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NFPA 407 Aircraft Fuel Servicing 1985

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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

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

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

Statement on NFPA Procedures

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

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NFPA 407

Standard for

Aircraft Fuel Servicing

1985 Edition

This edition of NFPA 407, *Standard for Aircraft Fuel Servicing*, was prepared by the Technical Committee on Aircraft Fuel Servicing, released by the Correlating Committee on Aviation, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 12-15, 1984 in San Diego, California. It was issued by the Standards Council on December 7, 1984, with an effective date of December 27, 1984, and supersedes all previous editions.

The 1985 edition of this standard has been approved by the American National Standards Institute.

Origin and Development of NFPA 407

Active work by the National Fire Protection Association leading towards the development of this standard started in 1951. Since that date, the responsible Technical Committee has made every effort to keep the text up-to-date and progressive editions have been published almost every year from 1955 to 1975. The 21st edition was issued in 1980 and the Technical Committee completed a partial revision in 1984.

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

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

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Aircraft Fuel Servicing

1985 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.
Information on referenced publications can be found in Chapter 7 and Appendix B.

Chapter 1 Administration

1-1 Scope. This standard applies to the ground fuel servicing of all types of aircraft with liquid petroleum fuel. It does not apply to: (a) in-flight fueling; (b) fuel servicing of flying boats or amphibious aircraft on water; or (c) draining or filling of aircraft fuel tanks incidental to aircraft fuel system maintenance operations or manufacturing.

1-2* Purpose.

1-2.1 The purpose of this standard is to establish reasonable minimum fire safety requirements for procedures, equipment, and installations for the protection of persons, aircraft and other property during ground fuel servicing of aircraft with liquid petroleum fuels. These requirements are based upon sound engineering principles, test data and field experience.

1-2.2 The fire hazard properties of standard grades of aviation fuels vary, but, for the purpose of this standard, the same fire safety precautions are specified for all types.

1-3 Definitions.

Aircraft. A vehicle designed for flight that is powered by liquid petroleum fuel.

Aircraft Fuel Servicing Hydrant Vehicle (Hydrant Vehicle). A vehicle equipped with facilities to transfer fuel between a fuel hydrant and an aircraft.

Aircraft Fuel Servicing Tank Vehicle (Fueler). A tank vehicle (tank truck, tank full trailer, tank semitrailer) designed for or employed in the transportation and transfer of fuel into or from an aircraft.

Aircraft Fueling Vehicle. A Fuel Servicing Hydrant Vehicle or an Aircraft Fuel Servicing Tank Vehicle.

Aircraft Servicing Ramp or Apron. An area or position at an airport used for the fuel servicing of aircraft.

Airport Fueling System. An arrangement of aviation fuel storage tanks, pumps, piping, and associated equipment, such as filters, water separators, hydrants, cabinets, and pits installed at an airport and designed to service aircraft at fixed positions.

Approved. Acceptable to the "authority having jurisdiction."

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

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, 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 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."

Baffle. A non-liquid-tight transverse partition in a cargo tank.

Bulkhead. A liquid-tight transverse closure between compartments of a cargo tank.

Burst Pressure. See Pressure.

Carcass Saturation. The condition where fuel has permeated the reinforcing materials of a hose carcass.

Cargo Tank. A container having a liquid capacity in excess of 100 gallons, used for the carrying of aviation fuels, and mounted permanently or otherwise secured on a tank vehicle. The term "cargo tank" does not apply to any container used solely for the purpose of supplying fuel for the propulsion of the vehicle on which it is mounted.

Cathodic Protection. An electrical method of reducing, stopping or diverting the flow of electrical currents which, if not controlled, cause corrosion of metal components of airport fueling systems which are in contact with the ground.

Compartment. A liquid-tight division in a cargo tank.

Deadman Control*. A device which requires a positive continuing action of an operator to allow the flow of fuel.

Design Pressure. See Pressure.

Fueler. See Aircraft Fuel Servicing Tank Vehicle.

Fuel Servicing. Fueling and defueling of aircraft fuel tanks, not including aircraft fuel transfer operations and testing of aircraft fuel systems during aircraft maintenance or manufacturing operations.

Fuel Servicing Cabinet. An aboveground structure containing hose, meters and auxiliary equipment, connected to an airport fueling system, to enable fuel to be dispensed into aircraft.

Fuel Servicing Pit. A pit containing hose, meters and auxiliary equipment, connected to an airport fueling system, to enable fuel to be dispensed into aircraft.

Head. A liquid-tight transverse closure at the end of a cargo tank.

Hydrant. An outlet of an Airport Fueling System which includes a deadman controlled valve and adapter assembly to which a coupler on a hose in an aircraft fuel servicing vehicle can be connected.

Hydrant Valve. See Hydrant.

Hydrant Vehicle. See Aircraft Fuel Servicing Hydrant Vehicle.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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.

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

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Overshoot. The quantity of fuel passing through the valve after the deadman control is released.

Pressure:

Burst Pressure. The pressure at which any component will rupture.

Test Pressure. The pressure to which the system or a component of such system may be subjected to verify the integrity of the system or component. It is usually expressed as a multiple of the working pressure.

Working Pressure. The maximum pressure, including momentary surge pressure, to which a system, hose or other component may be safely subjected in service. On aircraft fueling hose this is the pressure shown on the label.

Shall. Indicates a mandatory requirement.

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

Standard Grades of Aviation Fuel*. Any petroleum fuel intended for use in aircraft engines.

Tank Full Trailer. A vehicle that is not self-propelled and which has a cargo tank for the transportation of aviation fuel mounted thereon or built as an integral part thereof. It is so constructed that its weight and load rest on its own wheels.

Tank Semitrailer. A vehicle that is not self-propelled and which has a cargo tank for the transportation of aviation fuel mounted thereon or built as an integral part thereof. It is so constructed that when drawn by a tractor by means of a fifth wheel connection, some of its load and weight rests upon the towing vehicle.

Tank Truck. A self-propelled vehicle having a cargo tank for the transportation of aviation fuel.

Tank Vehicle. Any tank truck, tank full trailer, or tractor and tank semitrailer combination.

Test Pressure. See Pressure.

Transfer Pipeline. Piping used to transfer fuel in an airport fueling system.

Working Pressure. See Pressure.

1-4 Units. When a value for a measurement as given in this standard is followed by an equivalent value in other units, the first stated shall be regarded as the requirement. A given equivalent value may be approximate.

Chapter 2 General Requirements

2-1 Fuel Servicing Personnel. Only authorized personnel trained in the safe operation of the equipment they use, in the operation of emergency controls, and in procedures to be followed in an emergency shall fuel or defuel aircraft.

2-2* Prevention and Control of Spills.

2-2.1 Fuel servicing equipment shall comply with the requirements of this standard and be maintained in safe operating condition. Leaking or malfunctioning equipment shall be removed from service.

2-2.2 Self-closing nozzles or deadman controls shall not be blocked open or bypassed.

2-2.3 Fuel nozzles shall not be dragged along the ground.

2-2.4 Pumps, either hand- or power-operated, shall be used when aircraft are fueled from drums. Pouring or gravity flow shall not be permitted.

2-2.5 Kinks and short loops in fueling hose shall be avoided.

2-2.6 When a spill is observed, the fuel servicing shall be stopped immediately by release of the deadman controls and operation of the emergency fuel shutoff. The supervisor shall be notified at once and the operation shall not be continued until he has determined that it is safe to do so.

2-2.7 The airport fire crew shall be notified if a spill is over 10 feet (3 m) in any dimension or over 50 square feet (5 m^2) in area; continues to flow; or is otherwise a hazard to persons or property.

2-2.8 Every fuel spill shall be investigated to determine the cause, whether emergency procedures were properly carried out, and what corrective measures are required.

2-2.9* Transferring fuel by pumping from one tank vehicle to another tank vehicle which is connected to and pumping fuel into an aircraft shall be prohibited.

2-2.10 Not more than one tank vehicle shall be permitted to be connected to the same aircraft fueling manifold unless means are provided to prevent fuel from flowing back into a tank vehicle because of difference in pumping pressure.

2-3* Bonding and Grounding.

2-3.1 To dissipate any charge of static electricity on the aircraft and any charge that may be generated by the flow of fuel through piping, valves, filters, hose or other components during aircraft fuel servicing, the aircraft and all fueling vehicles, hydrants, pits, cabinets, and nozzles shall be electrically bonded to each other and grounded before fuel flow starts. When servicing fixed wing aircraft at a rate not over 25 gpm using hose of not less than 1¼ in. nominal diameter, only bonding shall be required.

2-3.2* When a fueler or hydrant vehicle is used to service an aircraft, the following static bonding and grounding procedures shall be followed:

(a) Connect a grounding cable from the vehicle to a satisfactory ground.

(b) Connect a grounding cable from the ground to the aircraft grounding fitting, if one is provided; otherwise, connect the grounding cable to a convenient unpainted metal point on the aircraft. This connection shall not be made to a propeller, a radio antenna, or to highly-stressed components of the landing gear where scratches could initiate metal failure.

(c) Bond the vehicle to the aircraft. Where a "Y" or "V" cable permanently attached to the fueling vehicle is used to accomplish (a) and (b), a separate bonding cable is not necessary. Conductive hose shall not be accepted to accomplish this bonding.

