparatus of unusual design, the purchaser should carefully define the special requirements in the specifications. Height, width, under-vehicle clearance, wheelbase, turning radius, length, and other specifications can occasionally need special attention. For example, a community having low overpasses needs to have a refurbished apparatus capable of traveling underneath these overpasses. The specifications for the refurbished apparatus should state the maximum travel height allowed.

**Table A.29.1.5(b) Conversion Factors: SI Units to US Units**

| SI | US |
|---|---|
| 1 liter per minute (L/min) | 0.2642 gallon per minute (gpm) |
| 1 liter per minute (L/min) | 0.2200 imperial gallon per minute (igpm) |
| 1 kilopascal (kPa) | 0.1450 pound per square inch (psi) |
| 1 kilopascal (kPa) | 0.2962 inch of mercury (in. Hg) at 60°F (15.6°C) |
| 1 millimeter (mm) | 0.03937 inch (in.) |
| 1 meter (m) | 3.281 feet (ft) |
| 1 cubic meter ($m^3$) | 35.31 cubic feet ($ft^3$) |
| 1 kilometer per hour (km/hr) | 0.6214 mile per hour (mph) |
| 1 kilogram (kg) | 2.205 pounds (lb) |
| 1 lux (lx) | 0.09290 footcandle (fc) |

**Table A.29.1.5(c) Useful Conversion Factors**

| | | |
|---|---|---|
| 1 gallon per minute (gpm) | = | 0.833 imperial gallon per minute (igpm) |
| 1 imperial gallon per minute (igpm) | = | 1.2 gallons per minute (gpm) |
| 1 foot (ft) of water | = | 0.433 pound per square inch (psi) |
| 1 pound per square inch (psi) | = | 2.31 feet (ft) of water |
| 1 pound per square inch (psi) | = | 2.036 inches of mercury (in. Hg) |
| 1 inch of mercury (in. Hg) | = | 1.135 feet (ft) of water |
| 1 inch of mercury (in. Hg) | = | 0.491 pound per square inch (psi) |
| 1 gallon of water | = | 8.34 pounds (lb) |
| 1 gallon of water | = | 231 cubic inches ($in.^3$) |
| 1 metric ton (mton) | = | 1000 kilograms (kg) |
| 1 kilopascal (kPa) | = | 0.01 bar |
| 1 bar | = | 100 kilopascals (kPa) |

**Table A.29.1.5(d) Abbreviations Used in Standard**

| Abbreviation | Term | Abbreviation | Term |
|---|---|---|---|
| A | ampere | km/hr | kilometers per hour |
| ac | alternating current | kPa | kilopascal |
| C | Centigrade | L | liter |
| dc | direct current | L/min | liters per minute |
| F | Fahrenheit | lx | lux |
| fc | footcandle | m | meter |
| ft | feet | mm | millimeter |
| gpm | gallons per minute | mph | miles per hour |
| in. | inch | psi | pounds per square inch |
| in. Hg | inches of mercury | V | volt |
| kg | kilograms | | |

**A.29.3** The refurbishing of a fire apparatus generally involves a major investment and should be treated as such. Fire apparatus are complex mechanical equipment that should not be refurbished in a haphazard manner. A decision to refurbish should be made only after a detailed study of the fire department's apparatus needs, taking into consideration other equipment the department owns or plans to buy.

**A.29.4.1** Depending on the scope of the refurbishing, the detailed description could include estimated in-service weight, wheelbase, principal dimensions, angle of approach, angle of departure, ramp breakover angle, transmission ratios, axle ratios, and, if applicable, the rated capacity of the aerial device. The purpose of these contractor specifications is to define what the contractor intends to furnish and deliver to the purchaser.

**A.29.4.2** Depending on the scope of the refurbishing, a qualified and responsible representative of the contractor should instruct personnel, specified by the purchaser, in the operation, care, and maintenance of the refurbished fire apparatus and equipment delivered. If the refurbishing does not change any of the operating procedures of the apparatus, instruction on the operation, care, and maintenance of the refurbished fire apparatus and equipment might not be required.

**A.29.8.1** The engine compartment and the underside of the vehicle are not considered areas of normal nonmaintenance operation.

**A.29.8.4** Uniformity of safety signage is a desirable objective. Examples of common safety sign solutions are depicted in FAMA TC010, *Standard Product Safety Sign Catalog for Automotive Fire Apparatus*, and should be considered where deemed applicable by the manufacturer. [**1900:**A.7.10.4]

**A.29.9** The carrying capacity of a fire apparatus is one of the least understood features of design, and one of the most important. All apparatus have a GVWR or maximum total weight, which should not be exceeded by the apparatus refurbisher or by the user after the vehicle has been placed in service. For tractor-drawn vehicles, the GCWR weight should not be exceeded. There are many factors that make up the GVWR, including the design of the springs and suspension system, the rated axle capacity, the rated tire loading, and the distribution of the weight between the front and rear wheels.

One of the most critical factors is the size of the water tank. Water weighs approximately 8⅓ lb/gal (1 kg/L). A value of 10 lb/gal (1.2 kg/L) can be used when estimating the weight of the tank and its water, making a 500 gal (2000 L) tank and its water about 2.5 tons (2400 kg).

If the completed apparatus is not to be overloaded, the purchaser should provide the contractor with the weight of equipment to be carried.

Overloading the apparatus by the refurbisher through design, or by the user through specifying a larger water tank on a small chassis, or by the user adding a great deal of equipment after the apparatus has been returned to service will materially reduce the life of the vehicle and will undoubtedly result in increased maintenance costs, particularly with respect to transmissions, clutches, and brakes. Overloading can also seriously affect handling characteristics, making steering and braking particularly difficult.

The distribution of the weight between the front and rear wheels is also a factor for major consideration, as improper design will seriously affect the handling characteristics. Too little weight on the front wheels can cause a front-end skid and, over bumpy roads, can cause the front of the vehicle to veer from side to side; at the very least it will be difficult to keep the vehicle under control. Too much weight on the front wheels will reduce the traction of the rear wheels and can result in a rear-end skid or difficulty in traveling over unpaved roads or in mud and snow. Further, overloading of either the front or rear wheels might require that the tires be of different sizes.

Fire apparatus should be able to perform their intended service under adverse conditions that could require operation off paved streets or roads. Chassis components should be selected with the rigors of service in mind.

**A.29.9.2(4)** A weight of 250 lb (114 kg) for a fully equipped firefighter is used in other NFPA standards. The 200 lb (90 kg) per person weight used in 29.9.2(4) does not include the weight of SCBA and tools carried by a firefighter, as the weight of this equipment is accounted for in 29.9.2(8).

**A.29.9.4.3** If equipment (e.g., radio, data communications) is going to be installed after delivery, consulting the future installer as to what accommodations the apparatus manufacturer needs to provide to make their work easier might be helpful.

**A.29.9.4.5(4)** If a vehicle data recorder (VDR) is provided, it should provide at least the following minimum capabilities:

(1) The VDR should be capable of recording the data shown in Table A.29.9.4.5(4)(a) at least once per second.
(2) Data should be stored at the sampling rate in a 48-hour loop.
(3) Memory should be sufficient to record 100 engine hours' worth of minute-by-minute summary showing the data in Table A.29.9.4.5(4)(b).
(4) When the memory capacity is reached, the system should erase the oldest data first.
(5) All data stored in the VDR should be able to be uploaded by the user to a computer or fire department management/engineering system via cable, Wi-Fi, data channel, cellular data, or other technology.
(6) As a minimum, the user should have the capability to view the data as follows:
    (a) Raw second-by-second data over a specified data/time range
    (b) Daily log for the time the engine is running for a given date (i.e., minute-by-minute output of all values)
    (c) Weekly summary (i.e., maximum values each hour for each day of the week)
    (d) Monthly summary (i.e., maximum values each day for each day of the month)

**Table A.29.9.4.5(4)(a) VDR Data**

| Data | Unit of Measure |
|---|---|
| Vehicle speed | mph |
| Acceleration (from speedometer) | mph/sec |
| Deceleration (from speedometer) | mph/sec |
| Engine speed | rpm |
| Engine throttle position | % of full throttle |
| Antilock braking system event | On/Off |
| Seat occupied status | Occupied: Yes/No by position |
| Seat belt status | Buckled: Yes/No by position |
| Master optical warning device switch | On/Off |
| Time | 24-hour clock |
| Date | Year/Month/Day |

**Table A.29.9.4.5(4)(b) VDR Summary Data**

| Data | Unit of Measure |
|---|---|
| Maximum vehicle speed | mph |
| Maximum acceleration (from speedometer) | mph/sec |
| Maximum deceleration (from speedometer) | mph/sec |
| Maximum engine speed | rpm |
| Maximum engine throttle position | % of full throttle |
| Antilock braking system event | On/Off |
| Seat occupied with seat belt unbuckled | Yes/No by position at 30 seconds |
| Master optical warning device switch | On/Off at 30 seconds |
| Time | 24-hour clock |
| Date | Year/Month/Day |

**A.29.9.4.5(5)** Vehicle to everything (V2X) communications transmit information from a vehicle to other systems. This can include dedicated short-range communications, cellular communications, WLAN, WiFi (in station), and, in the case of emergency vehicles, existing radio network data channels. Vehicles might communicate with other vehicles (V2V), infrastructure such as traffic signals (V2I), pedestrians (V2P), networks (V2N), portable devices such as smartphones (V2D), power grids (V2G), and other systems such as maintenance/engineering departments and other technologies. This is a rapidly growing and developing area of technology with almost unlimited possibilities to improve safety and efficiency. Purchasers need to research available equipment and capabilities, and then direct the contractor to provide the capabilities desired. Standards related to these communications include NFPA 950.

**A.30.1** The National Highway Traffic Safety Administration (NHTSA) in the United States has a regulation, 49 CFR 571.7e, for determining when the modifications to a used vehicle are so extensive that the resulting vehicle will be considered new for the purposes of the Federal Motor Vehicle Safety Standards (FMVSS). Section 571.7(e) states: "Combining new and used

components. When a new cab is used in the assembly of a truck, the truck will be considered newly manufactured … unless the engine, transmission, and drive axle(s) (as a minimum) of the assembled vehicle are not new, and at least two of these components were taken from the same vehicle."

**A.30.2** Vehicles are designed with a specific GAWR and GCWR, or GVWR, based on the safe carrying capacity of components and/or the entire vehicle. Increasing the weight over these limits can result in loss of stability, lack of adequate braking, or other handling problems, all of which have the potential for injury or death to firefighters and civilians. Requesting a contractor to exceed these limits or to compound an overweight problem creates a potential liability issue for both the purchaser and the contractor. Vehicles at or above their GAWR and GCWR or GVWR should not be considered for refurbishing unless upgraded components are installed to increase the weight ratings, or the refurbishing will result in a net decrease in vehicle weight.

**A.30.3.4** The projections of total equipment payload and mounting locations are essential for proper engineering of a refurbished fire apparatus. The purchaser of the fire apparatus should maintain the side-to-side loading requirement in 30.3.4 as equipment is loaded or installed on the apparatus.

The percentage difference in tire load should be calculated as shown in the following formula:

**[A.30.3.4]**

$$\frac{\left(\begin{matrix}\text{heavier}\\ \text{weight}\end{matrix}\right)-\left(\begin{matrix}\text{lighter}\\ \text{weight}\end{matrix}\right)}{\text{total weight}}\times 100 = \text{percent difference}$$

**A.30.3.5** NFPA 1900 requires electronic stability control for those apparatus that fail to pass the established roll stability criteria. The following items impact the roll stability safety of the apparatus and should be considered when making decisions on how to refurbish the apparatus.

*Custom fire apparatus cab.* The nature of the custom fire apparatus cab makes it much stronger in rollovers than typical conventional commercial chassis cabs. There is much anecdotal evidence to indicate that the crashworthiness of a typical custom fire apparatus cab is significantly greater than a typical commercial cab, and most custom chassis manufacturers can provide test data on cab integrity.

*Lateral acceleration alert device.* There are both mechanical and electronic devices available that will measure the lateral acceleration of a vehicle. Although these devices will not prevent rollover, they can be used effectively as a driver training tool to indicate when the vehicle is approaching the roll threshold and as a reminder to the driver that excessive lateral acceleration can lead to a rollover event.

*Side roll protection.* Many custom fire apparatus manufacturers offer side air bags or curtains that inflate during a roll event and are usually combined with seat belt pretensioning devices and suspension seat pull-down devices. This option can reduce injury during a rollover as long as the occupants are seated and belted.

*Roll stability control.* This technology electronically senses the lateral acceleration of the vehicle and takes action by depowering the engine and applying the brakes if the vehicle approaches a roll threshold. The effectiveness of this product is limited to events on relatively flat pavement, since it cannot do much to help once a vehicle is off the road and leaning into a ditch.

*Electronic stability control (ESC).* ESC uses a steering wheel position sensor, a vehicle yaw sensor, a lateral accelerometer, and individual wheel brake controls in conjunction with the antilock brake system (ABS). The system tracks the direction that the driver intends to steer and uses brake application at individual wheels to help straighten out the vehicle.

*Driver skill and experience.* While the design and features of the vehicle are important to safe driving, the most important aspect of crash prevention is the skill and experience of the operator. The operator's attitude, training, experience, and qualifications, and the application of those qualities, are the most important elements in crash prevention. The operator must ensure that the physical limits of the vehicle are not exceeded. Driver skill is developed only through training and practice.

**A.30.6.2** It should be noted that older engines might not meet current EPA standards and might not be able to be economically upgraded to current standards.

**A.30.11.1.3.1** A purchaser might elect to configure the fire apparatus to tow a trailer. However, even if the combination vehicle is within the GCWR, it might be impossible for the combination vehicle to be operated safely or to hold on a grade when parked, if the trailer is not equipped with its own braking system. The purchaser should ensure that any added trailers have sufficient braking capacity for safe operation.

**A.30.11.2.2** Due to the hazards associated with split rims and the injuries resulting from them, they should be considered for replacement with solid rims whenever possible.

Consideration should be given to replacement of tires per the tire manufacturer's recommendations. Tires are subject to other factors besides wear, including, but not limited to, dry rot, sidewall damage, and cuts. Tires with any of these conditions should be replaced.

**A.30.13** A driving/crew compartment replacement with increased seating capacity can have an impact on the vehicle weight, which should be taken into consideration. A fully enclosed driving/crew compartment to seat more than the original number of personnel can require upgrades to suspension, axles, tires, and other components. Driving/crew compartment extensions with full enclosures are also acceptable means to accomplish this safety design feature. The use of three-point seat belts is encouraged. All forward-facing seats adjacent to a side wall should be provided with a Type 2 pelvic and upper torso restraint–style seat belt assembly conforming to the Federal Motor Vehicle Safety Standard (FMVSS) No. 209, "Seat belt assemblies."