(d) Bond the fuel nozzle to the aircraft. For overwing servicing, connect a bonding cable from the fuel nozzle to the aircraft. For underwing servicing, this bond shall be achieved by metal to metal contact between the aircraft fitting and the nozzle. A separate bonding cable shall not be required.

1. Where aircraft and fuel nozzles are equipped with plug and jack bonding facilities, the nozzle bonding plug shall be inserted in the aircraft jack before the aircraft fuel tank filler cap is opened.

2. When fueling aircraft not having bonding jacks and in fueling all aircraft having fabric covered wings, the bonding clip at the end of the nozzle bond wire shall first be touched to the tank filler before it is opened to assure that no difference in electrostatic potential exists between the two elements. The nozzle shall be equipped with a strong bond wire having a spring clamp which shall then be firmly attached to a bonding post or other uninsulated metallic part of the aircraft and this contact shall be maintained until the flow of fuel has been discontinued and all measuring completed.

(e) Disconnection shall be in reverse order on completion of fuel servicing.

(f) Nozzles, hoses and cables used for bonding and grounding shall be securely stowed when the fuel servicing operation is completed.

2-3.3 When a pit or cabinet is used for fuel servicing, static grounding shall be provided in the construction for all portions of the system isolated for purposes of cathodic protection. The following procedure shall be followed:

(a) Connect a bonding cable from a satisfactory bonding connection at the dispenser to the aircraft as required by 2-3.2(b).

(b) For overwing servicing, connect a bonding cable to the aircraft as required by 2-3.2(d).

(c) Disconnection shall be in reverse order on completion of fuel servicing.

2-3.4* When a funnel is used in aircraft fueling it shall be metal. The funnel shall be electrically bonded to the aircraft and to the fueling nozzle. This requirement is in addition to any other applicable requirements and it shall not be waived. Funnels shall be of at least 2 gallons (8 liters) capacity to minimize possibility of spillage.

2-3.5 Where aircraft are serviced from drums by means of pumps, the procedures in 2-3.2.1 shall be followed.

2-3.6 Bonding cables shall be of flexible, durable design and material.

2-3.7 The plug and jack assembly and the spring clamp shall be of unpainted metal.

2-3.8 Bonding and grounding connections shall be electrically and mechanically firm. Jacks, plugs, clamps, and connecting points shall be clean, unpainted metal to provide a positive electrical connection.

2-3.9* An adequate number of suitable grounding connections shall be provided on aircraft servicing ramps or aprons.

2-3.10 Conductive hose shall not be used to accomplish required bonding.

2-4 Operation of Aircraft Engines, Auxiliary Power Units, and Heaters.

2-4.1 Other than as permitted in 2-4.2, fuel servicing shall not be done on an aircraft while an engine is operating.

2-4.2 In an emergency resulting from the failure of an onboard auxiliary power unit on a jet aircraft and in the absence of suitable ground support equipment, a jet engine mounted at the rear of the aircraft or on the wing on the side opposite from the fueling point may be operated during fueling to provide power, provided that the operation follows written procedures approved by the authority having jurisdiction.

2-4.3 A turbine-powered auxiliary power unit installed aboard an aircraft may be operated during fueling provided its design, installation, location, and combustion air source do not constitute a fuel-vapor source.

2-4.4 Combustion heaters on aircraft (e.g., wing and tail surface heaters, integral cabin heaters) shall not be operated during fueling operations.

2-5* Automotive Equipment (Other than Aircraft Fuel Servicing Vehicles) on Airport Servicing Ramps or Aprons.

2-5.1 Automotive equipment, other than those performing aircraft servicing functions, shall not be permitted within 50 feet (15 m) of aircraft during fuel servicing operations.

2-5.2 Automotive equipment performing aircraft servicing functions shall not be positioned within a 10-foot (3-m) radius of aircraft fuel system vent openings.

2-5.3 During overwing aircraft fuel servicing or where aircraft fuel system vents are located on the upper wing surface, automotive vehicles shall not be positioned under the trailing edge of the wing.

2-6 Electrical Equipment Used on Aircraft Servicing Ramps.

2-6.1 Battery chargers shall not be connected, operated, or disconnected while fuel servicing is being done on the aircraft.

2-6.2* Aircraft ground-power generators or other electrical ground-power supplies shall not be connected or disconnected while fuel servicing is being done on the aircraft. During overwing fueling or where aircraft fuel servicing vents are located on the upper wing surface, ground-power generators shall not be positioned under the trailing edge of the wing. Ground-power generators shall not be positioned within a 10-foot (3-m) radius of aircraft fuel system vent openings.

2-6.3* Electric tools, drills, buffers, or similar tools likely to produce sparks or arcs shall not be used while fuel servicing is being done on the aircraft.

2-6.4 Photographic flash bulbs or electronic flash equipment shall not be used within 10 feet (3 m) of fueling equipment or of the fill or vent points of aircraft fuel systems.

2-7 Open Flames on Aircraft Servicing Ramps.

2-7.1 Open flames and lighted open flame devices shall be prohibited on aircraft servicing ramps or aprons and in other locations within 50 feet (15 m) of any aircraft fuel servicing operation or fueling equipment. Entrances to fueling areas shall be posted with "NO SMOKING" signs.

2-7.2 Included in the category of open flames and lighted open-flame devices are the following:

(a) Lighted cigarettes, cigars, pipes, etc.

(b) Exposed flame heaters, liquid, solid or gaseous devices, including portable and wheeled gasoline or kerosine heaters.

(c) Welding or cutting torches, blowtorches, etc.

(d) Flare pots or other open-flame lights.

2-7.3 The authority having jurisdiction may establish other locations where open flames and open-flame devices shall be prohibited.

2-8 Carriage of Lighters and Matches by Aircraft Fuel Service Personnel. Personnel shall not carry lighters or matches on their person while engaged in fuel servicing operations.

2-9* Radar Equipment.

2-9.1 Aircraft Radar Equipment.

2-9.1.1 Surveillance radar equipment in aircraft shall not be operated within 300 feet (90 m) of any fuel servicing or other operation in which flammable liquids or vapors may be present or created.

2-9.1.2 Weather-mapping radar equipment in aircraft shall not be operated when the aircraft in which it is mounted is undergoing fuel servicing.

2-9.2 Ground Radar Equipment.

2-9.2.1 Antennas of airport flight traffic surveillance radar equipment shall be located so that the beam will not be directed toward any fuel storage or loading racks within 300 feet (90 m). Aircraft fuel servicing shall not be conducted within this 300-foot (90-m) distance.

2-9.2.2 Antennas of airport ground traffic surveillance radar equipment shall be located so that the beam will not be directed toward any fuel storage or loading racks within 100 feet (30 m). Ailrcraft fuel servicing or any other operations involving flammable liquids or vapors shall not be conducted within 100 feet (30 m) of such antennas.

2-10* Lightning Precautions. Fuel servicing operations shall be suspended when there are lightning discharges in the immediate vicinity of the airport.

2-11 Aircraft Fuel Servicing Locations.

2-11.1 Aircraft fuel servicing shall be done outdoors.

2-11.2* Aircraft being fueled shall be positioned so that aircraft fuel system vents or fuel tank openings are not closer than 25 feet (8 m) from any terminal building, hangar, service building, or enclosed passenger concourse other than a loading walkway or within 50 feet (15 m) of any combustion and ventilation air intake to any boiler, heater, or incinerator room facing the ramp side of the terminal or concourse.

2-11.3* Accessibility to aircraft by emergency fire equipment shall be considered in establishing aircraft fuel servicing positions.

2-12* Fueling During Boarding and Deplaning of Passengers. Operators shall determine for each aircraft type the areas through which it might be hazardous for boarding or deplaning passengers to pass while the aircraft is being fueled. Controls shall be established so that passengers avoid such areas.

2-13 Aircraft Occupancy During Fuel Servicing Operations. If passengers remain on board an aircraft during fuel servicing, at least one qualified person trained in emergency evacuation procedures shall be in the aircraft at or near a door at which there is a passenger loading walkway, integral stairs which are down, or a passenger loading stair or stand. A clear area for emergency evacuation of the aircraft shall be maintained at no less than one additional exit. Aircraft operators shall establish specific procedures covering emergency evacuation under such conditions for each type aircraft they operate. A "NO SMOKING" sign shall be displayed in the cabin(s) and the rule enforced.

2-14 Positioning of Aircraft Fuel Servicing Vehicles.

2-14.1 Aircraft fuel servicing vehicles shall be positioned so that they can be moved promptly after all aircraft fuel hoses have been disconnected and stowed.

2-14.2 The propulsion or pumping engine of aircraft fuel servicing vehicles shall not be positioned under the wing of aircraft during overwing fueling or where aircraft fuel system vents are located on the upper wing surface. Aircraft fuel servicing vehicles shall not be positioned within a 10-foot (3-m) radius of aircraft fuel system vent openings.

2-14.3 Hand brakes shall be set on fuel servicing vehicles before operators leave the vehicle cab.

2-15* Portable Fire Extinguishers on Aircraft Servicing Ramps or Aprons. Portable fire extinguishers shall be available on aircraft servicing ramps or aprons in accordance with the following:

2-15.1 Where the open hose discharge capacity of the aircraft fueling system or equipment is not more than 200 gallons per minute (750 L/min), at least two listed extinguishers having a rating of not less than 20-B each shall be provided.

NOTE: The "open hose discharge capacity" is the "broken hose" capacity, not the actual delivery rate of any particular operation.

2-15.2 Where open hose discharge capacity of the aircraft fueling system or equipment is more than 200 gallons per minute (750 L/min) but not over 350 gallons per minute (1300 L/min), at least one listed wheeled extinguisher having a rating of not less than 80-B and a minimum capacity of 125 pounds (55 kg) of agent shall be provided.

2-15.3 Where the open hose discharge capacity of the aircraft fueling system or equipment is more than 350 gallons per minute (1300 L/min), at least two listed wheeled extinguishers each having a rating of at least 80-B and a minimum capacity of 125 pounds (55 kg) of agent shall be provided.

2-15.4 Extinguishers shall conform with the requirements of NFPA 10, *Standard for Portable Fire Extinguishers.*

2-15.5* Extinguishers shall be kept clear of ice, snow, etc. Extinguishers located in enclosed compartments shall be readily accessible and their location shall be clearly marked in letters at least 2 inches (50 mm) high.

2-15.6* Fuel servicing personnel shall be trained in the use of the available fire extinguishing equipment they might be expected to utilize.

2-16 Defueling. The transfer of fuel from an aircraft to a tank vehicle through a hose is generally similar to fueling and the same requirements apply. In addition, each operator shall establish procedures to prevent the overfilling of the tank vehicle, which is a special hazard to defueling. The procedures in Chapter 9 of NFPA 410, *Standard on Aircraft Maintenance*, shall be followed when draining residual fuel from aircraft tanks incidental to aircraft fuel system maintenance or testing, manufacturing, and during aircraft salvage or recovery operations.

2-17 Deadman Control Fuel Flow. The valve which controls the flow of fuel to an aircraft shall have a deadman control. The deadman control shall be arranged so that the fuel serviceman can observe the operation while he is holding the control. The fuel flow control valve may be:

(a) In a hydrant. *See 5-8.2; or*

(b) At the tank outlet on a tank vehicle. *See 4-9.7(b); or*

(c) A separate valve on the tank vehicle; or

(d) On the hose nozzle for overwing servicing with a tank vehicle. *See 4-9.3.*

The flow control system shall be designed to minimize surge pressure and overshoot when fuel flow is shut off. The system shall be designed to cut off fuel flow effectively when the deadman control is released. It shall function even with a reduction of pressure such as could result from a hose or line break. It shall fail safe by closing completely in the event of control power loss. In an aircraft fueling system the control valve shall be located and designed so that it will not be rendered inoperative by a surface accident, power failure or spill.

The use of any means that would defeat the deadman control shall be prohibited.

Chapter 3 Aircraft Fueling Hose

3-1 Aircraft Fueling Hose Requirements.

3-1.1 Performance Requirements.

3-1.1.1 Materials used in the fabrication of aircraft fueling hose shall be resistant to damage from exposure to aviation fuels. The hose cover shall be resistant to damage by abrasion, bending, crushing or kinking.

3-1.1.2 Aircraft fueling hose shall be flexible and serviceable at ambient temperatures as low as −31°F (−35°C). Special low temperature hose shall be flexible and serviceable at ambient temperatures of −61°F (−55°C).

3-1.1.3 The working pressure of aircraft fueling hose shall be at least 150 psi (1000 kpa). The minimum burst pressure shall be four (4) times the working pressure.

3-1.1.4 Each length of new hose shall be hydrostatically tested by the manufacturer at a minimum of one and one-half (1½) times the working pressure.

3-1.2 Additional requirements.

3-1.2.1 Each coupled length of hose shall have at least one permanent label or marking at intervals not exceeding 6 ft (1.8 m) showing the manufacturer's name or trademark, the year and quarter of manufacturer, the working pressure and the identification "Aircraft Fueling Hose — NFPA 407."

3-1.2.2 Aircraft fueling hose shall not have an internal bonding wire.

3-2* In-Service Inspection and Maintenance.

3-2.1 Aircraft fueling hose shall be inspected each day before it is put into use. The hose shall be extended as it normally would be for fueling. Check the portion of the hose that is exposed and extended for evidence of blistering, carcass saturation or separation, cuts, nicks or abrasions which expose reinforcement material and for slippage, misalignment or leaks at couplings. If coupling slippage or leaks are found the cause of the problem shall be determined. Defective hose shall be removed from service.

3-2.2 At least once each month the hose shall be completely extended and inspected. Inspect as required for daily inspection in 3-2.1. Examine the hose couplings and the hose for about 12 in. (305 m) adjacent to the coupling. Check for structural weakness by pressing the hose in this area around its entire circumference and feeling for soft spots. Hose that shows evidence of soft spots shall be removed from service. Examine the nozzle screens for rubber particles. Presence of such particles indicates possible deterioration of the interior and the hose shall be removed from service. With the hose still completely extended it shall be checked at normal operating pressure. Any abnormal twisting or ballooning during this test indicates a weakening of the hose carcass and the hose shall be removed from service.

3-2.3 A hose assembly that has been subjected to abuse, such as severe end pull, flattening or crushing by a vehicle, sharp bending or kinking shall be removed from service. It shall be hydrostatically tested at one and one-half (1½) times the working pressure to assure its serviceability before it is returned to service.

3-2.4 If inspection shows that a portion of a hose that has been removed from service in accordance with the requirements of this section is still serviceable and is of a useable length, the damaged portion may be cut off and the undamaged portion recoupled. Only couplings that are an exact match for the interior and exterior dimensions of the hose shall be used. Recoupled hose assemblies shall be hydrostatically tested at a minimum of one and one-half (1½) times the working pressure.

3-2.5 Before any hose assembly, new or recoupled, is placed in service it shall be visually inspected for evidence of damage or deterioration.

3-3 Hydrostatic Testing. Required hydrostatic testing shall be done in accordance with ASTM D-380, *Standard Methods of Testing Rubber Hose*.

Exception: The check required by 3-2.2 shall be done at normal operating pressure without uncoupling the hose.

3-4 Records. Suitable records shall be kept of required inspections and hydrostatic tests.

Chapter 4 Aircraft Fuel Servicing Vehicles

4-1 Use on Public Highways. Aircraft fuel servicing tank vehicles which are used on public highways shall also comply with NFPA 385, *Recommended Regulatory Standard for Tank Vehicles for Flammable and Combustible Liquids*.

4-2 Materials.

4-2.1 General. In addition to any specific requirements in this chapter, only materials safe for use in the service intended shall be used in the construction of aircraft fuel servicing vehicles.

4-2.2 Magnesium. Magnesium shall not be used in the construction of any portion of an aircraft fuel servicing tank vehicle.

4-3 Vehicles' Assembly, Static Protection, Design Features and Protection.

4-3.1 Assembly. Every cargo tank shall be supported by and attached to, or be a part of, the tank vehicle upon which it is carried in accordance with 2-3.6, Supports and Anchoring, of NFPA 385, *Recommended Regulatory Standard for Tank Vehicles for Flammable and Combustible Liquids*.

4-3.2 Static Protection.

4-3.2.1 Cargo tanks and vehicle chassis shall be electrically bonded to prevent a difference in electrostatic potential.

4-3.2.2 Provision shall be made in the tank structure of the vehicle for the bonding of vehicle fill pipe(s) during loading operations.

4-3.2.3* Static discharge cables shall be provided on the vehicle to permit the bonding and grounding operations specified in Section 2-3.

4-3.2.4 A cable with a clamp or plug shall be attached to each overwing nozzle to facilitate compliance with 2-3.2.1(d).

4-3.3 Vehicle Propulsion Fuel System.

4-3.3.1 Vehicle fuel tanks shall be so designed, constructed and installed as to present no unusual hazard. No part of any fuel tank or its intake pipe shall project beyond the overall width of the vehicle. Any fuel tank mounted outside the frame of the vehicle, or in an exposed location, shall be listed for such use. Fuel tanks shall be arranged to vent during filling operations and to permit drainage without removal from their mountings.

4-3.3.2 Gravity feed fuel systems shall not be used.

4-3.3.3 All portions of the fuel feed system, including carburetor, pumps, and all auxiliary mechanisms and connections shall be constructed and installed in a workmanlike manner, and so constructed and located as to minimize the fire hazard, with no readily combustible materials used therein, and shall, except for Diesel fuel connections, be well separated from the engine exhaust system. A pressure release device shall be provided where necessary. The fuel feed lines shall be made of materials not adversely affected by the fuel to be used or by other materials likely to be encountered, of adequate strength for their purpose and well secured to avoid chafing or undue vibration. Joints in fuel feed lines depending upon solder for mechanical strength and liquid tightness shall not be used in the fuel system at or near the engine, or its accessories, unless the solder has a melting point of not less than 340°F (170°C), or unless a self-closing, thermally controlled valve set to operate at not exceeding 300°F (149°C), or other equivalent automatic device, shall be installed in the fuel line on the fuel tank side of such joint.

4-3.3.4 The engine air intake shall have an approved flame arrestor to prevent the emission of flame in case of backfiring.

4-3.3.5 When provided, the sediment bowl in the fuel supply line shall be of steel or material of equivalent fire resistance.