The purchaser should consider specifying remote controls on the mirrors to facilitate correct mirror adjustment. When necessary, heated mirrors should also be considered.

**A.30.14.4** All exposed ferrous metal surfaces that are not chrome-plated or stainless steel should be cleaned and prepared and should be painted to the color(s) specified by the purchaser. If nonferrous body components are furnished, the purchaser should specify which surfaces are to be painted. The paint, including the primer, should be applied in accordance with the paint manufacturer's recommendations.

**A.30.16.2** When dealing with a new water tank installation, the specified changes must take into consideration the overall weight of the tank cradle, additional plumbing required, and water or agent weight, as well as the tank itself. Apparatus stability and braking ability can be adversely affected by exceeding the maximum allowable configurations. Contractors as well as purchasers can be held accountable and liable if maximum limits are exceeded. Therefore, exceeding the maximum should not be considered and if additional tank size is still preferred or required, weight reductions in other areas such as hose load, miscellaneous equipment, or newer lightweight components should be utilized to maintain, yet not exceed, the maximum allowable limits.

**A.30.19.10.4** NFPA 1901 did not have any requirements for foam prior to the 1991 edition. It is recommended that the foam system manufacturer's test requirements be utilized for apparatus that were purchased prior to the effective date of NFPA 1901, 1991 edition, and retain their original foam systems.

**A.30.19.11** Any time the engine or drivetrain is altered or replaced with different components, the purchaser should require road testing to ensure the refurbished apparatus meets minimum acceptable standards.

**A.31.1** The National Highway Traffic Safety Administration (NHTSA) in the United States has a regulation, 49 CFR 571.7e, for determining when the modifications to a used vehicle are so extensive that the resulting vehicle will be considered new for the purposes of the Federal Motor Vehicle Safety Standards (FMVSS). Section 571.7(e)7 states: "Combining new and used components. When a new cab is used in the assembly of a truck, the truck will be considered newly manufactured … unless the engine, transmission, and drive axle(s) (as a minimum) of the assembled vehicle are not new, and at least two of these components were taken from the same vehicle."

**A.31.2** Vehicles are designed with specific GAWR and GCWR, or GVWR ratings based on the safe carrying capacity of components and/or the entire vehicle. Increasing the weight over these limits can result in loss of stability, lack of adequate braking, or other handling problems, all of which have the potential for injury or death to firefighters and civilians. Requesting a contractor to exceed these limits or to compound an overweight problem creates a potential liability issue for both the purchaser and the contractor. Vehicles at or above their GAWR and GCWR, or GVWR ratings should not be considered for refurbishing unless upgraded components are installed to increase the weight ratings, or the refurbishing will result in a net decrease in vehicle weight.

**A.31.3** Vehicle stability is one of the most critical factors in apparatus safety. When a chassis manufacturer's requirement on center of gravity and weight distribution are known, they should be complied with to ensure a stable apparatus.

**A.31.3.1** All other factors being equal, an apparatus with a lower height will be more stable and less prone to overturning.

**A.31.3.2** Front axle loads should not be less than the minimum axle loads specified by the chassis manufacturer, under full load and all other loading conditions. Apparatus with extreme weight bias at front or rear can be difficult to control on curves or on road surfaces with poor adhesion.

**A.31.3.4** The projections of total equipment payload and mounting locations are essential for proper engineering of a refurbished fire apparatus. The purchaser of the fire apparatus should maintain the side-to-side loading requirement in 31.3.4 as equipment is loaded or installed on the apparatus.

The percentage difference in tire load should be calculated as shown in the following formula:

**[A.31.3.4]**

$$\frac{\left(\begin{matrix}\text{heavier}\\ \text{weight}\end{matrix}\right)-\left(\begin{matrix}\text{lighter}\\ \text{weight}\end{matrix}\right)}{\text{total weight}}\times 100 = \text{percent difference}$$

**A.31.6.1** The purchaser should consider the following tests when the engine or engine system is to be refurbished:

(1) Compression test
(2) Blowby test
(3) Fuel pressure test
(4) Oil analysis

**A.31.6.2** It should be noted that older engines might not meet current EPA standards and may not be able to be economically upgraded to current standards.

**A.31.11.1.1** Problems with the vehicle braking system have the potential for causing serious accidents, resulting in injury or death to both firefighters and civilians. In addition, there is a corresponding liability issue in the operation of a vehicle with an inadequate braking system. It is recommended that all required braking system repairs be made before the apparatus is returned to service.

**A.31.11.1.2** Consideration should be given to installing an antilock braking system (ABS) when the braking system is to be upgraded.

**A.31.11.2.1** Due to the hazards associated with split rims and the injuries resulting from them, they should be considered for replacement with solid rims whenever possible.

**A.31.11.2.5** See A.30.11.1.3.1.

**A.31.11.6** If the purchaser wants the tow hooks or tow eyes to be accessible without having to open compartment doors, the specifications should state that fact.

**A.31.12.1** This section defines the requirements for upgraded alternators, batteries, load management, and instrumentation to detect incipient electrical system failure. The intent is to require that an upgraded electrical system will operate the apparatus using power supplied by the alternator, shed nonessential electrical loads where necessary, and provide early warning of electrical failure in time to permit corrective action.

**A.31.12.2** All components to be upgraded should be replaced with components meeting the applicable chapters of NFPA 1900. The current standard provides additional lighting for safety and provides for two modes of operation: responding and blocking the right-of-way. Consideration should also be given to having the contractor furnish a wiring schematic of the rewired areas of the apparatus to enable vehicle repair technicians to more easily troubleshoot the electrical system or make additions to the system.

**A.31.12.3.3(7)** The purchaser needs to analyze the electrical loads that have to be maintained to fulfill the mission of the refurbished apparatus and to define those loads for the refurbisher of the apparatus. The purchaser needs to understand,

however, that there is a limit to the output capacity of an alternator system on the apparatus' engine, and that this standard requires that the apparatus be capable of maintaining the minimum continuous electrical load under the conditions defined in 31.12.3.2. When that load is exceeded and larger alternators are not available, the purchaser and the refurbisher need to work together to determine how to reduce the minimum continuous electrical load so that it can be sustained under the conditions defined in 31.12.3.2.

**A.31.12.3.4.1** Reduced crew sizes have forced the apparatus operator to assume new fireground tasks besides that of operating the apparatus. Even if the operator is at the apparatus, he is too busy with higher priority tasks to pay much attention to monitoring the condition of the electrical system.

Electrical loads on modern fire apparatus frequently exceed the alternator capacity and can be supplied only by the deep discharge of the apparatus batteries. The high-cycle batteries designed to provide the large amount of amperage to crank modern diesel engines are severely damaged when deeply discharged. The automatic load management is intended to protect the electrical system from needless damage while maintaining the operation of essential devices.

It is important that the priority of all managed loads be specified by the purchaser so that electrical loads, as they are disconnected from the apparatus' electrical system, are shed in an order least likely to affect emergency operations. Optical warning devices in excess of the minimum required in the applicable chapter of NFPA 1900 can and should be load managed.

**A.31.12.4** Consideration should be given to upgrading the optical warning devices to the applicable chapter of NFPA 1900, both to improve safety during emergency responses and to minimize current draw when operating at the scene. The upgraded lighting should provide an increased measure of safety and minimize loads to the low-voltage electrical system.

**A.31.13** The purchaser should consider specifying remote controls on the mirrors to facilitate correct mirror adjustment. When necessary, heated mirrors should also be considered.

**A.31.13.2** Cab replacements with increased seating capacity can have an impact on the vehicle weight, and this should be taken into consideration. A fully enclosed cab for more than the original number of personnel can require upgrades to suspension, axles, tires, and other components. Canopy cab extensions with patio door–type closures or separate telephone booth–type personnel enclosures are also acceptable means to accomplish this safety design feature. The use of three-point seat belts, where available, is encouraged.

**A.31.14.2** It is recommended that any upgrades to the existing body, compartmentation, or hose storage area be made according to current NFPA standards.

**A.31.16.2** When dealing with a new tank installation, the specified changes must take into consideration the overall weight of the tank cradle, additional plumbing required, and water or agent weight, as well as the tank itself. Apparatus stability and braking ability can be adversely affected by tank modifications. Contractors as well as purchasers can be held accountable and liable if maximum limits are exceeded. Therefore, exceeding the maximum should not be considered, and if additional tank size is still preferred or required, weight reductions in other areas such as hose load, miscellaneous equipment, or newer lightweight components should be utilized to maintain, yet not exceed, the maximum allowable limits. *(See Sections 31.2 and 31.3.)*

**A.31.19.10.2.1** A substantial change would include replacing the alternator, adding or replacing the load management system, upgrading the electrical control systems, or increasing the total connected load by 20 percent or more over the original as-delivered load.

**A.31.19.10.3.1** A substantial change would include replacing the power source, replacing the line-voltage control system, or increasing total line-voltage load by 20 percent or more over the original as-delivered load.

**A.31.19.10.4** There were no foam system requirements for apparatus built prior to the adoption of the 1991 edition of NFPA 1901.

**A.31.19.11.1** Any time the engine or drivetrain is altered or replaced with different components, the purchaser should require road testing to ensure the refurbished apparatus meets minimum acceptable standards.

**A.32.3.2** The purchaser is responsible for providing sufficient information to enable the contractor to prepare a bid and a complete description of the apparatus the contractor proposes to supply. The Apparatus Purchasing Specification Form in Annex E of NFPA 1900 might raise other issues to consider when specifying a firefighting vessel.

**A.32.3.2.2(3)(h)** Consideration should be given for minimum pumping capacity where minimum flow would require diverting water and for how low flow is accommodated where diverting water is not wanted.

**A.33.1** The Insurance Services Office (ISO) maintains a fire suppression rating schedule that is designed to measure a community's structural fire defenses. Marine firefighting vessels are not typically considered under ISO's fire suppression rating schedule and have no impact on a community's public fire protection classification. Communities who wish to receive ISO credit for a marine firefighting vessel must equip the vessel similarly to an engine company and apply specifically to ISO for marine firefighting vessel consideration.

**A.34.2.1** Fittings and valves that are designed for low friction losses should be selected. Elbows should be of the long radius pattern.

**A.34.2.11.1** Consideration should be given to providing both a high and low sea chest to permit continuous operation in rough water and shallow water. Consideration should be given to providing a means, such as a vent cock, for eliminating air from fire pump casings.

**A.34.2.11.3** The committee notes that a larger cross-sectional area for the sea chest inlet should be used if the boat will be working in areas of debris or shallow water.

**A.34.2.12.4** The location of the relief valve discharge outlet above the load waterline should permit removal of the valve for maintenance without having the vessel in dry dock. Consideration should be given to the hazard to personnel or property in the vicinity of the vessel when the relief valve operates.

**A.34.3.7** It is recommended that multiple pumps of equal or very similar capacity be provided to achieve maximize redundancy in operation.

**A.34.3.8.1** See Section 5.1 for numbers of discharge outlets required for each vessel classification.

**A.34.3.8.2.1** See also stability requirements for all marine firefighting vessels in Chapter 39.

**A.35.1.2** It is recommended that the purchaser discuss the "foam-specific" requirements, from the mission and capability study, with the foam system manufacturer(s) prior to development of the final purchase specification.

**A.35.2.3** The foam manufacturer should be consulted regarding the need for mixing and/or circulation. Appropriate provisions should be included in the foam system.

**A.35.6.4.1** Examples of mechanical means are a threaded cap or a gasketed hinged cover with a mechanical latching device.

**A.35.6.8** A removable top is recommended; however, alternative systems are acceptable for special tanks such as oval tanks and tanks less than 200 gal (800 L).

**A.35.7.1** The foam concentrate pump is a critical component of both balanced pressure and direct injection foam-proportioning systems. Positive displacement pumps are recommended for several reasons. Positive displacement pumps are relatively slow speed when compared to centrifugal pumps, which are desirable with viscous foam concentrates that are difficult to shear. Centrifugal pumps can become air bound when trying to pump viscous foam concentrates, resulting in a complete shutdown of the system. The self-priming feature of positive displacement pumps allows them to draw foam concentrate from drums or any external source without priming the pump.

**A.35.7.6** Where the foam concentrate pump is used with a pressure balance system, a minimum of one 2½ in. (65 mm) external gated intake connection for foam concentrate should be provided. A 2 in. (50 mm) pickup device with a 2½ in. (65 mm) adapter should be provided to supply the system from drums or pails through the external intake connection. At least one 1½ in. (38 mm) external gated foam concentrate pump discharge connection should also be provided.

**A.36.2** The US Coast Guard requires that all inspected vessels be operated by a US Coast Guard licensed captain. Although most marine firefighting vessels are not inspected vessels, it is the recommendation of the NFPA Marine Firefighting Vessels Committee that operators of Type I through Type IV marine fire-fighting vessels possess an active US Coast Guard license. Type V vessel operators should have attended a recognized safe boating course.

**A.37.5.1** A manually activated fixed inert gas or equivalent extinguishing system should be installed in all enclosed engine compartments or spaces in Type IV and Type V marine firefighting vessels.

**A.37.6.1** The principal difference in extinguishers approved for marine use is in the mounting bracket, which is designed to firmly clamp the extinguisher in place.

**A.38.2.1** It is recommended that where 30-minute-rated service life cylinders are provided with the SCBA, 60-minute-rated service life cylinders also be provided for use during extended firefighting operations. Typically, 30-minute cylinders do not allow firefighters enough air to reach the seat of the fire, extinguish, and return to a safe environment. Long-duration, closed-circuit SCBA should also be considered. Type I and Type II vessels should have onboard provision for the refilling of all assigned SCBA at a rate where 50 percent of the SCBA are available for use. Type I vessels should be capable of refilling six cylinders every 15 minutes for at least 2 hours.

**A.38.6** Marine firefighting vessels frequently respond to and are designated for emergency response to a variety of incidents. The intended use and mission of the vessel as well as the size and storage capacity within the vessel should be evaluated by the AHJ when determining the specific medical and first aid equipment that the vessel will be required to carry.

**A.40.3.3** For vessels with displacement hulls where propulsion engines are used to drive fire pumps, provisions for station keeping while pumping at total vessel capacity should be considered.

NOTE: The lack of availability of smaller reduction gears with controllable slippage output, suitable for operating at predictable (1500–1800) input rpm for pumping, and the lack of availability of smaller, controllable pitch propellers to control propeller speed, presently limit the capability for station keeping for most planing hull designs. Also, using fire main thrusters equal to the flow of monitors to compensate for nozzle reaction is contrary to the efficient and safe use of fire pumps.

**A.40.3.4.1** It is not the intent to have engines shut down automatically under any circumstances. Operators should have complete control over vessel operations.