4-3.4 Engine Exhaust System.

4-3.4.1 The engine exhaust system shall be designed, located and installed so as to minimize the hazard of fire in the event of:

(a) Leakage of fuel from the vehicle fuel tank or fuel system,

(b) Leakage from the fuel dispensing system of the vehicle,

(c) Spillage or overflow of fuel from the vehicle fuel tank or the cargo tank, or

(d) Spillage of fuel during the servicing of an aircraft.

4-3.4.2 Exhaust system components shall be secured and located clear of components carrying flammable liquids and separated from any combustible materials used in the construction of the vehicle.

4-3.4.3 Where necessary, suitable shielding shall be provided to safely drain possible fuel spillage or leakage away from exhaust system components. (*See also 4-5.2.*)

4-3.4.4 Exhaust gases shall not be discharged where they could ignite fuel vapors that may be released during normal operations or by accidental spillage or by leakage of liquid fuel.

4-3.4.5 A muffler (or silencer) cutout shall not be provided.

4-3.5 Vehicle Brakes.

4-3.5.1 Vehicle brakes shall be of acceptable commercial quality for this type of vehicle service.

4-3.5.2 Each tank full trailer and semitrailer shall be equipped with reliable brakes on all wheels. Provision shall be made for their efficient operation from the driver's seat of the vehicle drawing the trailer, or semitrailer.

4-3.6 Tires. Aircraft fuel servicing vehicles shall be equipped with rubber tires on all wheels. Tires shall meet the load limitations specified by the Tire and Rim Association's Yearbook.

4-3.7 Protection Against Collision. Cargo drawoff valves or faucets projecting beyond the frame at the rear of a tank vehicle shall be protected against damage by bumpers or other suitable means.

4-3.8 Vehicle Lighting and Electrical Equipment.

4-3.8.1 Wiring shall be of adequate size to provide required current carrying capacity and mechanical strength. It shall be installed so as to provide protection from physical damage and from contact with possible fuel spill either by location or by being enclosed in metal conduit or other oil-resistant protective covering. All circuits shall have overcurrent protection. Junction boxes shall be sealed.

4-3.8.2 Spark plugs and other terminal connections shall be insulated to prevent sparking in the event of contact with conductive materials.

4-3.8.3* Motors, alternators, generators, and associated control equipment located outside of the engine compartment or vehicle cab shall be of a type listed for use in Class I, Group D, Division 1 locations. (*See NFPA 70, National Electrical Code®.*)

4-3.8.4 Electrical equipment and wiring located within a closed compartment shall be of a type listed for use in Class I, Group D, Division 1 locations. (*See NFPA 70, National Electrical Code.*)

4-3.8.5 Electrical service wiring between a tractor and an aircraft fuel servicing tank vehicle shall be designed for heavy duty service. The connector shall be of the positive engaging type. The plug on the tank unit shall be securely mounted.

4-3.8.6 Lamps and switching devices, other than those covered in 4-3.8.3 and 4-8.3.4, shall be enclosed, gasketed weatherproof type. Other electrical components shall be of a type listed for use in Class I, Group D, Division 2 locations as defined in Article 500 of NFPA 70, *National Electrical Code*.

4-3.9 Cabinets Housing Vehicle Auxiliary Equipment. All cabinets housing vehicle auxiliary equipment shall have expanded metal, perforated metal or grating type flooring to facilitate air circulation within the enclosed space and to prevent accumulation of spilled liquid.

4-3.10 Fire Extinguishers for Aircraft Fuel Servicing Vehicles.

4-3.10.1 Each aircraft fuel servicing tank vehicle shall have two listed extinguishers each having a rating of at least 20B, mounted one on each side of the vehicle.

4-3.10.2 Each hydrant vehicle shall have one listed extinguisher having a rating of at least 20B installed on it.

4-3.10.3 Extinguishers shall be readily accessible from the ground. The area of the paneling or tank shell adjacent to or immediately behind the extinguisher(s) on fueling vehicles shall be painted with a contrasting color.

4-3.10.4 Extinguishers that could be exposed to ice or snow shall be enclosed in compartments or protected by covers or other suitable means. When covered, their locations shall be clearly marked in letters at least 2 in. (50 mm) high.

4-3.10.5 Extinguishers shall conform with the requirements of NFPA 10, *Standard for Portable Fire Extinguishers*.

4-3.11 Full Trailers and Semitrailers.

4-3.11.1 Trailers shall be firmly secured to the vehicle towing them in accordance with recognized good practice.

4-3.11.2 Trailer connections shall be designed to prevent the towed vehicle from swerving from side to side at the speeds anticipated so that the trailer will track substantially in the path of the towing vehicle.

4-3.12 Smoking Restrictions.

4-3.12.1 A "No Smoking" sign shall be posted prominently in the cab of every aircraft fuel servicing vehicle.

4-3.12.2 Smoking equipment such as cigarette lighters and ash trays shall not be provided. If vehicle has such equipment when initially procured, it shall be removed or rendered inoperable.

4-4 Cargo Tanks.

4-4.1 Cargo Tanks Constructed of Mild Steel. Tanks constructed of mild steel shall comply with the material specifications in Section 2-2 of NFPA 385, *Recommended Regulatory Standard for Tank Vehicles for Flammable and Combustible Liquids*.

4-4.2 Cargo Tanks Constructed of Low Alloy, Low Carbon (High Tensile) Steel. Tanks constructed of low alloy, low carbon steel, commonly known as high tensile, shall comply with the material specifications in Section 2-2 of NFPA 385, *Recommended Regulatory Standard for Tank Vehicles for Flammable and Combustible Liquids*.

4-4.3 Cargo Tanks Constructed of Aluminum. Tanks constructed of aluminum shall comply with the material specifications in Section 2-2 of NFPA 385, *Recommended Regulatory Standard for Tank Vehicles for Flammable and Combustible Liquids*. In cargo tanks constructed of aluminum alloys, all joints in and to tank shells, heads, and bulkheads shall be welded. All welded aluminum joints shall be made in accordance with recognized good practice, and the efficiency of a joint shall not be less than 85 percent of the annealed properties of the material in question. Aluminum alloys for high strength welded construction shall be joined by an inert gas arc welding process using filler metals R-GR40A, E-GR40A (5154 alloy) and R-GM50A, E-GM50A (5356 alloy) as conforming to AWS A5.10.

4-4.4 Tank Outlets. Tank outlets shall be of substantial construction and shall be securely attached to the tank.

4-4.5* Tank Bulkheads or Compartments. Aircraft fuel servicing tank vehicles used solely on an airport shall not be required to have bulkheads or compartments.

Exception No. 1: The authority having jurisdiction may require compartments to limit the amount of spill which might result from a tank rupture.

Exception No. 2: Cargo tanks with compartments carrying different types of aviation fuel or different grades of the same type of fuel shall have an air space between compartments. Such air spaces shall be equipped with drainage facilities which shall be maintained in operative condition at all times. Compartments carrying different grades of fuel shall have independent delivery systems to dispense the fuels.

4-4.6 Baffles. Every cargo tank or compartment over 90 inches (2286 mm) in length shall be provided with baffles, the number of which shall be such that the distance between any two adjacent baffles, or between any tank head or bulkhead and the baffle nearest it, shall in no case exceed 60 inches (1524 mm). The cross-sectional area of each baffle shall be not less than 80 percent of the cross-sectional area of the tank and the thickness of such baffle shall be not less than that required for heads and bulkheads of the cargo tank in which installed.

4-5 Venting of Cargo Tanks.

4-5.1 Normal Venting. Each cargo tank or tank compartment shall be provided with pressure and vacuum vents having a minimum through area of 0.44 square inch (284 mm²). All pressure vents shall be set to open at no more than 1 psig (7.0 kPa gage) and all vacuum vents at no more than 6 oz. per square inch (2.6 kPa). Vents shall be designed to prevent loss of liquid through the vent in case of vehicle overturn.

4-5.2 Emergency Venting for Fire Exposure.

4-5.2.1 Total Capacity. Each cargo tank or tank compartment shall be provided with one or more devices with sufficient capacity to limit the tank internal pressure to 5 psig (35 kPa gage). This total emergency venting capacity shall be not less than that determined from Table 4-5.2, using the external surface of the cargo tank or tank compartment as the exposed area.

Table 4-5.2
Minimum Emergency Vent Capacity in Cubic Feet Free Air/Hour (14.7 psia and 60°F.)

Exposed Area Square Feet	Cubic Feet Free Air per Hour	Exposed Area Square Feet	Cubic Feet Free Air per Hour
20	15,800	275	214,300
30	23,700	300	225,100
40	31,600	350	245,700
50	39,500	400	265,000
60	47,400	450	283,200
70	55,300	500	300,600
80	63,300	550	317,300
90	71,200	600	333,300
100	70,100	650	348,800
120	94,900	700	363,700
140	110,700	750	378,200
160	126,500	800	392,200
180	142,300	850	405,900
200	158,100	900	419,300
225	191,300	950	432,300
250	203,100	1,000	445,000

For SI Units
1 psi = 6.895 kPa
°C = (°F − 32) × 5/9
1 ft² = 0.0929 m²
1 ft³ = 0.0283 m³

NOTE 1: Interpolate for intermediate sizes.