**A.41.1.1** Auxiliary machinery and systems should be designed or specified with space availability, weight, and environmental compatibility in mind. The purchaser should indicate the type and performance required.

**A.41.1.2** See A.41.1.1.

**A.41.8.3** Means for de-icing deck and hand rails should be considered where operations in freezing conditions are anticipated.

**A.41.8.4** Pantograph wipers are superior to pendulum type for this application.

**A.41.8.5** Filtering is essential to prevent clogging of small-diameter spray nozzles.

**A.42.4.4** Light position and placement should consider effects of glare on the operator and operator's night vision.

**A.43.2** Type V marine firefighting vessels should have approved marine sanitation device(s) and sink(s) commensurate with the number of the crew.

**A.43.6.2** The owner/operator should consider local operating conditions when specifying the type of anchor and length of rode.

**A.43.6.3** The owner/operator should consider local operating conditions when specifying the type of anchor and length of rode.

**A.43.6.5** Where it is necessary to anchor in deeper water, additional lengths of anchor rode should be provided to accommodate those depths.

**A.43.9** Although designed with the capability for emergency towing, marine firefighting vessels are not to be considered as towing vessels.

**A.43.10.2** On longer vessels, consideration should be given to providing access from both sides.

**A.43.11** All marine firefighting vessels must carry one Type I, II, III, or V personal flotation device (PFD) for each person on board, plus at least one Type IV (throwable) device. The limitations on the acceptability of Type Vs are described in the following list. Personal flotation device descriptions are as follows:

(1) Type I is an offshore PFD that will turn an unconscious person's face upward and will keep the face and mouth out of the water.
(2) Type II is a bib-style jacket, usually attached with a strap across the back. It is less likely to keep the face out of the water, especially in rough water.
(3) Type III includes many float coats, fishing vests, and water-skiing jackets. They are good for calm, inland water, where help will come quickly. They will not turn a person's face upward, but they have the same buoyancy as a Type II. Type IIIs are meant to be worn at all times when underway.
(4) Type IV is a "throwable" device: a life ring, horseshoe buoy, or flotation cushion. As of May 1, 1995, Type IVs no longer fulfill the one-per-person requirement. However, at least one Type IV is required, immediately available for a person overboard.
(5) Type V PFDs are intended for specific activities. Many deck suits, sailboard vests, and exposure suits are of this type. They can be carried instead of another PFD only if used according to the approval conditions on the label.

Type V inflatable jackets or vests count toward the minimum requirement if they are worn at all times. Inflatables require more maintenance than any other type and are more expensive. When worn, however, they offer better comfort and buoyancy than any other kind. Even if Type Vs are selected, it is prudent to have a Type I or II PFD onboard as well.

The crew should be trained on the use and donning of PFDs and their limitations. The power supplies for the strobe lights attached to the PFD should be checked regularly, and the batteries replaced in accordance with the manufacturer's instructions.

**A.43.11.1** Immersion suits should be considered as standard equipment on all vessels to aid in water rescue operations.

**A.43.11.2** A written plan should be prepared for person overboard operations, and regular training should be conducted in the equipment and procedures.

**A.43.12.2** All assigned crew members should be trained in the safe firing of all pyrotechnic devices used on the vessel. All devices should be checked at regular intervals to ensure they are protected and in operational condition.

**A.43.13.1** The BLS equipment needs to be determined by the AHJ.

**A.44.1.1** Where emergency medical procedures are to be carried out onboard the vessel, a medical multichannel radio should be provided. Also, if citizens band (CB) radios are commonly used in the area, a CB radio should be provided. Where the fire department has wired communication systems, such systems should be available at the vessel berth and to the vessel.

**A.44.1.2** One radio should be permanently set on marine channel 16 (156.800 MHz FM), the international distress and calling frequency.

One radio (power limited to one watt) should be set on the marine bridge-to-bridge channel. This channel should be on a dedicated hand-portable radio that is used for no other purpose.

A multichannel marine radio capable of operating on at least the 10 most locally used marine channels should include the US Coast Guard channel 22 (157.100 MHz FM) and the intership channel 6 (156.300 MHz FM).

**A.45.1.1** Navigational publications should include the following:

(1) Charts of the area waters
(2) Sailing directions
(3) Coast pilots
(4) Light lists
(5) Notices to mariners
(6) Tide tables
(7) Current tables
(8) Other necessary nautical publications

In addition to a compass, a global positioning system (GPS) is recommended. A GPS is a satellite-supported navigation system. Installation of a GPS for assistance in the navigation of the vessel is not required. However, the accuracy of this system is well-established, and it is common to interface the GPS with onboard systems such as autopilots, plotters, and so forth.

**A.45.2.2** The term *radar* (radio detecting and ranging) refers to a method of detecting distant objects and determining their distance, velocity, or other information by analysis of very high frequency radio waves.

**A.46.2** Anodes should be arranged to minimize hull drag and positioned to avoid contact with lifting slings or dry-dock blocks. Consideration should be given to anode materials, depending on various environments.

**A.46.4.1** The surface should be inspected and approved by the coating manufacturer's representative prior to application of the coating. Where multiple coats are applied, the coating manufacturer's representative should inspect and approve the surface prior to each application.

**A.47.3.14.1** Equipment locations should be inspected for efficient operations and positioning.

**A.47.3.22.9** The test itself ensures function and stability of the rudder and props.

**A.47.3.31.1** Representatives of the pump manufacturer and pump driver manufacturer should be present for the acceptance test. An independent third-party certification organization can conduct or witness the pump tests and certify the pump test results.

The acceptance test should indicate that the pump as installed performs as specified. Annual retests should determine whether the pump performance has deteriorated due to wear or to an obstruction within the pump.

Flow tests are made by measuring discharge from one or more monitors flowing through smooth bore nozzle tip(s). The flows are determined using a pitot tube and gauge and taking

the flow [gpm (L/min)] from a chart for the noted pressure and tip diameter.

Pump speed (rpm) and suction and discharge pressures should be recorded for each flow.

To avoid creating excess pressure in the discharge and distribution piping, the pump being tested should be run at a speed that produces rated pump discharge pressure for each flow point tested.

During the test, each monitor should be flowed at least once. This indicates conditions on the piping supplying that monitor.

Following the test, flows and net pressures should be plotted on a copy of the performance curve. The test results should have pressure and flow corrected to rated speed using the pump affinity laws.

**A.48.1.1** Local maintenance and repair facilities should be researched prior to final vessel design.

**A.48.1.2** A maintenance schedule should be developed to determine and record those systems and equipment requiring periodic maintenance and inspection during haul-out.

**A.48.3.1** The facility to be used for the vessel should meet the operational directives for the vessel. Where the vessel is to be used at any time, there should be 24-hour access to the vessel. Items that should be of concern are the tides, bridges that have to be opened, and area construction.

Where the vessel is to be used for EMS responses, the dock area, as well as access to and from the dock, has to be able to accommodate a stretcher and patient movement. No ladders should be used for the handling of EMS patients. Where the dock cannot accommodate patient off-loading, an alternate location for patient transfer should be designated.

**A.48.4.1** Trailers should conform to local and state requirements, as appropriate.

**A.48.5.1** Where the marine firefighting vessel is involved in an incident (accident) producing any damage that could result in unsafe operation or unreliable service, the marine firefighting vessel should be placed out of service until repairs can be accomplished.

**A.48.5.3** In areas of extreme cold, waterflow tests should be run only when the weather conditions allow and using the manufacturer's recommendation for cold weather operations.

**A.49.1.1** There are certain components on emergency response vehicles that are not considered unique. It is not the intent of this document to restrict the authority having jurisdiction from using persons they feel are qualified to perform inspection, diagnosis, maintenance, repair, diagnostic checks, and performance tests of those components. However, an emergency response vehicle is a complex piece of machinery, and there are many components that are highly integrated (e.g., the engine, transmission, and pump with the electronic lockups and interlocks, remote engine controls, multiplexing, and special cooling considerations).

Because of this complexity, this document requires that a person qualified as an emergency vehicle technician possess minimum skills and knowledge to inspect, diagnose, identify correct replacement part or repair procedures, and perform repairs. The root cause of a problem can be beyond the unique component where the symptom is present and in fact can be related to a component that otherwise might not be considered unique.

Certain tasks are generic to all motor vehicles and can be performed by persons considered qualified by the authority having jurisdiction. Examples of such tasks include changing engine and transmission oil and filters, servicing and changing tires, servicing differentials, adjusting brakes, servicing wheel bearings, body work, and painting.

**A.49.1.2** The committee believes that this document specifies the minimum JPRs for Emergency Vehicle Technician I, Emergency Vehicle Technician II, and Emergency Vehicle Technician III. The committee recognizes that emergency services organizations might have to invest considerable resources to provide the equipment and training needed to perform safely and efficiently. The committee does not mean to imply that organizations with limited resources cannot provide response services, only that the individuals charged with responsibilities are qualified to specific levels according to this standard.

**A.49.1.2.3** Organization or management responsibilities should be addressed by the agency that personnel represent. The authority having jurisdiction should define the agency requirements for progression to positions of management responsibility.

**A.49.1.2.6** The technical committee recognizes the importance of formal and continuing education and training programs to ensure EVT I, EVT II, and EVT III maintain and update the necessary skills and knowledge for the level of qualification. Continuing education and training programs can be developed or administered by local, state, provincial, or federal agencies as well as professional associations and accredited institutions of higher education. Methods of learning should include technology, refresher training, skills practices, and knowledge application to standards. The subject matter should directly relate to the requirements of this standard.

Acceptable continuing education includes, but is not limited to, the following:

(1) Pump manufacturer schools and update programs
(2) Aerial device schools and update programs
(3) Electrical system schools and update programs
(4) Brake manufacturer schools and update programs
(5) Engine manufacturer schools and update programs
(6) Transmission manufacturer schools and update programs
(7) Apparatus safety programs
(8) Chassis manufacturer update programs
(9) Chassis manufacturer measuring sessions

Maintaining professional competence is important for any practitioner in a field, and is particularly important in the rapidly changing and developing field of the fire service. The AHJ might consider establishing a path by which members can demonstrate continued JPR compliance and competency through continuing education or practice within the field consistent with current duties. It is recommended that any such program consider the following factors:

(1) Demonstrated and documented knowledge and competence of additions and/or revisions to the latest editions of standards
(2) Documented training and education (including online) related to standards since the last certification

(3) Documented experience in the field (e.g., emergency operational experience for EVTs, firefighters, fire officers, instructors)
(4) Demonstrated and documented successful performance of duties, which might include skills assessment
(5) Annual performance appraisals
(6) Documented teaching and instruction related to the field
(7) Commendations, awards, or recognition for the performance of related duties

Other items for consideration might include the following:

(1) Membership in professional organizations, including any positions held or special activities involved
(2) Published articles in trade journals, web-based publications, and other information distribution avenues
(3) Research and development activities related to the field
(4) Documented attendance at relevant conferences and training events

The above list is not all inclusive and other factors specific to the field should be considered for inclusion.

**A.49.1.2.7** The technical committee has determined that EVTs need to obtain a majority of their continuing education with a hands-on approach such that they are able to demonstrably apply the knowledge learned.

**A.49.1.3.4** It is recommended, where practicable, that evaluators be individuals who were not directly involved as instructors for the requirement being evaluated.

**A.49.1.3.13** The AHJ should incorporate the exposure and contamination control approaches identified in Chapter 14 of NFPA 1500.

**A.49.2.1** There are several requirements in NFPA 1002 that make the driver/operator responsible for performing certain daily/weekly inspections and operational checks on the apparatus. The technician needs to be aware of the driver/operator's responsibilities. This standard includes a chapter that lists the required items that should be visually and operationally checked within 24 hours of a call or at least weekly. A check sheet for the daily/weekly checks is also included in this standard. The EVT Certification Commission, Inc. has developed an exam to test the knowledge of the driver/operator on performing the daily/weekly checks.

The beginning of preventive maintenance starts with the driver/operator, and in many cases the driver/operator and the technician are the same person. In order to perform these inspections and operational checks, it is critical that this person(s) possesses a minimum degree of general knowledge and skills as they apply to the EVT.

**A.49.3** Due to the fact that there are a large number of different chassis components and manufacturers in the fire apparatus market, EVTs will need to become familiar with many of these. The following are many of these components and the different types in service today:

(1) Steering systems and gear boxes [Shepard, Merritor (Rockwell), Eaton]
(2) Hydraulic systems, valves, and pumps (Rexroth, Parker, Enerpac, Sun)
(3) Suspension systems: air and spring [Hendrickson, Merritor (Rockwell), Firestone]
(4) Drive axles and drive lines [Merritor (Rockwell), Eaton, Dayton]
(5) Engines (Caterpillar, Detroit, Cummins, International, Mercedes)
(6) Transmissions (Allison, Caterpillar, Eaton, Zetef)
(7) Braking systems: disc, drum, air, and hydraulic [Bendix, Merritor (Rockwell), Eaton]

**A.49.5.1** Electronic controls that are inspected under this duty include electronic control modules (ECMs), sensors, thermal switches, vehicle interface modules (VIMs), switch interface modules (SIMs), and aerial interface modules (AIMs). Test equipment includes diagnostic readers.

**A.49.5.2** Low-voltage electrical components that an EVT will find on an emergency response vehicle that will require maintenance include, but are not limited to, alternators, voltage regulators, cab instrument cluster gauges, load management systems, multiplex systems, sensors, thermal switches, water level sensors and gauges, DOT lighting, emergency lighting, aerial device controls and sensors, air-conditioning controls, switches, pressure switches, clutch coils, temperature monitoring and control devices, electronic control modules (ECMs), vehicle interface modules (VIMs), switch interface modules (SIMs), antilock brake systems (ABS), and aerial interface modules (AIMs).

**A.49.6.3** Related components include priming devices, transfer valves, pressure-governing systems, thermal sensors, sacrificial anodes, lubrication systems, and so forth.

**A.49.10.1** Foam-proportioning systems can include the following:

(1) In-line eductor foam-proportioning systems
(2) Self-educting master stream nozzles
(3) Intake-side foam-proportioning systems
(4) Around-the-pump proportioning systems
(5) Balanced pressure foam-proportioning systems
(6) Direct injection foam-proportioning systems
(7) Water motor–type foam-proportioning systems

Refer to NFPA 1900 for guidance on foam-proportioning systems.

**A.49.10.5** See *NFPA 70*, NFPA 70B, *NFPA 70E*, and NFPA 1900 for information on electrical safety.

**A.50.7.5** The repair facility should check with local and state authorities for licensing requirements for persons working on line voltage systems. See *NFPA 70* and NFPA 1900 for additional information on electrical systems.

**A.50.7.7** The repair facility should check with local and state authorities for licensing requirements for persons working on line voltage systems.

**A.51.1** The level of sophistication of the emergency response vehicle requires the EVT to be computer literate in order to perform the job and be effective. Many components on emergency response vehicles such as transmissions, engines, multiplex systems, and others now require the use of personal computers (PCs) and/or laptops to diagnose problems and reprogram the system if necessary. In order to use a PC or lap top for these purposes an EVT will need to be trained and proficient in their use.

**A.51.2.3** Figure A.51.2.3 shows a sample evaluation form.

## EMPLOYEE PERFORMANCE APPRAISAL

| Employee's name (last, first): | Title/assignment/shift: | Annual ❑<br>Monthly ❑ |
|---|---|---|

**Rating System:** 3 = Exceeds expectations (explanation required in narrative)
2 = Meets expectations
1 = Does not meet expectations (explanation required in narrative)
(NOTE: Leave blank if the element does not apply)

| **Personal Relations** | |
|---|---|
| Cooperation with co-workers | |
| Response to supervisor requests | |
| Public relations | |

| **Communication Skills** | |
|---|---|
| Ability to assimilate new information | |
| Speaking skills (clear, succinct, etc.) | |
| Writing skills (reports, memos, etc.) | |
| Technology skills (computer, fax, etc.) | |

| **Job Performance** | |
|---|---|
| Ability to prioritize and multi-task | |
| Timeliness/punctuality | |
| Initiative | |
| Safety | |
| Need for supervision | |
| Work ethic | |
| Use of department resources | |
| Hands-on skills | |
| Job knowledge | |
| Awareness and application of priorities | |

| **Performance as a Supervisor** | |
|---|---|
| Planning, organizing, monitoring | |
| Directing and guiding subordinates | |
| Setting personal example | |
| Decision making | |
| Management skills (i.e., delegates appropriately) | |
| Meets key performance objectives (i.e., appraisals, training requirements) | |

**Narrative:** (If necessary, attach additional narrative, memos, commendations, etc. to this form)

| Date: | Employee signature: | Supervisor signature: | 2nd level review (initials): |
|---|---|---|---|

**Employee Comments:**



**FIGURE A.51.2.3 Evaluation Form.**

## Annex B Conducting Pumping Tests (NFPA 1911)

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

**B.1 Test Parameters.** At the start of the test, attention should be paid to the ease with which the pump can develop a vacuum. The following tasks should be performed before starting to prime the pump:

(1) Close all discharge, drain, and water tank valves and petcocks.
(2) Make sure that the gaskets in the suction hose are in place and free of foreign matter.
(3) Open all intake valves.
(4) Tighten all intake caps and couplings.

The priming mechanism should be started, noting the starting time and the time after prime is obtained. The starting time is defined as the instant the priming device begins to operate. The pump is considered primed when water under pressure has entered a discharge hose. For pumps of less than 1500 gpm (6000 L/min), the priming device should be able to create the necessary vacuum in 30 seconds to lift water 10 ft (3 m) through 20 ft (6 m) of suction hose of the appropriate size. The priming device on pumps of 1500 gpm (6000 L/min) or larger should be able to accomplish this in 45 seconds. An additional 15 seconds might be needed where the pump system includes an auxiliary 4 in. (100 mm) or larger intake pipe having a volume of 1 $ft^3$ (28,317 $cm^3$) or more. The controls should be operated as necessary to develop pressure, and then one discharge valve should be opened to allow the flow of water.

Testing a pump involves three interrelated, variable factors — pump speed, net pump pressure, and pump discharge rate — and a change in one factor will always produce a change in at least one of the others. For example, an increase in speed of the pump will increase the discharge rate, the pressure, or both. Adjustments of variables through changing the position of the engine throttle (which modifies pump speed), changing the hose layout or position of the discharge valves (which modifies pump pressure), or changing the nozzle size (which modifies discharge) are the only ways to reach the desired standard test condition.

The pump should be operated at reduced capacity and pressure for several minutes to allow the engine and transmission to warm up. Gradually, the pump speed should be increased until the desired pressure at the pump is reached. If the desired pressure is not attained, a length or two of hose might have to be added, a smaller nozzle used, or a discharge valve throttled. When the desired pressure is obtained at the pump, the pitot should be read to see if the required amount of water is being delivered.

If the discharge is not as great as desired and it is believed that the pump will deliver a greater quantity of water, the discharge can be increased by further speeding up the pump. If speeding up the pump increases the pump pressure more than 5 psi or 10 psi (34 kPa or 68 kPa), a length of hose should be taken out, a discharge valve should be opened slightly, or a larger nozzle should be used.

A speed reading should be taken at the time that the pressure readings are taken. Counting the revolutions for 1 minute generally ensures that readings will be sufficiently accurate.

When a stopwatch is used, the best and most accurate method is to leave the stopwatch running at all times, engaging the revolution counter at a chosen instant and disengaging when the hand of the stopwatch passes the same point on the dial 1 minute later.

After the engine has warmed up, there should be little change in the engine speed. It should be understood that any change in engine speed must, of necessity, produce a corresponding change in pump discharge pressure and, hence, in pitot reading, and that, other factors being equal, any change in pitot reading indicates a change in engine speed. A change in pump speed will also cause a change in discharge pressure so that whenever pump speed, discharge pressure, and pitot readings do not show corresponding changes, it is safe to assume that some reading is in error or some condition has arisen that affects the readings and needs correction. Engine speeds can be changed by working the hand throttle at the operator's position.

Automatic relief valves or pressure regulators controlling the speed of the pump should be disengaged during the test.

It is common but faulty practice to read a pressure gauge at the highest point in the swing of its needle; the center of the needle swing should always be read, as this is the average pressure. A needle valve ("snubber") in the line to the gauge can be throttled to prevent excessive vibration, but if the valve is throttled too much, the gauge pointer will no longer indicate the pressure correctly. It might not be possible to eliminate all of the pointer movement. Leaks in the line to the test gauge also can result in an incorrect gauge reading.

Special care should be taken in reading the pitot pressure; the pitot tube should be held in the center of the stream with the tip about half the nozzle diameter away from the end of the nozzle. If the pitot is brought closer to the nozzle, the reading will be increased erroneously.

Short lines of hose are always more convenient for a test layout than long ones. Generally, it is better to use a single line of 100 ft (30 m) for the pressure tests and to restrict the discharge at the pump discharge valve enough to increase the friction loss so that the desired discharge pressure will be obtained. By closely watching the pitot reading, the valve gradually can be closed as the engine speed is increased, until the discharge pressure and pitot pressure readings are both as desired. Care should be taken to ensure that the valve is not jarred open or closed as, in either case, both the capacity and discharge pressure will be affected.

When operating a pump, it is important that the engine temperature be kept within the proper range; neither a cold engine nor an excessively hot engine will provide service as good as an engine run at the proper temperature.

The oil pressure on the engine should be watched to ensure that the engine is being lubricated properly. The transmission gears should be watched for overheating. Any unusual vibration of the engine or the pump, or any leak in the pump casing or connections, should be noted and addressed. Centrifugal pumps are not self-priming and could lose their prime if there is a leak in the suction line.

Other defects in the performance of the engine or the pump should be recorded. Minor defects should be corrected immediately if possible.

**B.2 Troubleshooting.** Most tests are conducted without incident. Nevertheless, trouble does develop during some tests, and an effort should be made to locate the source of trouble while the apparatus remains at the test site. Some difficulties that could be experienced, and suggestions on how to trace and correct them, are discussed in B.2.1 through B.2.7.

**B.2.1** Failure to prime a centrifugal pump is a frequent source of trouble, and the usual reason for the failure is an air leak in the suction hose or pump. One way to trace this trouble is to remove all discharge hoselines, cap all discharge openings and the suction hose, and operate the priming mechanism in accordance with the manufacturer's recommendations. The intake gauge should be studied to determine the maximum vacuum that is developed, which should be at least 22 in. Hg (75 kPa) at altitudes of less than 1000 ft (305 m). The primer should be stopped. If the vacuum drops 10 in. Hg (34 kPa) or more in less than 5 minutes, there is a leak in the suction hose or pump assembly; it could be in a valve, draincock, piping, casing, or pump packing. The leakage might be located by listening for air movement. Another method of checking for leaks is to connect the pump to a convenient hydrant, cap the pump discharge outlets, open the hydrant, and watch for water leaks. A leak can usually be corrected at the test site.

**B.2.2** Two possible causes for failure of the pump to deliver the desired capacity, pressure, or both are insufficient power and restrictions in the intake arrangement. Insufficient power is indicated by the inability of the engine to reach the required speed for the desired pumping condition. Some possible causes of insufficient power are as follows:

(1) The operator might have failed to advance the throttle far enough or might be using the wrong transmission gear position.
(2) The engine might be in need of a tune-up.
(3) The grade of fuel might be improper for adequate combustion.
(4) There might be vaporization in the fuel line.

**B.2.3** Restriction in the intake arrangement is indicated if the pump speed is too high for the capacity and attained pressure levels and could be the result of any one or a combination of the following conditions:

(1) Suction hose is too small.
(2) Altitude is too high.
(3) Lift is too high.
(4) Strainer type is incorrect.
(5) Intake strainer is clogged at the pump or at the end of the suction hose.
(6) Water is aerated.
(7) Water is too warm [above 90°F (32°C)].
(8) Suction hose is collapsed or defective.
(9) Foreign material is in pump.

**B.2.4** An air leak in the suction hose connections or in the pump intake manifold also will result in excessive pump speed and eventually could cause loss of prime and complete cessation of flow.

**B.2.5** Insufficient pressure when operating a centrifugal pump could be the result of pumping too much water for the available power and, in multistage pumps, pumping in "volume" position instead of the required "pressure" position. This problem can be checked by partially closing off all discharge valves until only a small flow is observed and then opening the throttle until the desired pressure is reached, followed by slowly opening discharge valves and increasing engine speed as necessary to maintain pressure until the desired capacity is obtained. An improperly adjusted or inoperative transfer valve can prevent the development of adequate pressure. Likewise, the pressure control system might be set too low or be defective.

**B.2.6** Engine speed differences from the original pump test could be the result of any one or a combination of the following conditions:

(1) Operating apparatus with the wrong transmission gear in use
(2) Stuck or out-of-adjustment throttle control system
(3) Restrictions in the intake arrangement
(4) Suction hose under an insufficient depth of water
(5) Air leak on the intake side of the pump
(6) Changes in environmental conditions
(7) Pump or engine wear

**B.2.7** A slip of the revolution counter or its fitting will show an apparently decreased speed, and frequent checks should be made with the apparatus tachometer to verify a change in speed. A clogged pitot tube will cause a drop in the gauge reading.

**B.3 Calculating the Results.** If nozzles and pitot tubes have been used to measure pump capacity, the values of capacity in gallons per minute are determined by the following equation:

**[B.3a]**

$$\text{gpm} = 29.83\ c(d)^2\sqrt{p}$$

where:
$c$ = coefficient of discharge of the nozzle used
$d$ = diameter of nozzle (in.)
$p$ = pressure at pitot gauge (psi)

If the nozzle diameter is measured in millimeters, the diameter should be divided by 25.4 to convert the measurement to inches. If the pressure is measured in kilopascals (kPa), the pressure should be divided by 6.895 to convert the measurement to pounds per square inch (psi). The resulting flow can be converted from gallons per minute (gpm) to liters per minute (L/min) by multiplying by 3.785.

The pitot pressure should be the average of several readings and should be corrected for gauge error.

For nozzles sized from ¼ in. to 2½ in. (6.3 mm to 63 mm), values of capacity can be approximated from Table B.3(a), Table B.3(b), Table B.3(c), and Table B.3(d); however, because these values are based on certain assumed coefficients of discharge, they can be considerably at variance with the actual values. For nozzles larger than 2½ in. (63 mm), approximate values of capacity in gallons per minute can be determined by the following equation:

**[B.3b]**

$$\text{gpm} = F\sqrt{p}$$

where:
$F$ = nozzle factor from Table B.3(e)
$p$ = pressure at pitot gauge (psi)

**Table B.3(a) Discharge Table for Smooth Nozzles — 1/4 Inch Through 7/16 Inch — in Gallons per Minute (Nozzle Pressure Measured by Pitot Gauge)**

| Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1/4 | 5/16 | 3/8 | 7/16 | | 1/4 | 5/16 | 3/8 | 7/16 |
| **5** | 4 | 6 | 9 | 13 | **62** | 14 | 22 | 32 | 44 |
| **6** | 4 | 6 | 10 | 14 | **64** | 14 | 22 | 32 | 45 |
| **7** | 4 | 7 | 11 | 15 | **66** | 14 | 23 | 33 | 46 |
| **8** | 5 | 7 | 11 | 16 | **68** | 14 | 23 | 33 | 46 |
| **9** | 5 | 8 | 12 | 17 | **70** | 15 | 24 | 34 | 47 |
| **10** | 6 | 9 | 13 | 18 | **72** | 15 | 24 | 34 | 48 |
| **12** | 6 | 10 | 15 | 19 | **74** | 15 | 24 | 35 | 48 |
| **14** | 7 | 11 | 15 | 21 | **76** | 15 | 24 | 35 | 49 |
| **16** | 7 | 12 | 16 | 22 | **78** | 15 | 24 | 36 | 50 |
| **18** | 7 | 12 | 17 | 24 | **80** | 16 | 25 | 36 | 50 |
| **20** | 8 | 13 | 18 | 25 | **82** | 16 | 25 | 37 | 51 |
| **22** | 8 | 13 | 19 | 26 | **84** | 16 | 25 | 37 | 51 |
| **24** | 8 | 13 | 20 | 27 | **86** | 16 | 26 | 37 | 52 |
| **26** | 9 | 14 | 21 | 29 | **88** | 16 | 26 | 38 | 53 |
| **28** | 9 | 14 | 21 | 30 | **90** | 17 | 27 | 39 | 53 |
| **30** | 10 | 15 | 22 | 31 | **92** | 17 | 27 | 39 | 54 |
| **32** | 10 | 15 | 23 | 32 | **94** | 17 | 27 | 39 | 54 |
| **34** | 11 | 16 | 23 | 33 | **96** | 17 | 27 | 40 | 55 |
| **36** | 11 | 16 | 24 | 34 | **98** | 17 | 27 | 40 | 55 |
| **38** | 11 | 17 | 25 | 35 | **100** | 18 | 28 | 41 | 56 |
| **40** | 11 | 18 | 26 | 35 | **105** | 18 | 29 | 42 | 57 |
| **42** | 11 | 18 | 26 | 36 | **110** | 19 | 29 | 43 | 59 |
| **44** | 12 | 18 | 27 | 37 | **115** | 19 | 30 | 43 | 60 |
| **46** | 12 | 19 | 28 | 38 | **120** | 19 | 31 | 44 | 61 |
| **48** | 12 | 19 | 28 | 39 | **125** | 20 | 31 | 45 | 63 |
| **50** | 13 | 20 | 29 | 40 | **130** | 20 | 32 | 46 | 64 |
| **52** | 13 | 20 | 29 | 40 | **135** | 21 | 33 | 47 | 65 |
| **54** | 13 | 20 | 30 | 41 | **140** | 21 | 33 | 48 | 66 |
| **56** | 13 | 21 | 30 | 42 | **145** | 21 | 34 | 49 | 68 |
| **58** | 13 | 21 | 31 | 43 | **150** | 22 | 34 | 50 | 69 |
| **60** | 14 | 22 | 31 | 43 | | | | | |

Note: 1 mm = 0.03937 in.; 1 kPa = 0.1450 psi; 1 gpm = 3.785 L/min.
*Assumed coefficient of discharge = 0.983, 0.983, 0.985, 0.9856.