NOTE 2: The venting capacities have been calculated on the basis of 75 percent of the total exposed area of the cargo tank, using the formulas for heat input contained in NFPA 30, *Flammable and Combustible Liquids Code*. The derivation of these formulas is also explained in NFPA 30.

4-5.2.2 Pressure-Actuated Venting. Each cargo tank or tank compartment shall be equipped with pressure-actuated vent or vents set to open at not less than 3 psig (21 kPa) or more than 5 psig (35 kPa gage). The minimum venting capacity for pressure-actuated vents shall be 6,000 cubic feet (170 m³) of free air per hour [14.7 psia and 60°F (101 kPa absolute and 15.6°C)] at 5 psig (35 kPa). Pressure-activated devices shall be designed so as to prevent leakage of liquid past the device in case of surge or vehicle upset but shall function in case of pressure rise when in upset position.

4-5.2.3 Fusible Venting. If the pressure-actuated venting required by 4-5.2.2 does not provide the total venting capacity required by 4-5.2.1, additional capacity shall be provided by adding fusible venting devices each having a minimum area of 1.25 square inches (806 mm²). The fusible vent or vents shall be actuated by elements which operate at a temperature not exceeding 250°F (121°C). when the tank pressure is between 3 and 5 psig (21 and 35 kPa absolute). When fusible venting devices are used, no less than two such devices shall be used on any cargo tank or tank compartment over 2,500 gallons (9500 L) in capacity, and at least one such device shall be located close to each end of the cargo tank or tank compartment.

4-5.3 Location of Pressure-Activated Vents. Vents shall be located near the center of the tank or compartment to minimize surge spillage when the vehicle is stopping or accelerating.

4-5.4* Flow Testing and Marking of Vents. Each venting device shall be flow tested in the ranges specified in the applicable preceding paragraphs. The actual rated flow capacity of the vent in cubic feet of free air per hour (m³/hour of free air) at the pressure in psig (kPa gage) at which the flow capacity is determined shall be stamped on the device. The fusible vent or vents shall have their flow rating determined at 5 psig (35 kPa) differential.

4-6 Fill Openings and Top Flashings.

4-6.1 Dome Covers. Filler opening dome covers shall be provided with a forward mounted operating hinge, self-latching catches (to hold the cover closed), and fitted with watertight seals or gaskets (designed to prevent spillage or leakage from overturn or the weather).

4-6.2 Flashing Around Dome Covers. Flashing shall be provided around filler opening dome covers to prevent spilled fuel from draining near possible sources of ignition (including the engine, the engine exhaust system, electrical equipment) or into any portion of the vehicle housing auxiliary equipment.

4-6.3 Protection Against Overturn. The tank filler openings shall be protected against overturn damage by a rigid member or members fixed to the tank and extending a minimum of 1 inch (25 mm) above any dome cover, handle, vent opening or projection of the unit. Overturn protection shall be adequately braced to prevent collapse. Where overturn protection creates a trough or pocket which can collect rain water or snow, it shall have a drain that is exterior to the cargo tank.

4-7 Piping, Joints, Flanged Connections, and Couplings.

4-7.1 Design Criteria. Product discharge piping shall be of metal and rated for at least 125 psi (860 kPa) working pressure.

4-7.2 Joints. Except as provided in 4-7.3, all joints shall be welded. Elbows and fittings shall be kept to a minimum and, where used, shall be of the preformed welding type.

4-7.3 Flanged Connections or Couplings. Flanged connections or approved couplings shall be provided to avoid the need for cutting and welding when servicing or replacing components. Gaskets in flanged connections shall be of a material and design that will resist fire exposure for a time comparable to the flange and bolts.

4-7.4 Support of Piping. Brackets or supports shall be used to provide rigidity to the piping and to support it if any section or component is removed for servicing.

4-8 Outlet Valves and Emergency Shutoff Controls.

4-8.1 Outlet Valve Shutoffs. The outlets of each cargo tank or compartment, including water drawoff valves, shall be equipped with a shutoff valve located inside the shell, or in the sump when it is an integral part of the shell, and designed so that the valve must be kept closed except during loading and unloading operations. Water drawoff valves shall be of a type that cannot be locked open.

4-8.2 Operating Mechanisms. The operating mechanism for each tank outlet valve shall be adjacent to the fuel delivery system operating controls and shall be arranged so that the outlet valve(s) can be simultaneously and instantly closed in the event of fire or other emergency. There shall be at least two quick-acting emergency tank outlet valve shutoff controls, remote from each other (preferably on opposite sides of the vehicle) and from the fill openings and discharge outlets, which can be operated from a ground level standing position. In addition, all vehicles equipped with a top deck platform shall have an emergency tank outlet valve shutoff control accessible from the deck.

4-8.3 Placarding of Emergency Shutoffs. Emergency tank outlet valve shutoff controls shall be placarded "EMERGENCY SHUTOFF" in letters at least 2 inches (50 mm) high and of a color that contrasts with the background for ready visibility. Method of operation shall be indicated by an arrow or by the word "PUSH" or "PULL," as appropriate. The word "EMERGENCY" shall not be used to identify any control or device on the vehicle other than these tank outlet emergency shutoff controls.

4-8.4 Fusible Device on Discharge Valves. Each discharge valve shall be provided with a standard fusible device which will cause the valve to close automatically in case of fire.

4-8.5 Shear Section Requirements. In every case there shall be provided, between shutoff valve seats and discharge outlets, a shear section which will break under strain unless the discharge piping is so arranged as to afford the same protection and leave the shutoff valve seat intact.

4-8.6 Protection of Tank Openings. All openings into cargo tank compartments connected to pipe or tubing (which extends through the cargo tank and where such tubing is subject to undetected breakage or failure) shall be plugged unless the pipe or tubing is fitted with a spring loaded check valve, a self-closing valve, or similar device to prevent the accidental discharge of fuel in case of equipment malfunction or line breakage. Unless such valves are located inside the tank, they shall be equipped with a shear section as described in 4-8.5.

4-9 Fuel Dispensing System.

4-9.1 Deadman Control of Fuel Flow. The valve that controls the flow of fuel from an aircraft fuel servicing vehicle to an aircraft shall have deadman control in accordance with the requirements of Section 2-17 of this standard.

4-9.2 Hydrant Vehicle Fuel Control Valves. Any hydrant vehicle used with a hydrant system that has more than 3 outlets or a rate of flow of more than 60 gallons (227 L) per minute per outlet shall not have a fuel control valve installed on it. On such vehicles this function shall be provided by a deadman control of the hydrant valve. (*See also 5-8.2.*)

4-9.3 Nozzles for Overwing Servicing. Nozzles for overwing servicing on aircraft fuel servicing tank vehicles may have the deadman flow control in the nozzle. Notches or latches in the nozzle handle which could allow the valve to be locked open shall be prohibited. Each overwing servicing nozzle shall have a cable with a plug or clip for bonding to the aircraft. See 2-3.2.1.

4-9.4 Nozzles for Underwing Servicing. Nozzles for underwing servicing shall be designed so that they must be securely and completely seated in the mating connection on the aircraft before the poppet valve can be opened. It shall not be possible to disengage the nozzle from the aircraft fitting until the poppet valve is fully closed.

4-9.5 Fuel Flow Control Valve on Tank Vehicles Used for Underwing Servicing. On aircraft fuel servicing tank vehicles used for underwing fuel servicing, the fuel flow control valve shall be located ahead of the fuel line to the aircraft fuel servicing nozzle. The deadman control shall be arranged so that the fuel serviceman can observe the operation while he is holding the control (*see A-1-4.2*).

4-9.6 Integrity of Fuel Dispensing System. Fuel servicing pump mechanisms shall be designed and arranged so that failure or seizure will not cause rupture of the pump housing, a tank or of any fuel containing component. Fuel pressure shall be controlled within the stress limits of the hose and plumbing by means of either an engine speed controller, a system pressure relief valve, or other suitable means. The working pressure of any system component shall equal or exceed any pressure to which it may be subjected.

4-9.7 Pumping Arrangements on Trailer Vehicles. On tank full trailer or tank semitrailer vehicles, the use of a pump in the tractor unit with flexible connections to the trailer shall be prohibited unless:

(a) Flexible connections are arranged above the liquid level of the tank in order to prevent gravity or siphon discharge in case of a break in the connection or piping, or

(b) The cargo tank discharge valves required by 4-8.1 are arranged to be normally closed and to open only when the brakes are set and a control is held manually by an operator. The manual control must be of the deadman type so that the valves will close at once if the control is released.

4-9.8 Hose Reels. Where provided, hose reels shall be of sufficient size for the length and diameter of the hose to be used.

4-9.9 Connections to Hose Reels. Hose shall be connected to rigid piping or coupled to the hose reel in a manner which will prevent undue bending action or mechanical stress on the hose or hose couplings.

4-9.10 Servicing Hose/Brake Interlock. Aircraft fuel servicing vehicles having provision for underwing fuel servicing shall have a system or device which will prevent the vehicle from being moved unless all fuel lines are disconnected from the aircraft and stowed properly on the vehicle.

4-10 Tests.

4-10.1 Cargo Tanks. Cargo tanks, at the time of manufacture, shall be tested by a minimum air or hydrostatic pressure of 5 psi applied to the whole tank (or each compartment thereof if the tanks are compartmented). Such pressure shall be maintained for a period of at least 5 minutes, during which, if the test is by air pressure, the entire exterior surface of all joints shall be coated with a solution of soap and water, heavy oil, or other material suitable for the purpose, foaming or bubbling of which will indicate the presence of leaks. Hydrostatic pressure, if used, shall be gaged at the top of the tank. The tank shall be inspected at the joints for the issuance of liquid to indicate leaks. Any leakage discovered by either of the methods described, or by any other method, shall be deemed as evidence of failure to meet these requirements.

4-10.2 Fuel Dispensing System. At the time of manufacture the section of the fuel dispensing system which is under pressure during service shall be subjected to a hydrostatic test pressure equal to 150 percent of the working pressure of the system for at least 30 minutes and proven tight before it is placed in service. Hose connections may be plugged during this test.

4-11 Marking of Aircraft Fuel Servicing Vehicles. Each aircraft fuel servicing vehicle shall have a sign on each side and the rear to indicate the product. The sign shall have letters at least 3 in. (75 mm) high of a color sharply contrasting with the background. It shall show the word "FLAMMABLE" and the name of the product carried, such as "JET A," "JET B" or "GASOLINE."

4-12 Maintenance of Aircraft Fuel Servicing Vehicles.

4-12.1 Serviceability. Aircraft fuel servicing vehicles shall not be operated unless they are in proper repair and free of accumulations of grease, oil, or other combustibles in other than normal storing and transfer tanks and lines.

4-12.2 Leaking Vehicles. Leaking vehicles shall be removed from service, defueled, and parked in a safe area until repaired.

4-12.3 Location of Fuel Servicing Vehicle Maintenance Operations. Maintenance and servicing of aircraft fuel servicing vehicles shall be done outdoors or in a building approved for this purpose.

Exception: If emergency repairs are required on an aircraft fuel servicing vehicle during inclement weather and no such approved building is available, minor repairs necessary to get the vehicle back into service may be done in a hangar, provided that the following requirements are observed:

(a) Approval to perform the work in the hangar shall be secured from the supervisor responsible for the hangar operation. The approval shall be in writing. It shall specify the work to be done, the location assigned for the work, the requirements listed below, and any special requirements deemed necessary.

(b) Not more than one such vehicle shall be permitted in a hangar at one time. Repairs shall be limited to those needed to get the vehicle back in service.

(c) Approval shall be limited to vehicles used for Jet A fuels only.

(d) Welding, cutting or open flames shall be prohibited.

(e) Portable electrical equipment used during the repair of the vehicle shall conform to the requirements of Article 513 of NFPA 70, National Electrical Code.

(f) The hangar shall be constructed and protected in accordance with the provisions of NFPA 409, Standard for Aircraft Hangars.

(g) At least two wheeled dry chemical extinguishers, each having a minimum rating of 80-B and a minimum capacity of 125 lbs (57 kg) shall be located within 50 feet (15 m) of the vehicle being serviced.

(h) A separation of at least 50 feet (15 m) shall be maintained between the vehicle being serviced and the nearest part of any aircraft in the hangar.

4-13 Parking Aircraft Fuel Servicing Tank Vehicles. Parking areas for aircraft fuel servicing tank vehicles shall be arranged to:

(a) Facilitate dispersal of the vehicles in the event of emergency;

(b) Provide at least 10 feet (3 m) of clear space between parked vehicles for accessibility for fire control purposes;

(c) Prevent any leakage from draining to an adjacent building;

(d) Minimize exposure to damage from out-of-control aircraft;

(e) Provide at least 50 feet (15 m) from any airport terminal building, aircraft cargo building, aircraft hangar, or other airport structure housing the public which has windows or doors in the exposed walls.

4-14 Loading of Aircraft Fuel Servicing Tank Vehicle Cargo Tanks.

4-14.1 General Requirements.

4-14.1.1 Filling of the vehicle cargo tank shall be under the observation and control of a qualified and authorized operator at all times.

4-14.1.2 Required deadman or automatic fill controls shall be in normal operating condition during the filling operation. They shall not be blocked open or otherwise bypassed.

4-14.1.3 The engine of the tank vehicle shall be shut off before starting tank filling.

4-14.1.4 The cargo tank shall be bonded to the fill pipe before the dome covers are opened and the bonding connection shall be maintained until after the dome covers are securely closed (after filling is completed).

4-14.1.5 No cargo tank or compartment shall be loaded liquid full. The outage expansion space shall not be less than 1 percent of the volume of the tank compartment. Where local climatic conditions warrant, the outage expansion space shall be increased to prevent leakage or overflow from expansion of the contents due to a rise in atmospheric temperature or direct exposure to the sun.

4-14.1.6 A heat-actuated shutoff valve shall be provided in the piping immediately upstream of the loading hose or swing arm connection.

4-14.2 Top Loading.

4-14.2.1 Drop tubes used in top loading or overhead loading of tank vehicles shall be designed to minimize turbulence.

4-14.2.2 Fixed drop tubes permanently mounted in the vehicle tank shall extend to the bottom of the tank or to inside the sump to maintain submerged loading and avoid overshoot or splash loading of the fuel.

4-14.2.3 Drop tubes attached to loading assemblies extending into the vehicle tank shall extend to the bottom of the tank and be maintained in that position until the tank is loaded to provide submerged loading and avoid splashing or free fall of fuel through the tank atmosphere.

4-14.2.4 Metal loading arms shall be properly counterbalanced.

4-14.2.5 A deadman control shall be provided, located so that the operator can observe the liquid level in the tank as it fills (*see A-1-4.2*).

4-14.3 Bottom Loading of Tank Vehicles.

4-14.3.1 Loading hose shall conform to the requirements of Chapter 3. Swivel connections shall be provided at each end of the hose to allow free inovement to compensate for changes in the attitude of the vehicle connection during loading.

4-14.3.2 Swinging loading arms of metal shall be properly counterbalanced. Swivel joints shall be used to allow free movement and to compensate for changes in the attitude of the vehicle connection during loading.

4-14.3.3 The connection between the tank truck and the arm or hose shall be a self-sealing, leakproof, dry-break coupler which cannot be opened until it is engaged to the vehicle tank companion adapter. It shall not be possible to disconnect the hose coupler from the tank vehicle connection unless the internal valving of both components is fully closed.

4-14.3.4* The bottom loading fitting on the tank vehicle shall be of self-sealing spring-loaded check valve type which will remain in closed position until opened by connecting the companion coupler.

4-14.3.5 The supply piping terminating at the loading hose or swing arm shall be supported to carry the load imposed.

4-14.3.6 Control of the filling of the vehicle cargo tank shall be by a preset metered liquid control, a float-actuated shutoff, a sensing or other automatic device, and by a deadman type manual control located at a position where the operator can observe the liquid level in the tank Any liquid bled from a sensing device during loading shall be returned to the bottom of the cargo tank through a closed system.

4-14.3.7 If fill control is by means of a liquid level device, a manual precheck system shall be provided. Prechecking shall check both the level sensing and shutoff device as an integral system operation. A visible means, such as a pressure gauge, shall be provided so that the operator will have a positive signal that the shutoff works.

4-14.3.8 The fill pipe and valving on bottom loading tank vehicles shall be arranged so as to prevent fuel spraying and turbulence in the cargo tank. Inlet baffling may be used to accomplish this.

4-14.3.9 The tank vehicle emergency shut-off system shall be capable of operation when the vehicle is connected to the bottom loading station.

4-14.4* Emergency Remote Control Stations.

4-14.4.1 Each tank vehicle loading station shall be provided with an emergency shutoff system. This requirement is in addition to the deadman control required by 4-14.2.5 for top loading and by 4-14.3.6 for bottom loading. It shall be the purpose of this system to shut down the flow of fuel in the entire system or in sections of the system if an emergency occurs.

4-14.4.2* One or more emergency shutoff stations shall be provided. Each station location shall be placarded "EMERGERNCY FUEL SHUTOFF" in letters at least 2 inches (50 mm) high. Method of operation shall be indicated by an arrow or by the word "PUSH" or "PULL," as appropriate. Any action required to gain access to the shutoff device (e.g., "BREAK GLASS") shall be clearly shown. Lettering shall be on a background of a contrasting color for ready visibility. Placards shall be weather resistant, shall lie at least 7 feet (2.1 m) above the ground, and located so that they can be readily seen from a distance of at least 25 feet (7.6 m).

4-14.4.3 The emergency shutoff system shall be designed and constructed so that delivery of fuel will be shut off if an emergency shutoff station control is operated or if the control operating energy source fails.

Chapter 5 Airport Fueling Systems

5-1 Approval of Plans and Specifications. Work shall not be started on the construction in alteration of an airport fueling system until the design, plans and specifications shall have been approved by the authority having jurisdiction.

5-2 Acceptance Inspection. The authority having jurisdiction may require that they inspect and approve the completed system before it is put into service.

5-3 General Requirements.

5-3.1 System Approval. Each installation planned shall be designed and installed in conformity with the requirements of this standard and with any additional fire safety measures deemed necessary by the authority having jurisdiction.