**B.4 Lift.** The lift is the difference in elevation between the water level and the center of the pump intake when an apparatus is drafting water. The maximum lift is the greatest difference in elevation at which the apparatus can draft the required quantity of water under the established physical characteristics of operation, which include the following:

(1) Design of pump
(2) Adequacy of engine
(3) Condition of pump and engine
(4) Size and condition of suction hose and strainers
(5) Elevation of pumping site above sea level
(6) Atmospheric pressure
(7) Temperature of water

The theoretical values of lift and maximum lift must be reduced by the entrance and friction losses in the suction hose equipment to obtain the actual or measurable lift.

The vacuum, or negative pressure, on the intake side of a pump is measured in inches of mercury, usually written as "in. Hg" or "Hg" (Hg is the chemical symbol for mercury). A vacuum of 1 in. of mercury is equal to a negative pressure of 0.49 psi, or 1 in. Hg = 0.49 psi. A positive pressure of 0.49 psi at the bottom of a 1 $in.^2$ (645 $mm^2$) container will support a column of water that is 1.13 ft (0.344 m) high; therefore, a negative pressure of 0.49 psi at the top of the container will support the same column of water. This means 1 in. Hg = 0.49 psi = 1.13 ft (0.344 m) of water head.

**Table B.3(b) Discharge Table for Smooth Nozzles — ½ Inch Through 1 Inch — in Gallons per Minute (Nozzle Pressure Measured by Pitot Gauge)**

| Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | | Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ½ | ⅝ | ¾ | ⅞ | 1 | | ½ | ⅝ | ¾ | ⅞ | 1 |
| **5** | 16 | 26 | 37 | 50 | 66 | **62** | 58 | 90 | 132 | 177 | 233 |
| **6** | 18 | 28 | 41 | 55 | 72 | **64** | 59 | 92 | 134 | 180 | 237 |
| **7** | 19 | 30 | 44 | 59 | 78 | **66** | 60 | 93 | 136 | 182 | 240 |
| **8** | 21 | 32 | 47 | 64 | 84 | **68** | 60 | 95 | 138 | 185 | 244 |
| **9** | 22 | 34 | 50 | 67 | 89 | **70** | 61 | 96 | 140 | 188 | 247 |
| **10** | 23 | 36 | 53 | 71 | 93 | **72** | 62 | 97 | 142 | 191 | 251 |
| **12** | 25 | 40 | 58 | 78 | 102 | **74** | 63 | 99 | 144 | 193 | 254 |
| **14** | 27 | 43 | 63 | 84 | 110 | **76** | 64 | 100 | 146 | 196 | 258 |
| **16** | 29 | 46 | 67 | 90 | 118 | **78** | 65 | 101 | 148 | 198 | 261 |
| **18** | 31 | 49 | 71 | 95 | 125 | **80** | 66 | 103 | 150 | 201 | 264 |
| **20** | 33 | 51 | 75 | 101 | 132 | **82** | 66 | 104 | 152 | 204 | 268 |
| **22** | 34 | 54 | 79 | 105 | 139 | **84** | 67 | 105 | 154 | 206 | 271 |
| **24** | 36 | 56 | 82 | 110 | 145 | **86** | 68 | 107 | 155 | 208 | 274 |
| **26** | 37 | 59 | 85 | 115 | 151 | **88** | 69 | 108 | 157 | 211 | 277 |
| **28** | 39 | 61 | 89 | 119 | 157 | **90** | 70 | 109 | 159 | 213 | 280 |
| **30** | 40 | 63 | 92 | 123 | 162 | **92** | 70 | 110 | 161 | 215 | 283 |
| **32** | 41 | 65 | 95 | 127 | 167 | **94** | 71 | 111 | 162 | 218 | 286 |
| **34** | 43 | 67 | 98 | 131 | 172 | **96** | 72 | 113 | 164 | 220 | 289 |
| **36** | 44 | 69 | 100 | 135 | 177 | **98** | 73 | 114 | 166 | 223 | 292 |
| **38** | 45 | 71 | 103 | 138 | 182 | **100** | 73 | 115 | 168 | 225 | 295 |
| **40** | 46 | 73 | 106 | 142 | 187 | **105** | 75 | 118 | 172 | 230 | 303 |
| **42** | 47 | 74 | 109 | 146 | 192 | **110** | 77 | 121 | 176 | 236 | 310 |
| **44** | 49 | 76 | 111 | 149 | 196 | **115** | 79 | 123 | 180 | 241 | 317 |
| **46** | 50 | 78 | 114 | 152 | 200 | **120** | 80 | 126 | 183 | 246 | 324 |
| **48** | 51 | 80 | 116 | 156 | 205 | **125** | 82 | 129 | 187 | 251 | 331 |
| **50** | 52 | 81 | 118 | 159 | 209 | **130** | 84 | 131 | 191 | 256 | 337 |
| **52** | 53 | 83 | 121 | 162 | 213 | **135** | 85 | 134 | 195 | 262 | 343 |
| **54** | 54 | 84 | 123 | 165 | 217 | **140** | 87 | 136 | 198 | 266 | 350 |
| **56** | 55 | 86 | 125 | 168 | 221 | **145** | 88 | 139 | 202 | 271 | 356 |
| **58** | 56 | 87 | 128 | 171 | 225 | **150** | 90 | 141 | 205 | 275 | 362 |
| **60** | 57 | 89 | 130 | 174 | 229 | | | | | | |

Note: 1 mm = 0.03937 in.; 1 kPa = 0.1450 psi; 1 gpm = 3.785 L/min.
*Assumed coefficient of discharge = 0.985, 0.988, 0.988, 0.99.

**B.5 Effect of Altitude.** When drafting water, the pump produces a partial vacuum in the suction hose, and the atmospheric pressure on the surface of the water forces water into the suction hose and the pump. As the elevation above sea level of the pumping site increases, the atmospheric pressure decreases. The loss of lift at various elevations is given in Table B.5.

The data in Table B.5 assume that the engine of the apparatus is adequate at all elevations. However, the available power for driving a pump from naturally aspirated gasoline engines decreases about 4 percent (up to 3 percent for diesel engines that are naturally aspirated) for each 1000 ft (305 m) of elevation. Therefore, a gasoline engine that was just adequate at sea level would be about 35 percent deficient at a 7000 ft (2135 m) altitude.

A difference in atmospheric pressure due to weather conditions will have the same result as a change in altitude. The difference in atmospheric pressure due to operation on a rainy day instead of a cool, clear day could easily mean a 1 ft (0.3 m) difference in lift.

**Table B.3(c) Discharge Table for Smooth Nozzles — 1⅛ Inch Through 1⅝ Inch — in Gallons per Minute (Nozzle Pressure Measured by Pitot Gauge)**

| Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | | Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1⅛ | 1¼ | 1⅜ | 1½ | 1⅝ | | 1⅛ | 1¼ | 1⅜ | 1½ | 1⅝ |
| **5** | 84 | 103 | 125 | 149 | 175 | **62** | 295 | 363 | 441 | 525 | 617 |
| **6** | 92 | 113 | 137 | 163 | 192 | **64** | 299 | 369 | 448 | 533 | 627 |
| **7** | 99 | 122 | 148 | 176 | 207 | **66** | 304 | 375 | 455 | 542 | 636 |
| **8** | 106 | 131 | 158 | 188 | 222 | **68** | 308 | 381 | 462 | 550 | 646 |
| **9** | 112 | 139 | 168 | 200 | 235 | **70** | 313 | 386 | 469 | 558 | 655 |
| **10** | 118 | 146 | 177 | 211 | 248 | **72** | 318 | 391 | 475 | 566 | 665 |
| **12** | 130 | 160 | 194 | 231 | 271 | **74** | 322 | 397 | 482 | 574 | 674 |
| **14** | 140 | 173 | 210 | 249 | 293 | **76** | 326 | 402 | 488 | 582 | 683 |
| **16** | 150 | 185 | 224 | 267 | 313 | **78** | 330 | 407 | 494 | 589 | 692 |
| **18** | 159 | 196 | 237 | 283 | 332 | **80** | 335 | 413 | 500 | 596 | 700 |
| **20** | 167 | 206 | 250 | 298 | 350 | **82** | 339 | 418 | 507 | 604 | 709 |
| **22** | 175 | 216 | 263 | 313 | 367 | **84** | 343 | 423 | 513 | 611 | 718 |
| **24** | 183 | 226 | 275 | 327 | 384 | **86** | 347 | 428 | 519 | 618 | 726 |
| **26** | 191 | 235 | 286 | 340 | 400 | **88** | 351 | 433 | 525 | 626 | 735 |
| **28** | 198 | 244 | 297 | 353 | 415 | **90** | 355 | 438 | 531 | 633 | 743 |
| **30** | 205 | 253 | 307 | 365 | 429 | **92** | 359 | 443 | 537 | 640 | 751 |
| **32** | 212 | 261 | 317 | 377 | 443 | **94** | 363 | 447 | 543 | 647 | 759 |
| **34** | 218 | 269 | 327 | 389 | 457 | **96** | 367 | 452 | 549 | 654 | 767 |
| **36** | 224 | 277 | 336 | 400 | 470 | **98** | 370 | 456 | 554 | 660 | 775 |
| **38** | 231 | 285 | 345 | 411 | 483 | **100** | 374 | 461 | 560 | 667 | 783 |
| **40** | 237 | 292 | 354 | 422 | 496 | **105** | 383 | 473 | 574 | 683 | 803 |
| **42** | 243 | 299 | 363 | 432 | 508 | **110** | 392 | 484 | 588 | 699 | 822 |
| **44** | 248 | 306 | 372 | 442 | 520 | **115** | 401 | 495 | 600 | 715 | 840 |
| **46** | 254 | 313 | 380 | 452 | 531 | **120** | 410 | 505 | 613 | 730 | 858 |
| **48** | 259 | 320 | 388 | 462 | 543 | **125** | 418 | 516 | 626 | 745 | 876 |
| **50** | 265 | 326 | 396 | 472 | 554 | **130** | 427 | 526 | 638 | 760 | 893 |
| **52** | 270 | 333 | 404 | 481 | 565 | **135** | 435 | 536 | 650 | 775 | 910 |
| **54** | 275 | 339 | 412 | 490 | 576 | **140** | 443 | 546 | 662 | 789 | 927 |
| **56** | 280 | 345 | 419 | 499 | 586 | **145** | 450 | 556 | 674 | 803 | 944 |
| **58** | 285 | 351 | 426 | 508 | 596 | **150** | 458 | 565 | 686 | 817 | 960 |
| **60** | 290 | 357 | 434 | 517 | 607 | | | | | | |

Note: 1 mm = 0.03937 in.; 1 kPa = 0.1450 psi; 1 gpm = 3.785 L/min.
*Assumed coefficient of discharge = 0.99, 0.99, 0.993, 0.995, 0.995.

**Table B.3(d) Discharge Table for Smooth Nozzles — 1¾ Inch Through 2½ Inch — in psi (Nozzle Pressure Measured by Pitot Gauge)**

| Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | | Nozzle Pressure (psi) | Nozzle Diameter (in.)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1¾ | 1⅞ | 2 | 2¼ | 2½ | | 1¾ | 1⅞ | 2 | 2¼ | 2½ |
| **5** | 203 | 234 | 266 | 337 | 416 | **62** | 716 | 823 | 936 | 1187 | 1464 |
| **6** | 223 | 256 | 292 | 369 | 455 | **64** | 727 | 836 | 951 | 1206 | 1487 |
| **7** | 241 | 277 | 315 | 399 | 492 | **66** | 738 | 850 | 965 | 1224 | 1510 |
| **8** | 257 | 296 | 336 | 427 | 526 | **68** | 750 | 862 | 980 | 1242 | 1533 |
| **9** | 273 | 314 | 357 | 452 | 558 | **70** | 761 | 875 | 994 | 1260 | 1555 |
| **10** | 288 | 330 | 376 | 477 | 588 | **72** | 771 | 887 | 1008 | 1278 | 1577 |
| **12** | 315 | 362 | 412 | 522 | 644 | **74** | 782 | 900 | 1023 | 1296 | 1599 |
| **14** | 340 | 391 | 445 | 564 | 695 | **76** | 792 | 911 | 1036 | 1313 | 1620 |
| **16** | 364 | 418 | 475 | 603 | 744 | **78** | 803 | 924 | 1050 | 1330 | 1642 |
| **18** | 386 | 444 | 504 | 640 | 789 | **80** | 813 | 935 | 1063 | 1347 | 1663 |
| **20** | 407 | 468 | 532 | 674 | 831 | **82** | 823 | 946 | 1076 | 1364 | 1683 |
| **22** | 427 | 490 | 557 | 707 | 872 | **84** | 833 | 959 | 1089 | 1380 | 1704 |
| **24** | 446 | 512 | 582 | 739 | 911 | **86** | 843 | 970 | 1102 | 1396 | 1724 |
| **26** | 464 | 533 | 606 | 769 | 948 | **88** | 853 | 981 | 1115 | 1412 | 1744 |
| **28** | 481 | 554 | 629 | 799 | 984 | **90** | 862 | 992 | 1128 | 1429 | 1763 |
| **30** | 498 | 572 | 651 | 826 | 1018 | **92** | 872 | 1002 | 1140 | 1445 | 1783 |
| **32** | 514 | 591 | 673 | 854 | 1051 | **94** | 881 | 1012 | 1152 | 1460 | 1802 |
| **34** | 530 | 610 | 693 | 880 | 1084 | **96** | 890 | 1022 | 1164 | 1476 | 1821 |
| **36** | 546 | 627 | 713 | 905 | 1115 | **98** | 900 | 1032 | 1176 | 1491 | 1840 |
| **38** | 561 | 645 | 733 | 930 | 1146 | **100** | 909 | 1043 | 1189 | 1506 | 1859 |
| **40** | 575 | 661 | 752 | 954 | 1176 | **105** | 932 | 1070 | 1218 | 1542 | 1905 |
| **42** | 589 | 678 | 770 | 978 | 1205 | **110** | 954 | 1095 | 1247 | 1579 | 1950 |
| **44** | 603 | 694 | 788 | 1000 | 1233 | **115** | 975 | 1120 | 1275 | 1615 | 1993 |
| **46** | 617 | 710 | 806 | 1021 | 1261 | **120** | 996 | 1144 | 1303 | 1649 | 2036 |
| **48** | 630 | 725 | 824 | 1043 | 1288 | **125** | 1016 | 1168 | 1329 | 1683 | 2078 |
| **50** | 643 | 740 | 841 | 1065 | 1314 | **130** | 1036 | 1191 | 1356 | 1717 | 2119 |
| **52** | 656 | 754 | 857 | 1087 | 1340 | **135** | 1056 | 1213 | 1382 | 1750 | 2160 |
| **54** | 668 | 769 | 873 | 1108 | 1366 | **140** | 1076 | 1235 | 1407 | 1780 | 2199 |
| **56** | 680 | 782 | 889 | 1129 | 1391 | **145** | 1095 | 1257 | 1432 | 1812 | 2238 |
| **58** | 692 | 796 | 905 | 1149 | 1416 | **150** | 1114 | 1279 | 1456 | 1843 | 2277 |
| **60** | 704 | 810 | 920 | 1166 | 1440 | | | | | | |

Note: 1 mm = 0.03937 in.; 1 kPa = 0.1450 psi; 1 gpm = 3.785 L/min.
*Assumed coefficient of discharge = 0.995, 0.996, 0.997, 0.997, 0.997.