5-3.2 Working Pressure. The system and each of its components shall be designed for a working pressure not less than that to which they will be subjected to in service. Surge pressures shall be controlled by pressure regulating equipment, slow closing valves, surge suppressors and/or other devices properly placed in the system.

5-3.3 Emergency Shutoffs. Emergency shutoffs shall be designed and installed as an integral part of the airport fueling system. Operating controls for emergency shutoff of the system shall be located so as to be readily and safely accessible in the event of an accident or spill (*see also 5-5.2*).

5-3.4 Deadman Controls. Valves which control the flow of fuel to the aircraft shall have deadman controls (*see also Section 5-8 and A-1-4.2*).

5-3.5 Accessibility of Aircraft Fuel Dispensing Locations. In establishing each aircraft fuel dispensing location, consideration shall be given to the accessibility of the location in an emergency by fire fighting personnel and equipment.

5-4 Fuel Storage Tanks.

5-4.1* General. The construction and spacing of fuel storage tanks shall conform to the applicable requirements of NFPA 30, *Flammable and Combustible Liquids Code*.

5-4.2 Clearances from Runways and Taxiways. The authority having jurisdiction shall determine the clearances required from runways and taxiways to any aboveground fuel storage structures or fuel transfer equipment with due recognition given to national and international standards establishing clearances from obstructions. Tanks located in aircraft movement areas or aircraft servicing areas shall be underground or mounded over with earth. Vents from such tanks shall be constructed in a manner to minimize collision hazards with operating aircraft. Aircraft operators shall be consulted as to the height and location of such vents to avoid venting flammable vapors in the vicinity of ignition sources, including operating aircraft and automotive equipment permitted in the area.

5-5 Emergency Shutoff System.

5-5.1 General. Each fueling system, as required by 5-3.3, shall have means for quickly and completely shutting off the flow of fuel in an emergency. This requirement is in addition to the requirement in 5-8.2 for deadman control of fuel flow.

5-5.2 Location of Shutoff Devices.

5-5.2.1* The method of fuel transfer (gravity, pumping, or using hydraulic or inert gas pressure) shall be considered in the design of the emergency shutoff system and the location of the emergency shutoff device. Long pipe lines downstream of the shutoff device that could drain and add to the severity of a spill shall be avoided.

5-5.2.2 The emergency shutoff system shall include shut-off stations located outside of probable spill areas and near the route that would be normally used to leave the spill area or to reach the fire extinguishers provided for the protection of the area.

5-5.2.3 At least one emergency shutoff control station shall be conveniently accessible to each fueling position.

5-5.2.4* The emergency shutoff system shall be designed so that operation of a station will shut off fuel flow to all hydrants that have a common exposure (e.g., all hydrants on one side of a passenger concourse).

5-5.3 Operation with Energy Failure. Emergency shutoff systems shall be designed so that they will shut off flow of fuel if the operating energy fails.

5-5.4* Placarding of Shutoff Stations. Each emergency shutoff station shall be placarded "EMERGENCY FUEL SHUTOFF" in letters at least 2 inches (50 mm) high. Method of operation shall be indicated by an arrow or by the word "PUSH" or "PULL," as appropriate. Any action required to gain access to the shutoff device (e.g., "BREAK GLASS") shall be clearly shown. Lettering shall be on a background of a contrasting color for ready visibility. Placards shall be weather resistant, shall be at least 7 feet (2.1 m) above the ground, and located so that they can be readily seen from a distance of at least 25 feet (7.6 m). Valves used to shut off a hydrant for maintenance purposes shall not have placards that could cause confusion in an emergency.

5-5.5 Access To Control Stations. Access to emergency shutoff control stations shall be kept clear at all times.

5-5.6 Reinstatement After Shutoff. If the fuel flow is stopped for any reason, it shall first be presumed that the emergency shutoff system has been operated. The cause of the shutoff shall be corrected before fuel flow is reinstated.

5-6 Transfer Piping.

5-6.1* General. Transfer piping shall be located outdoors. Underground piping shall be used in the vicinity of aircraft traffic zones unless the piping is protected by a substantial barrier guard. Piping shall be protected by suitable sleeves or casings to protect the pipe from shock hazards where it crosses sewer manholes, service tunnels, catch basins or other underground services. Piping shall be laid on firm supports using clean, noncorrosive backfill.

5-6.2 Piping Under Buildings. Fuel piping that runs under a building or a passenger concourse shall be protected by a steel casing that encloses only the piping.

5-6.3 Basic Design Criteria. Piping, valves and fittings shall be of metal, suitable for aviation fuel service, and designed for the working pressures and mechanically and thermally produced structural stresses to which they may be subjected. The minimum requirements of ANSI B31.3, *Code for Pressure Piping, Petroleum Refinery Piping*, shall be used as a basic guide. Deviations from B31.3 may be authorized by the authority having jurisdiction when engineering data can be presented to justify such deviations.

5-6.4 Limitations on Use of Cast Iron. Cast iron piping and fittings shall not be used where subject to fire exposure.

5-6.5 Limitations on Use of Aluminum. Aluminum piping and fittings may be used only when specifically approved by the authority having jurisdiction.

5-6.6 Pipes, Valves and Fittings. In the selection of pipe, valves and fittings, the following shall be given consideration:

5-6.6.1 Service Pressure.

5-6.6.2 Bending and external mechanical strength requirements (including settlement).

5-6.6.3 Allowance for internal and external corrosion; external corrosion protection shall be evaluated based on the type of corrosion protection system used, if any; internal corrosion shall be considered in connection with purity of the fuel handled.

5-6.6.4 Impact stresses.

5-6.6.5 Method of system fabrication and assembly.

5-6.6.6 Location of piping and accessibility of same for repair or replacement.

5-6.6.7 Possibility of mechanical, atmospheric, or fire damage.

5-6.6.8 Expected period of service and effect of future changes in fuel specifications on materials used.

5-6.7* Gaskets. Gaskets in flanged connections shall resist fire temperatures for a time period comparable to the flange and bolts.

5-6.8 Allowances for Thermal Expansion/Contraction. Allowances shall be made for thermal expansion and contraction by the use of pipe bends, welding elbows or other flexible design. Pressure relief valves shall be provided in long lines which may be valved off.

5-6.9 Welded Joints. Welded joints shall be made by qualified welders in accordance with the standards of the American Welding Society as approved by the American National Standards Institute.

5-7* System Component Isolation. Isolation valves or devices shall be provided to facilitate dismantling portions of the fueling system for maintenance purposes. When a valve is closed for maintenance purposes, it shall be placarded. The placard shall not be removed until the maintenance work has been completed.

5-8 Fuel Flow Control.

5-8.1 Hydrant Valves. Hydrant valves shall be so designed that the flow of fuel shall shut off when the hydrant coupler is disconnected or when the hydrant valve fails due to impact or tension loads.

5-8.2 Deadman Controls. The valve which controls the flow of fuel to the aircraft shall have a deadman control. The fuel flow control valve shall be located at the hydrant pit or cabinet. The use of any means which would allow fuel to flow without the operator holding this control shall be prohibited. The deadman control shall be arranged so that the fuel serviceman can observe the operation while he is holding the control. The flow control valve may be an integral part of the hydrant valve or shall be located on the supply side of the hydrant valve. The fuel control valve shall be arranged so that it shall not be rendered inoperative by a surface accident, spill or malfunction and shall be fail-safe by closing completely if the control power fails. The fuel control system shall be designed to minimize overshoot. The system shall be designed to shut off fuel flow quickly and effectively even though there may be a reduction of pressure downstream of the flow control valve such as could result from a major line or hose break. A screen shall be provided ahead of the valve to trap foreign material that could interfere with complete closure of the valve (*see A-1-4.2*).

Exception: On pit or cabinet systems and on hydrant systems which have not more than 3 hydrants, the authority having jurisdiction may waive the requirements for a deadman control, provided that the rate of flow is not more than 60 gpm (227 L/min) from any outlet.

5-9* Pressure Control. The pressure of the fuel delivered to the aircraft shall be automatically controlled so that it is not higher than that specified by the manufacturer of the aircraft being serviced. The automatic control device may be located at the hydrant or on the hydrant vehicle. If installed at the hydrant it may be either on the supply (upstream) side of the hydrant valve or integral with the valve.

5-10 Filter Separators. All sections of the filtering system shall have electrical continuity with adjoining piping and equipment. In freezing climates, filter separator pumps and associated piping which may contain water shall be protected to prevent freezing and bursting. Heaters shall be of a type suitable for this service.

5-11 Electrical Equipment — Airport Fueling Systems. All electrical equipment and wiring shall comply with the requirements of Article 515 of NFPA 70, *National Electrical Code*.

5-12 Fuel Servicing Hydrants, Pits and Cabinets.

5-12.1 General. Piping, valves, meters, filters, air eliminators, connections, outlets, fittings, and other components shall be designated to meet the working pressure requirements of the system.

5-12.2 Covers. Fueling hydrants and fueling pits that are recessed below a ramp or apron surface and subject to vehicle or aircraft traffic shall be fitted with a cover designed to sustain the load of vehicles or aircraft that taxi over all or part of it.

5-12.3 Separation from Buildings. Fueling hydrants, cabinets and pits having a flow rate in excess of 60 gallons (227 L) per minute shall be located at least 50 feet (15.2 m) from any terminal building, hangar, service building or enclosed passenger concourse (other than movable aircraft loading walkways).