**Table B.3(e) Nozzle Factors**

| Diameter of the Nozzle (in.) | Factors (*F*) | |
|---|---|---|
| | Freshwater | Saltwater (Seawater) |
| 2 | 119 | 117 |
| 2¼ | 150 | 148 |
| 2½ | 186 | 183 |
| 2¾ | 225 | 222 |
| 3 | 267 | 264 |
| 3¼ | 314 | 310 |
| 3½ | 364 | 359 |
| 3¾ | 418 | 413 |
| 4 | 476 | 470 |
| 4¼ | 537 | 530 |
| 4½ | 602 | 594 |
| 4¾ | 671 | 662 |
| 5 | 743 | 734 |
| 6 | 1070 | 1057 |

Note: 1 mm = 0.03937 in.

**Table B.5 Loss of Lift at Various Elevations**

| Elevation Above Sea Level | | Loss of Lift (Water) | |
|---|---|---|---|
| ft | m | ft | m |
| 1000 | 305 | 1.22 | 0.37 |
| 2000 | 610 | 2.38 | 0.73 |
| 3000 | 915 | 3.50 | 1.07 |
| 4000 | 1220 | 4.75 | 1.45 |
| 5000 | 1525 | 5.80 | 1.77 |
| 6000 | 1830 | 6.80 | 2.07 |
| 7000 | 2135 | 7.70 | 2.35 |

## Annex C Developing a Preventive Maintenance Program (NFPA 1911)

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

**C.1 General.** Emergency vehicles are increasingly complex pieces of machinery that require regular preventive maintenance to keep them safe and reliable and to maximize their life and value. It is not enough just to repair problems when they occur or to perform maintenance when it is convenient or someone thinks to have it done. In order to keep a fleet of emergency vehicles in good condition, a good plan is necessary to ensure that all the required maintenance is performed.

Fire departments vary widely in their character, and thus in their requirements of a preventive maintenance program. At one end might be a small rural volunteer fire department with two emergency vehicles and five runs per month. At the other end might be a large city with several hundred emergency vehicles, each of which makes 10 or more runs per day. While the specifics of the preventive maintenance program for each department will be different, the goals in each should be to ensure that all the necessary preventive maintenance is performed to make certain that the apparatus is ready and safe for responding to an emergency when needed. It is important that each department develop a program appropriate for its vehicles, circumstances, resources, capabilities, and special circumstances.

This annex is designed to provide some guidance to a department in developing a plan to ensure that the preventive maintenance program performs all the necessary work needed to keep the emergency vehicle in top condition.

Many departments already have a very effective preventive maintenance program in place. If the existing program works for the department and meets the requirements of this standard, then no changes are needed. If a department does not have a program in place, or its program is not meeting the requirements of this standard, then this annex can help guide the department through the process of setting up an effective preventive maintenance program.

**C.2 Resources.** Part of preparing a preventive maintenance program is to identify the resources that are available for maintenance and testing. A large city department might have extensive resources in a fire department or city public works shop. Even in such a department, some work, such as transmission overhauls and body work, might be sent to outside service facilities. The emergency responders and driver/operators who operate the equipment on a regular basis can, in most cases, perform daily or weekly operational checks.

In many areas of the country there are businesses that specialize in servicing emergency vehicles. There are also businesses and organizations that specialize in testing emergency vehicles, especially specific components, such as aerial devices and pumps. Many emergency vehicle dealers and manufacturers have personnel qualified to perform many service tasks. These services often can be performed in the fire station with mobile service trucks. Qualified personnel who perform service on other types of heavy trucks can perform many types of service on emergency vehicles, especially on components common with heavy trucks, such as drivetrains and suspensions. Many departments, especially volunteer departments, might find that they have personnel in the department who are qualified to do some of the required maintenance. These resources can be used to perform some of the maintenance and reduce costs.

It is helpful to identify not only the resources that will perform routine preventive maintenance and testing but also resources to perform emergency repairs. If such resources are not available within the fire department or city public works shop, these resources should be identified in advance, including establishing financial arrangements and 24-hour contact information, if possible. Services that should be included are as follows:

(1) Towing
(2) Tire service or replacement
(3) Provision of fuel and lubricants
(4) Repair of engine and drivetrain problems
(5) Repair of pump or plumbing problems
(6) Repair of fire service components, such as rescue tools
(7) Supplying replacement hose, tools, gear, and equipment damaged at an incident

In any case, it is up to the department and the AHJ to determine that the persons and facilities selected for maintenance and testing are qualified for the work they perform. Section 4.4 provides some requirements on the qualification of personnel.

**C.3 Form and Format.** The information needed for an effective preventive maintenance program can take many forms. It is

important that the information is easy to keep updated as emergency vehicles are replaced, and that it is easy for the fire department and the maintenance providers to use. Typically there are two types of information needed when establishing the preventive maintenance program. The first is when maintenance is needed, and the second is what maintenance tasks should be performed and, if necessary, how they should be performed.

Scheduled preventive maintenance activities are typically based on time (every 3 months, every 6 months, annually, and every 5 years) or a specified number of hours of operation.

Small departments might want to prepare a list, by month, of which emergency vehicle is due for service and which service is to be performed at that time. It is important that the schedule be updated whenever an emergency vehicle is added or removed. Larger departments might find it more functional to prepare a schedule by month or by number of hours for each piece of emergency vehicle.

There are many software programs available to assist in tracking maintenance schedules. Some vehicle record systems might even be available as a free download.

Operational checks that are to be performed at the start of each day, shift, or week are usually best documented with a check sheet to be used by the station crew. An example check sheet is shown in Figure C.3(a). It should be adapted for each emergency vehicle.

The documentation of which maintenance tasks should be performed at other intervals might be done in many ways. Simple tasks might be listed on the schedule. More extensive lists of tasks are often best put into a check sheet that the technician can use during the inspection and servicing process. An example of such a check sheet is shown in Figure C.3(b). This is just an example that must be customized to meet the requirements for specific emergency vehicles and department policies.

The performance testing described in Chapters 20 through 28 of this standard should be included in the maintenance schedule. The details of how to perform the testing, and the information that is to be collected, are detailed in those chapters. Figure C.3(c) is a form that can be used to record the performance test results for a pump or industrial supply pump. Figure C.3(d) is a form that can be used to record the inspection and performance test results for an aerial device. Figure C.3(e) is a form that can be used to record the performance test results for the low-voltage electrical system on the emergency vehicle, and Figure C.3(f) is a form that can be used to record the performance test results for a line voltage electrical system. Figure C.3(g) is a form that can be used to record the performance test results for a foam proportioning system and, if the emergency vehicles also has a CAFS compressor system, Figure C.3(h) is the form for recording the performance test results for that system.

**C.4 Establishing the Program.** The preventive maintenance program for any specific emergency vehicle, or for a department, needs to include requirements from several sources.

The first place to look is in the manufacturer's manuals. If the manuals that should have been delivered with the emergency vehicle when it was new are not available, contact the original manufacturer to determine if duplicates are available. Even if the full vehicle manuals are not available, maintenance recommendations for specific components, such as engines, transmissions, axles, pumps, and generators, can be obtained from their manufacturers. The documentation should be carefully reviewed for recommendations for inspections, lubrication, replacing parts, testing, or other periodic maintenance tasks. These manuals also might be the source for specifications needed for confirming proper operation in the performance testing.

The second place to look is in the requirements of this standard. In many cases, there will be significant overlap with the recommendations in the manufacturer's manuals. There will be some requirements in this standard that do not apply to a specific emergency vehicle. All applicable requirements from this standard should be included in the program as it is established.

As the various maintenance tasks that need to be performed are identified, each should be assigned to a schedule based on months, years, hours, or some other time frame that will determine when it is to be performed. Those who will perform the maintenance task should also be identified. In the case of a large fire department or city public works shops, this is simple. In other cases, different providers might perform different types of tasks. A department might have several providers that can perform the same type of work, with the decision of which provider to use being made based on any of several criteria.

Once the tasks to be performed, their required frequency, and who will perform the work have been identified, the preventive maintenance program can be organized into a series of schedules, check sheets, record sheets, and other documentation that will ensure that the program will be implemented correctly. If the entire program is being developed from scratch, it might be necessary to develop the program and then revise it as experience demonstrates which elements work smoothly and which do not.

**C.5 Record Maintenance.** The check sheets and other maintenance records should be kept for the life of the emergency vehicle. Part of setting up a preventive maintenance program is creating a filing system or other mechanism for retaining records. All records should be maintained by vehicle so that they can be delivered with the emergency vehicle when it is sold. In many cases, problems can only be detected by comparing current test results with previous test results. For these problems to be detected, it is important that the records be well organized and available for future review. In the event of an accident, the accident investigation will include a review of all maintenance records.

There are many different types of forms for reporting inspections, maintenance, and tests that could be used in connection with an emergency vehicle preventive maintenance program. Resources for forms other than those shown in this annex are the local or state fire apparatus mechanics association, emergency vehicle manufacturers, or the Emergency Vehicle Management Section of the International Association of Fire Chiefs.

## DAILY/WEEKLY WALK-AROUND CHECK FOR MOBILE FIRE EMERGENCY VEHICLE

Fire department name _____ Date _____

Emergency vehicle no. _____ Station no. _____

Start mileage _____ End mileage _____ Start engine hours _____ End engine hours _____

Inspectors: Mon _____ Tue _____ Wed _____ Thur _____ Fri _____ Sat _____ Sun _____

Legend: X = OK R = Repair required (requires a comment regarding problem)

| OPERATIONS | Mon | Tue | Wed | Thur | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| **Engine** | | | | | | | |
| 1. Check engine oil and transmission level. | | | | | | | |
| 2. Check engine coolant level. | | | | | | | |
| 3. Check for integrity of frame and suspension. | | | | | | | |
| 4. Check power steering fluid. | | | | | | | |
| **Outside** | | | | | | | |
| 1. Check for fluid leaks under vehicle. | | | | | | | |
| 2. Check steering shafts and linkages. | | | | | | | |
| 3. Check wheels and lug nuts. | | | | | | | |
| 4. Check tire condition. | | | | | | | |
| 5. Check tire air pressure. | | | | | | | |
| **Cab** | | | | | | | |
| 1. Check seats and seat belts. | | | | | | | |
| 2. Start engine, check all gauges. | | | | | | | |
| 3. Check windshield wipers. | | | | | | | |
| 4. Check rear view mirror adjustment and operation. | | | | | | | |
| 5. Check horn. | | | | | | | |
| 6. Check steering shafts. | | | | | | | |
| 7. Check cab glass and mirrors. | | | | | | | |
| **Body** | | | | | | | |
| 1. Check steps and running boards. | | | | | | | |
| 2. Check body condition. | | | | | | | |
| 3. Check grab handles. | | | | | | | |
| **Electric** | | | | | | | |
| 1. Check battery voltage and charging system voltage. | | | | | | | |
| 2. Check line voltage system. | | | | | | | |
| 3. Check all lights (ICC and warning). | | | | | | | |

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**FIGURE C.3(a) Daily/Weekly Emergency Vehicle Check Form.**

| OPERATIONS | Mon | Tue | Wed | Thur | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| **Brakes** | | | | | | | |
| 1. Check air system for proper air pressure. | | | | | | | |
| 2. Check parking brake. | | | | | | | |
| 3. Check hydraulic brake fluid level. | | | | | | | |
| **Pump** | | | | | | | |
| 1. Operate pump, check pump panel engine gauges. | | | | | | | |
| 2. Check pump for pressure operation. | | | | | | | |
| 3. Check discharge relief or pressure governor operation. | | | | | | | |
| 4. Check all pump drain valves. | | | | | | | |
| 5. Check all discharge and intake valve operation. | | | | | | | |
| 6. Check pump and tank for water leaks. | | | | | | | |
| 7. Check all valve bleeder/drain operation. | | | | | | | |
| 8. Check primer pump operation. | | | | | | | |
| 9. Check system vacuum hold. | | | | | | | |
| 10. Check water tank level indicator. | | | | | | | |
| 11. Check primer oil level (if applicable). | | | | | | | |
| 12. Check transfer valve operation (if equipped). | | | | | | | |
| 13. Check booster reel operation (if equipped). | | | | | | | |
| 14. Check all pump pressure gauge operation. | | | | | | | |
| 15. Check all cooler valves. | | | | | | | |
| 16. Check for oil leaks in pump area. | | | | | | | |
| **Aerial** | | | | | | | |
| 1. Operate aerial hydraulics. | | | | | | | |
| 2. Check aerial outrigger operation. | | | | | | | |
| 3. Check aerial operation. | | | | | | | |
| 4. Check aerial hydraulic fluid level. | | | | | | | |
| 5. Visually inspect aerial structure. | | | | | | | |

Comments _____

 

**FIGURE C.3(a)** ***Continued***

## QUARTERLY/ANNUAL
## MOBILE FIRE EMERGENCY VEHICLE INSPECTION REPORT

Inspection date _____

Fire department _____ Emergency vehicle no. _____

**Emergency Vehicle**

Manufacturer _____

Model _____

Serial no. _____

Hourmeter _____

**Chassis**

Make _____

Model _____

VIN _____

Odometer _____

**Legend:**
X =Acceptable visually, checked R = Requires repair or adjustment
U = Unsafe condition requires repair prior to use C = Corrected NA = Not applicable

### CHASSIS INSPECTION

#### Engine and Cooling Systems

_____ Oil level and condition
_____ Oil leaks
_____ Coolant level
_____ Antifreeze protection
_____ Coolant additive level
_____ Fuel system for leaks
_____ Fuel system plumbing condition
_____ Power steering fluid level
_____ Power steering pump and plumbing
_____ Coolant hose condition and leaks
_____ Alternator mounting brackets
_____ Alternator connections
_____ Charging system output _____ volts
_____ Auxiliary cooler connections
_____ Battery condition and hold downs
_____ Battery cables and clamps
_____ Battery fluid level
_____ Battery terminal voltage _____ volts
_____ Chassis grounds and connections
_____ Starter motor cable condition
_____ Starter motor operation
_____ Fan mounting bolts and adjustment
_____ Fan shroud clearance and condition
_____ Fan clutch or shutters operation
_____ Air filter element condition
_____ Air intake tubes and hoses
_____ All belts condition and adjustment
_____ After-cooler or intercooler tubes and hoses
_____ Motor mount condition
_____ Radiator cap pressure

Comments on engine and cooling systems inspection _____

 

**FIGURE C.3(b) Quarterly/Annual Emergency Vehicle Inspection Report.**

## Chassis and Components

*Fluid levels*

_____ Lubricate chassis

_____ All fluid levels

*Steering*

_____ Steering linkage and tie rods

_____ Steering box mounting

_____ Steering system plumbing for leaks

_____ Manual steering box fluid level

*Transmission*

_____ Auto trans fluid level

_____ Auto trans mounting and condition

_____ Auto trans and plumbing for leaks

_____ Auto trans lockup system

_____ Manual trans oil level

_____ Manual trans mounting

_____ Manual trans for leaks

*Fuel*

_____ Fuel tank and plumbing for leaks

_____ Fuel tank mounting

*Tires / Wheels*

_____ Tire and wheel conditions

_____ Lug nuts for torque

_____ Tire tread depth Front _____ Rear _____

_____ Tire air pressure Front _____ Rear _____

*Driveline*

_____ Driveline U-joints and yokes

_____ Driveline carrier bearings

_____ Differential oil level and leaks

*Front axle*

_____ Front spring and shock condition

_____ Front wheel bearings and king pins

*Rear axle*

_____ Rear spring condition

_____ Rear spring torque tubes and shocks

_____ Axle flanges for leaks and tightness

_____ Frame rails and cross members

*Brakes*

_____ Brake condition (amount of material)

_____ Brake adjustment and operation

_____ Air brake valves and tanks

_____ Lubricate brake pedal pivot pin

_____ Drain air tanks and check air dryer

_____ Air brake lines and chambers

_____ Air brake leaks and buildup

_____ Hydraulic brakes for leaks

_____ Hydraulic brake components

_____ Hydro-vac operation and mounting

_____ Parking brake operation

*Exhaust system*

_____ Exhaust system and muffler

Comments on chassis and components inspection _____

_____

_____

_____

_____

 

**FIGURE C.3(b)** ***Continued***

## Cab and Body

*Cab*

_____ Cab mounting and tilt mechanism
_____ Cab frame and sheet metal
_____ Cab hoist motor solenoid volt drop _____ volts
_____ Door mounting and latches
_____ Cab glass condition
_____ Cab seat condition and mounting
_____ Seat belt condition and mounting
_____ Steering wheel mounting and alignment
_____ Horn operation
_____ Heater and defroster operation
_____ Throttle controls and linkage
_____ Window operation
_____ Auto transmission shift controls
_____ Manual transmission shift controls
_____ Clutch pedal linkage
_____ Clutch pedal free play
_____ Windshield wipers and washers
_____ Mirror condition and mounting

*Body*

_____ Compartment door latches
_____ Compartment door and hinge condition
_____ Body compartment condition
_____ Step and auxiliary equipment condition

Comments on cab and body inspection _____

## Cab and Body Electrical

_____ Headlights and high beams
_____ Parking and clearance lights
_____ Tail and stop lights
_____ Backup lights and alarm
_____ Turn signal and hazard operation
_____ Cab spot lights operation
_____ Auxiliary light operation
_____ Front warning lights
_____ Rear warning lights
_____ Front beacon lights
_____ Intersection warning lights
_____ Body deck lights
_____ Compartment lights
_____ Siren operation and mounting
_____ Siren solenoid voltage drop _____ volts
_____ Voltage drops of all solenoids

List solenoids and voltage drop below

| Solenoid | Voltage Drop |
|---|---|
| | |
| | |
| | |
| | |

Comments on cab and body electrical inspection _____

 

**FIGURE C.3(b)** ***Continued***

### Line Voltage Inspection

_____ Power source
_____ Generator drive engine or power drivetrain
_____ Cord reels and receptacles
_____ Electrically driven equipment
_____ Electrical controls
_____ Output voltage _____ volts
_____ Output frequency _____ Hz

Comments on line voltage electrical inspection _____

### Road and Operational Test

_____ Engine oil pressure
_____ Engine coolant temperature
_____ Tachometer operation
_____ Auto transmission shifting
_____ Clutch release and operation
_____ Manual transmission shifting
_____ Brake operation
_____ Drive line vibration
_____ Air compressor operation
_____ Air compressor governor setting
_____ Speedometer operation
_____ Shimmy or front end noises
_____ Clutch fan or shutter operation

Comments on road and operational test _____

## PUMP AND WATER TANK INSPECTION

Pump manufacturer _____ Model _____ S/N _____
Pump location _____ Pump hours _____ Capacity _____

_____ Pump shift and indicator lights
_____ Automatic transmission lockup system
_____ Clutch disengagement and manual transmission
_____ Pump transmission shift cylinders or motor
_____ Pump transmission oil level and condition
_____ Pump panel tachometer and engine gauges
_____ Engine speed counter
_____ Pump panel electrical switches and panel light
_____ Master gauges for accuracy and operation
_____ Discharge gauges for accuracy and operation
_____ Water tank indicator system
_____ Pump

 

**FIGURE C.3(b)** ***Continued***

_____ Pump plumbing
_____ High-pressure pump system
_____ Pressure control device operation and response time
_____ Transfer valve operation
_____ Intake relief operation
_____ Primer operation
_____ Dry vacuum test
Initial reading _____ in. vacuum
Leakage in 5 minutes _____ in. vacuum
_____ Primer motor solenoid voltage drop _____ volts
_____ Pump packing—adjust if necessary
_____ Mechanical seals for leaks
_____ Discharge and intake valves
_____ Valves, linkage, remote rods, and pivot points
_____ Drain valves
_____ Tank-to-pump and tank fill valves
_____ Auxiliary cooler
_____ Suction strainer
_____ Preconnect valves and plumbing
_____ Deck gun valve and plumbing
_____ Front or rear suction valves and plumbing and valves
_____ Auto-lube level and fluid condition
_____ Water tank mounting and integrity
_____ Booster reel mounting and operation
_____ Anodes in tank and pump
_____ Reel motor solenoid voltage drop _____ volts
_____ Pump mounting integrity
_____ Pump driveline U-joints, yokes and flanges

Comments on pump and tank inspection _____

## FOAM PROPORTIONING SYSTEM INSPECTION

Foam system manufacturer _____ Model _____ S/N _____

_____ Instrumentation, gauges, and controls
_____ Strainer or filter
_____ Foam concentrate pump
_____ Lubricant level and condition
_____ Hydraulic pump
_____ Hydraulic system
_____ Hydraulic fluid tank mounting and integrity
_____ Foam concentrate tank mounting and integrity
_____ Foam eductor system, metering, and check valve

Comments on foam proportioning system inspection _____

 

**FIGURE C.3(b)** ***Continued***

## AERIAL DEVICE INSPECTION

Aerial manufacturer _____ Model _____ S/N _____

Aerial hours _____ Rated capacity _____

### Hydraulic Systems

*Turntable*

_____ Rotation gear reduction box
_____ Rotation hydraulic swivel
_____ Lines and hoses
_____ Control valve

*Chassis*

_____ Hydraulic tank
_____ Hydraulic fluid levels
_____ Hydraulic fluid sample
_____ PTO
_____ Hydraulic pump
_____ Auxiliary power pump
_____ Lines and hoses

*Stabilizer*

_____ Cylinders
_____ Control valve
_____ Lines and hoses
_____ Diverter valve

*Aerial*

_____ Elevation cylinder
_____ Extension cylinder
_____ Lines and hoses
_____ Tip controls

*Platform*

_____ Control valve
_____ Leveling cylinders
_____ Lines and hoses

### Structural Fasteners

_____ Turntable mounting bolts
_____ Torque box mounting to frame bolts
_____ Suspension system bolts

### Tractor Drawn Components

_____ Mounting to frame bolts
_____ Rotation gear reduction box mounting bolts
_____ Boom support/ladder cradle mounting bolts

### Stabilizer

_____ Mounting to frame or torque box
_____ Mounting bolts

### Lubrication

_____ Sheaves
_____ Cables
_____ Ladder section base rails
_____ Ladder heel pin
_____ Rotation gear and bearing
_____ Rotation gear reduction box
_____ Elevation cylinder pins
_____ Extension cylinder pins
_____ Stabilizer extension cylinder pins
_____ Aerial waterway pipe sections

### Indicators

_____ Rung alignment
_____ PTO engaged
_____ Aerial alignment
_____ Turntable alignment
_____ Elevation
_____ Extension
_____ Turntable level

### Turntable Components

_____ Safety signs
_____ Communication system
_____ Emergency hydraulic power
_____ Interlock systems
_____ Electrical lines





**FIGURE C.3(b)** ***Continued***

**Aerial Components**

_____ Gore tube
_____ Waterway
_____ Sheaves
_____ Pinable waterway
_____ Rung covers
_____ Breathing air
_____ Wear strips

**Stabilizers Components**

_____ Lights
_____ Pads
_____ Interlocks
_____ Safety pins

Comments on aerial device inspection _____

_____

_____

_____

_____

Inspector _____ Date _____

AHJ representative _____ Date _____

 

**FIGURE C.3(b)** ***Continued***

## PUMP PERFORMANCE TEST

Emergency vehicle number or designation _____ Year manufactured _____
Manufacturer _____ Model _____
Serial no. _____ Vehicle identification no. _____
Engine make _____ Model _____
Pump make _____ Model _____
Pump rated capacity _____ (gpm) (L/min) at _____ (psi) (kPa)
Speed check taken from _____ Ratio to engine _____
Test site location _____
Tests performed from ❑ Draft ❑ Hydrant
Suction hose size _____ (in.) (mm) Length _____ (ft) (m)

| | At start of tests | At end of tests |
|---|---|---|
| Atmospheric pressure | | |
| Air temperature | | |
| Water temperature | | |
| Elevation of test site | | |
| Lift | | |

Governed engine speed _____ Actual maximum engine speed _____
Verify operation of pump shift indicator _____
Verify operation of pump engine control interlock at pump operator's panel _____
Maximum vacuum attained _____ Vacuum drop in 5 minutes _____
Time to prime pump _____
Pressure control device test:
Rise while pumping capacity at 150 psi _____
Rise while pumping capacity at 90 psi _____
Rise while pumping 50 percent capacity at 250 psi _____
Intake relief valve test results _____
Tank to pump water flow test _____ (gpm) (L/min)
Gauge accuracy _____ Flowmeter accuracy _____

### Pump Test Results

| | Capacity test | Overload test | 200 psi test | 250 psi test |
|---|---|---|---|---|
| Duration | | | | |
| Average nozzle pressure | | | | |
| Corrected pressure | | | | |
| Gallons per minute | | | | |
| Average pump pressure | | | | |
| rpm—engine | | | | |
| rpm—pump | | | | |

Comments _____

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**FIGURE C.3(c) Pump Performance Test Form.**

## 20-Minute Capacity Test

Layout _____ Nozzle size _____ Position of transfer valve _____

| | | | | | | | | Pump Intake | | Pump Discharge | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | Counter (if used) | rpm | Tach | Engine Temperature | Oil Pressure | Voltage | Automatic Transmission Temp (if equipped) | Apparatus gauge | Test gauge | Apparatus gauge | Test gauge | Pitot/ Flow |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

## 5-Minute Overload Test

Layout _____ Nozzle size _____ Position of transfer valve _____

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

## 10-Minute 200 psi Test

Layout _____ Nozzle size _____ Position of transfer valve _____

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

## 10-Minute 250 psi Test

Layout _____ Nozzle size _____ Position of transfer valve _____

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

Person conducting the test _____

Representing _____

Signature _____ Date _____

AHJ representative _____ Date _____





**FIGURE C.3(c)** ***Continued***

## AERIAL DEVICE INSPECTION AND PERFORMANCE TEST

Emergency vehicle no. or designation _____ Year manufactured _____

Manufacturer _____ Model _____

Serial no. _____ Vehicle identification no. _____

Engine make _____ Model _____

Aerial device manufacturer _____ Model _____

Serial no. of aerial device _____ Rated vertical height _____

Type of aerial device ❑ Aerial ladder ❑ Elevating platform ❑ Water tower

Emergency vehicle miles _____ Emergency vehicle hours _____ Aerial hours _____

Reason for test _____

_____

Test location _____

Weather conditions at time of test _____

Temperature _____ (°F) (°C) Wind velocity (estimate) _____ (mph) (km/hr)

### Visual Inspection (attach copy of any checklist)

Comments _____

_____

_____

_____

_____

Disposition of any problems _____

_____

_____

### Operational Inspection

Comments _____

_____

_____

_____

_____

Disposition of any problems _____

_____

_____

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**FIGURE C.3(d) Aerial Device Inspection and Performance Test Form.**

### Load Test

Total weight used _____

Comments _____

_____

_____

_____

_____

Disposition of any problems _____

_____

_____

### Water System Test

Comments _____

_____

_____

_____

_____

Disposition of any problems _____

_____

_____

Person conducting the inspection and test _____

Representing _____

Signature _____ Date _____

AHJ representative _____ Date _____

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**FIGURE C.3(d)** ***Continued***

## LOW-VOLTAGE ELECTRICAL SYSTEM PERFORMANCE TEST

Emergency vehicle no. or designation _____ Year manufactured _____

Manufacturer _____ Serial no. _____

Number of batteries _____ Voltage _____

Battery manufacturer _____ Size/model _____

### Battery Tests

Battery rated CCA _____ Open circuit voltage(s) before testing _____

Conductivity test results: CCA value(s) _____ ❑ Pass ❑ Fail

or

Load test results: Test current _____ Battery temperature _____ °F (°C)

Minimum allowed voltage _____

Terminal voltage(s) _____ ❑ Pass ❑ Fail

### Starter Wiring Test

Voltage drop in positive (+) lead _____ ❑ Pass ❑ Fail

Voltage drop in negative (–) lead _____ ❑ Pass ❑ Fail

### Alternator Test

Alternator manufacturer _____ Model _____

Alternator nameplate rating _____

Alternator test output _____ ❑ Pass ❑ Fail

Voltage drop in positive (+) lead _____ ❑ Pass ❑ Fail

Voltage drop in negative (–) lead _____ ❑ Pass ❑ Fail

### Regulator Test

Regulator temperature _____

Regulator voltage, minimum load _____ ❑ Pass ❑ Fail

Regulator voltage, loaded _____ ❑ Pass ❑ Fail

### Battery Charger/Conditioner Test

Rated output _____ Test output _____ ❑ Pass ❑ Fail

Float voltage _____ ❑ Pass ❑ Fail

### Total Continuous Load Test

Battery voltage at start of test _____

Battery voltage at end of test _____ ❑ Pass ❑ Fail

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**FIGURE C.3(e) Low-Voltage Electrical System Performance Test Form.**

**Solenoid and Power Relay Test**

Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail
Device tested _____ Voltage drop _____ ❑ Pass ❑ Fail

Comments on low-voltage electrical system performance test _____

Person conducting the test _____
Representing _____
Signature _____ Date _____
AHJ representative _____ Date _____

 

**FIGURE C.3(e)** ***Continued***

## LINE VOLTAGE ELECTRICAL SYSTEM PERFORMANCE TEST

Emergency vehicle no. or designation _____ Year manufactured _____

Manufacturer _____ Serial no. _____

Power source type _____ Manufacturer _____

Model _____

Ratings — Volts _____ ac/dc _____ Phase _____ Frequency _____

Amps _____ Watts _____

Line voltage system is: ❑ Isolated ❑ Bonded neutral

### Power Source Annual Load Test

Test load total wattage _____

| Test Case | Voltage | Frequency |
|---|---|---|
| No load at start | | |
| Loaded at start | | |
| Loaded, 10 minutes | | |
| Loaded at end | | |
| No load at end | | |
| Minimum allowed | | |
| Maximum allowed | | |
| | ❑ Pass ❑ Fail | ❑ Pass ❑ Fail |

### Receptacle Wiring Tests

❑ Pass ❑ Fail Number of tests _____

Identify any problem receptacles _____

Comments _____

### Ground Fault Circuit Interrupters (GFCIs)

❑ Pass ❑ Fail Number of GFCIs tested _____

Comments _____

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**FIGURE C.3(f) Line Voltage Electrical System Performance Test Form.**

### Operational Tests of Line Voltage Equipment

❑ Pass ❑ Fail Describe any failures or problems _____

_____

Comments _____

_____

### Power Source Full Load Test

Test load total wattage _____

| Test Case | Voltage | Frequency |
|---|---|---|
| 0% load at start | | |
| 50% load at start | | |
| 100% load, 0 minutes | | |
| 100% load, 10 minutes | | |
| 100% load, 20 minutes | | |
| 100% load, 30 minutes | | |
| 100% load, 40 minutes | | |
| 50% load at end | | |
| 0% load at end | | |
| Minimum allowed | (–10%) | (–3Hz) |
| Maximum allowed | (+10%) | (+3Hz) |
| | ❑ Pass ❑ Fail | ❑ Pass ❑ Fail |

### Dielectric Withstand Test

❑ Pass ❑ Fail ❑ Not applicable Comments _____

_____

Comments on line voltage electrical system performance test _____

_____

_____

_____

Person conducting the test _____

Representing _____

Signature _____ Date _____

AHJ representative _____ Date _____





**FIGURE C.3(f)** ***Continued***

## FOAM PROPORTIONING SYSTEM PERFORMANCE TEST

Emergency vehicle no. or designation _____ Year manufactured _____

Manufacturer _____ Model _____

Serial no. _____ Vehicle identification no. _____

Foam proportioner make _____ Model _____

Foam proportioner type _____ Serial no. _____

Foam proportioner specifications:

| | | |
|---|---|---|
| Flow range | Min _____ | Max _____ |
| Pressure range | Min _____ | Max _____ |
| Percentage range | Min _____ | Max _____ |
| Foam concentrate viscosity | Min _____ | Max _____ |
| Power requirements | Min _____ | Max _____ |

Test conditions: Proportioning ratio _____ Waterflow _____ Water Pressure _____

Test method used:

- ❑ Substituting water for foam concentrate
- ❑ Measuring foam concentrate pump output directly
- ❑ Determining foam percentage by use of a refractometer
- ❑ Determining foam percentage by use of a conductivity meter

Calibration accuracy _____ Within minimum requirements? ❑ Yes ❑ No

Comments on foam proportioning system performance test _____

_____

_____

_____

_____

_____

Tested by _____ Date _____

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**FIGURE C.3(g) Foam Proportioning System Performance Test Form.**

## CAFS COMPRESSOR PERFORMANCE TEST

Emergency vehicle no. or designation _____ Year manufactured _____

Manufacturer _____ Model _____

Serial no. _____ Vehicle identification no. _____

Compressor make _____ Model _____

Compressor rate capacity at 125 psi (862 kPa) _____ SCFM

Compressor drive ❑ Belt ❑ Engine ❑ PTO ❑ Hydraulic

If engine, make _____ Model _____

Test device _____ Airflow meter _____ Fixed orifice _____ (size)

### Compressor Run Test

| Time | Air Pressure | Airflow (SCFM) | Compressor Temperature |
|---|---|---|---|
| Start | | | |
| 5 minutes | | | |
| 10 minutes | | | |
| 15 minutes | | | |
| 20 minutes | | | |

Maximum air pressure: psi _____

### Pressure Balance Test

| Time | Water Pressure | Air Pressure | Percent Difference |
|---|---|---|---|
| At test start | | | |
| With air flowing | | | |
| After 5 minutes | | | |

Comments on CAFS compressor performance test _____

Tested by _____ Date _____



**FIGURE C.3(h) CAFS Compressor Performance Test Form.**

## Annex D Guidelines for First-Line and Reserve Fire Apparatus (NFPA 1911)

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

**D.1 General.** To maximize firefighter capabilities and minimize risk of injuries, it is important that fire apparatus be equipped with the latest safety features and operating capabilities.

In the last 10 to 15 years, much progress has been made in upgrading functional capabilities and improving the safety features of fire apparatus. Apparatus more than 15 years old might include only a few of the safety upgrades required by the recent editions of the NFPA fire department apparatus standards or the equivalent Underwriters Laboratories of Canada (ULC) standards. Because the changes to NFPA 1901 and NFPA 1906 (which are now consolidated in NFPA 1900) have been truly significant, especially in the area of safety, fire departments should seriously consider the value (or risk) to firefighters of keeping fire apparatus more than 15 years old in first-line service.

It is recommended that apparatus more than 15 years old that have been properly maintained and are still in serviceable condition be placed in reserve status, be upgraded in accordance with this standard, and incorporate as many features as possible of the current fire apparatus standard *(see Section D.3)*. This will ensure that many of the improvements and upgrades required by the current editions of the standards are available to the firefighters who use the apparatus, even if the apparatus might not comply completely with current editions of automotive fire apparatus standards.

Apparatus that were not manufactured to the applicable NFPA fire apparatus standards or that are over 25 years old should be replaced.

**D.2 Evaluating Fire Apparatus.** It is a generally accepted fact that fire apparatus, like all types of mechanical devices, have a finite life. The length of that life depends on many factors, including vehicle mileage and engine hours, quality of the preventative maintenance program, quality of the driver training program, whether the fire apparatus was used within the design parameters, whether the apparatus was manufactured on a custom or commercial chassis, quality of workmanship by the original manufacturer, quality of the components used, and availability of replacement parts, to name a few.

In the fire service, there are fire apparatus with 8 to 10 years of service that are simply worn out. There are also fire apparatus that were manufactured with quality components, that have had excellent maintenance, and that have responded to a minimum number of incidents that are still in serviceable condition after 20 years. Most would agree that the care of fire apparatus while being used and the quality and timeliness of maintenance are perhaps the most significant factors in determining how well a fire apparatus ages.

Critical enhancements in design, safety, and technology should also play a key role in the evaluation of an apparatus life cycle. Previous editions of the fire department apparatus standards featured many requirements advancing the level of automotive fire apparatus safety and user friendliness.

Contained within the 2009 edition were requirements for rollover stability; tire pressure indicators; seat belt warning systems requiring all occupants be properly seated and belted; extended seat belt length requirements resulting from an in-depth anthropometric study evaluating the average size of today's fully dressed firefighter; roadability, including minimum accelerations and top speed limitations; enhanced step and work surface lighting; cab integrity testing; increased use of retroreflective striping in the rear of apparatus, providing a consistent identifiable set of markings for all automotive fire apparatus; and enhanced aerial control technologies, enabling short jacking and envelope controls.

**D.3 Upgrading Fire Apparatus.** Any apparatus, whether in first-line or reserve service, needs to be upgraded in accordance with Chapters 29 through 31, as necessary, to ensure that the following features are included as a minimum:

(1) Seat belts with seat belt warning systems are available for every seat and are new or in serviceable condition.
(2) Warning lights meet or exceed the current standard.
(3) Reflective striping meets or exceeds the current standard.
(4) Slip resistance of walking surfaces and handrails meets the current standard.
(5) A low-voltage electrical system load manager is installed if the total connected load exceeds the alternator output.
(6) The alternator output is capable of meeting the total continuous load on the low voltage electrical system.
(7) Where the gross vehicle weight rating (GVWR) is 36,000 lb (16,000 kg) or more, an auxiliary braking system is installed and operating correctly.
(8) Ground and step lighting meets or exceeds the current standard.
(9) Noise levels in the driving and crew compartment(s) meet the current standard, or appropriate hearing protection is provided.
(10) All horns and sirens are relocated to a position as low and as far forward as possible.
(11) Signs are present stating that no riding is allowed on open areas.
(12) A pump shift indicator system is present and working properly for vehicles equipped with an automatic chassis transmission.
(13) For vehicles equipped with electronic or electric engine throttle controls, an interlock system is present and working properly to prevent engine speed advancement at the operator's panel, unless either the chassis transmission is in neutral with the parking brake engaged, or the parking brake is engaged, the fire pump is engaged, and the chassis transmission is in pumping gear.
(14) All loose equipment in the driving and crew areas is securely mounted in accordance with the current standard.

**D.4 Proper Maintenance of Fire Apparatus.** In addition to needed upgrades to older fire apparatus, it is imperative that all fire apparatus be checked and maintained regularly to ensure that they will be reliable and safe to use. The manufacturer's instructions should always be followed when maintaining the fire apparatus. Special attention should be paid to ensure that the following conditions, which are particularly critical to maintaining a reliable unit, exist:

(1) Engine belts, fuel lines, and filters have been replaced in accordance with the manufacturers' maintenance schedule(s).

(2) Brakes, brake lines, and wheel seals have been replaced or serviced in accordance with the manufacturers' maintenance schedule.
(3) Tires and suspension are in serviceable condition, and tires are not more than 7 years old.
(4) The radiator has been serviced in accordance with the manufacturer's maintenance schedule, and all cooling system hoses are new or in serviceable condition.
(5) The alternator output meets its rating.
(6) A complete weight analysis shows the fire apparatus is not over individual axle rating or total GVWR.
(7) The fire pump meets or exceeds its original pump rating.
(8) The water tank and baffles are not corroded or distorted.
(9) If the apparatus is equipped with an aerial device, a complete test to original specifications has been conducted and certified by a certified testing laboratory.
(10) If so equipped, the generator and line voltage accessories have been tested and meet the current standard.

**D.5 Refurbishing or Replacing Fire Apparatus.** Fire department administrators and fire chiefs should exercise special care when evaluating the cost of refurbishing or updating an apparatus versus the cost of a new fire apparatus. Apparatus that are refurbished need to comply with the requirements of Chapters 29 through 31. A thorough cost–benefit analysis of the value of upgrading or refurbishing a fire apparatus should be conducted. In many instances, it will be found that refurbishing costs will greatly exceed the current value of similar apparatus.

Some factors to consider and evaluate when determining whether to refurbish or replace a fire apparatus include the following:

(1) What is the true condition of the existing apparatus? Has it been in a major accident, or has something else happened to it that would make spending significant money on it ill advised?
(2) What advancements in design, safety, and technology have improved the efficiency and safety of personnel?
(3) Does the current apparatus meet the program needs of the area it is serving? Is it designed for the way the fire department operates today and is expected to operate in the foreseeable future, or is the apparatus functionally obsolete? Can it carry everything that is needed to do the job without being overloaded?
(4) If the apparatus is refurbished, will it provide the level of safety and operational capability of a new fire apparatus? It should be noted that, in many cases, refurbishing does not mean increasing the GVWR, so it is not possible to add a larger water tank or additional foam agent tanks or to carry massive amounts of additional equipment. Enclosing personnel riding areas might add enough weight to the chassis that existing equipment loads need to be reduced to avoid overloading the chassis.
(5) What would the anticipated cost per year to operate the apparatus be if it were refurbished? What would the cost per year be for a new apparatus? Insurance costs, downtime costs, maintenance costs, depreciation, reliability, and the safety of the users and the public all have to be considered. At what rate are those costs rising each year? Are parts still readily available for all the components on the apparatus? For example, a refurbished 15-year-old apparatus still has 15-year-old parts in it. How long could the fire department operate without the apparatus if it suddenly needed major repairs?
(6) Is there a current trade-in value that will be gone tomorrow?

**D.6 Conclusion.** A fire apparatus is an emergency vehicle that must be relied on to transport firefighters safely to and from an incident and to operate reliably and properly to support the mission of the fire department. A piece of fire apparatus that breaks down at any time during an emergency operation not only compromises the success of the operation but might jeopardize the safety of the firefighters relying on that apparatus to support their role in the operation. An old, worn-out, or poorly maintained fire apparatus has no role in providing emergency services to a community.

## Annex E Fire Apparatus Refurbishing Specifications (NFPA 1912)

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

**E.1 General.** Fire apparatus refurbishing can range from simple cosmetic–type restorations to complete Level I refurbishing. Therefore, the amount of information that the contractor and purchaser require can vary greatly. Depending on the scope of the proposed work, the details discussed in some or all of the following paragraphs should be considered. It is recommended that the form in Figure E.1 be used to identify the necessary information to properly develop specifications for those portions of the fire apparatus to be modified or upgraded during the refurbishing.

The local fire chief and fire department staff know the conditions under which the apparatus will be used. However, competent advice should also be obtained from knowledgeable and informed sources such as other experienced fire service personnel, trade journals, training instructors, maintenance personnel, and fire equipment and component manufacturers. The fire insurance rating authority should also be consulted.

The study should look not only at current operations and risks protected but also at how these might change over the life of the fire apparatus.