5-12.4 Drainage.

5-12.4.1 Aircraft servicing ramps or aprons shall be sloped and drained in accordance with NFPA 415, *Standard on Aircraft Fueling Ramp Drainage*. The ramp or apron shall slope away from the rim or edge of fueling hydrants or fueling pits located below grade level to prevent flooding.

5-12.4.2 Fueling hydrant boxes or fueling pits which are connected to a ramp drainage system shall be fitted with vapor sealing traps.

5-12.5 Hose. The hose on aircraft fueling cabinets or pits shall meet the requirements of Chapter 3 and shall be maintained in accordance with its provisions.

5-12.6 Nozzles.

5-12.6.1 Overwing servicing nozzles shall conform to 4-9.3.

5-12.6.2 Underwing servicing nozzles shall conform to 4-9.4.

5-13* Cathodic Protection. Systems provided with cathodic protection shall have appropriate signs, located at points of entry, warning against separation of units without prior de-energization or without proper jumpers across the sections to be disconnected. Isolation flanges shall be installed as required to separate components protected by a cathodic system from those required to be grounded for protection from static electricity or other electrical requirements. See also 2-3.3.

5-14 Tests.

5-14.1 Acceptance Test — Piping and Components of Airport Fueling Systems. After completion of the installation (including fill and paving) that section of an airport fueling system between the pump discharge and the connection for the dispensing facility shall be subjected to a hydrostatic test pressure equal to 150 percent of the system working pressure for at least 30 minutes and proven tight before it is placed in service.

5-14.2 Acceptance Test — Pits and Cabinets. The fuel handling system of fueling pits and cabinets including piping, valves, meters, filters, air eliminators, connections, outlets, fittings, and other components shall be subjected to a hydrostatic test pressure equal to 150 percent of the system working pressure for at least 30 minutes and proven tight before being placed in service.

5-14.3 Leakage Tests. A leakage test shall be conducted annually in the same manner as the acceptance tests described in 5-14.1 and 5-14.2 except that the test pressure shall be 100 percent of the service pressure.

5-14.4 Hose Tests. For requirements for testing hoses, refer to Chapter 3.

5-14.5 Emergency Shutoff Device Tests. Emergency shutoff devices shall be operationally checked at least every three months.

5-14.6 Records. Suitable records shall be kept of tests required by this section.

Chapter 6 Fueling at Roof-Top Heliports

6-1 Approval Required. Fueling on roof-top heliports shall be permitted only when approved by the authority having jurisdiction.

6-2 General Limitations.

6-2.1 Basic Construction and Protection Requirements. In addition to the special requirements in this chapter, the heliport shall comply with the requirements of NFPA 418, *Standard on Roof-Top Heliport Construction and Protection*.

6-2.2 Low Flash Point Fuels Not Permitted. Facilities for dispensing fuel with a flash point below 100°F (37.8°C) shall not be provided at any roof-top heliport.

6-2.3 Restrictions on Operating Engines. Fueling shall not be conducted with the engine operating. The rotor blades shall be stopped and secured before fuel servicing is started.

6-3 Fueling Facilities.

6-3.1 General. In addition to the special requirements of this chapter, the fuel storage, piping and dispensing system shall comply with the requirements of NFPA 30, *Flammable and Combustible Liquids Code*, and with applicable portions of Chapters 3, 4 and 5 herein.

6-3.2 Pressure Limits. The entire system shall be designed so that no part of the system will be subjected to pressures above its allowable service pressure.

6-3.3 Fuel Storage. The fuel storage system shall be located at or below ground level.

6-3.4 Pumps.

6-3.4.1 Pumps shall be located at or below ground level. Relay pumping shall be prohibited.

6-3.4.2 Pumps installed outside of buildings shall be located not less than 5 feet (1.5 m) from any building opening. They shall be substantially anchored and shall be protected against physical damage from collision.

6-3.4.3 Pumps installed within a building shall be in a separate room with no opening into other portions of the building. The pump room shall be adequately ventilated. Electrical wiring and equipment shall conform to the requirements of Article 515 of NFPA 70, *National Electrical Code*. See also Section 5-11.

6-3.5 Piping. Piping above grade shall be steel and, unless otherwise approved by the authority having jurisdiction, shall be suitably cased or shall be installed in a duct or chase. Such piping duct or chase shall be so constructed that a piping failure will not result in the entry of fuel liquid or vapor into the building. All piping casings, ducts and/or chases shall be drained. Piping shall be anchored and shall be protected against physical damage for a height of at least 8 feet (2.4 m) above the ground. An isolation valve shall be installed on the suction and discharge piping of each pump. In addition, a check valve or other anti-reverse flow device shall be installed at the base of each fuel piping riser to automatically prevent the reverse flow of the fuel into the pump room in the event of pump seal failure, pipe failure or other malfunction.

6-3.6 Nozzles.

6-3.6.1 Overwing nozzles shall conform to 4-9.3.

6-3.6.2 Underwing nozzles shall conform to 4-9.4.

6-3.7 Hose. Hose shall comply with the requirements of Chapter 3.

6-3.8* Static Electricity. The provisions of Section 2-3 shall be followed, as appropriate, to guard against a static electrical hazard during helicopter fuel servicing operations. The piping of the fuel dispensing system shall not be used for grounding purposes.

6-3.9 Deadman Controls. Each fuel dispensing hose shall have a deadman controlled fuel shutoff conforming to requirements of Section 2-17.

6-4 Emergency Control Stations.

6-4.1 General. A system to completely shut off the flow of fuel in an emergency shall be provided. The system shall shut off the fuel at the grade level. The emergency shutoff controls shall be in addition to the normal operating controls for the pumps.

6-4.2 Location of Stations. At least two emergency shutoff stations located on opposite sides of the heliport at exitways or at similar locations shall be provided. An additional emergency shutoff station shall be at grade level near, but at least ten feet from, the pumps.

6-4.3* Placarding. Each emergency shutoff station shall be placarded "EMERGENCY FUEL SHUTOFF" in letters at least 2 inches (50 mm) high. Method of operation shall be indicated by an arrow or by the word "PUSH" or "PULL," as appropriate. Any action required to gain access to the shutoff device (e.g., "BREAK GLASS") shall be clearly shown. Lettering shall be on a background of a contrasting color for ready visibility. Placards shall be weather resistant. Placards on the operating deck shall be at least 7 feet (2.1 m) above the deck and located so that they can be readily seen from the fueling area. Valves used to shut off a hydrant for maintenance purposes shall not have placards that could cause confusion in an emergency.

6-5 Fire Protection.

6-5.1 Fixed Protection. Fixed fire protection shall conform to the requirements of NFPA 418, *Standard for Roof-Top Heliport Construction and Protection*.

6-5.2 Portable Extinguishers for Protection of Fueling Operations.

6-5.2.1 Two dry chemical extinguishers rated at least 20-B each and at least one 160-B dry chemical extinguisher shall be provided on the landing areas.

6-5.2.2* At the remote emergency station near the pumps an additional dry chemical extinguisher rated at least 20-B shall be provided.

6-6 Personnel Training. All heliport personnel shall be trained in the operation of emergency shutoff controls and in the use of the available fire extinguishers.

Chapter 7 Referenced Publications

7-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is current as of the date of the NFPA issuance of this document. These references are listed separately to facilitate updating to the latest edition by the user.

7-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1984, *Standard for Portable Fire Extinguishers*

NFPA 30-1984, *Flammable and Combustible Liquids Code*

NFPA 70-1984, *National Electrical Code*

NFPA 385-1985, *Recommended Regulatory Standard for Tank Vehicles for Flammable and Combustible Liquids*

NFPA 409-1985, *Standard on Aircraft Hangars*

NFPA 410-1980, *Standard on Aircraft Maintenance*

NFPA 415-1983, *Standard on Aircraft Fueling Ramp Drainage*

NFPA 418-1979, *Standard on Roof-Top Heliport Construction and Protection*

7-1.2 ANSI Publication. American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI B31.3-1976, *Chemical Plant and Petroleum Refinery Piping*

7-1.3 ASTM Publication. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D380-77, *Rubber Hose, Testing*

7-1.4 AWS Publication. American Welding Society, 2501 N.W., 7th Street, Miami, FL 33125.

AWS A5.10-71 *Filler Metal Comparison Charts.*

Appendix A

This appendix does not contain mandatory provisions and thus does not contain any official requirements. It does provide additional information, recommendations and typical procedures which may be useful to those using this standard.

(Paragraph numbers refer to similar numbers in the text of this standard.)

A-1-2 Fire Hazards in Aircraft Fuel Servicing.

(a) Aircraft fuel servicing involves the transfer of a flammable or combustible liquid fuel between a bulk storage system and the fuel tanks of an aircraft. It includes both fueling and defueling. The transfer is usually accomplished by using a tank vehicle, a hydrant vehicle, a fuel servicing cabinet, or a fueling pit. Sometimes drums and pumps are used.

(b) In overwing fueling the fuel is discharged through a hose with a hand-held nozzle into an opening in the aircraft fuel tank. The flow and splashing of fuel can cause the generation of static electricity and the production of flammable mists and vapors. Top loading of tank vehicles creates similar hazards.

(c) Underwing servicing, hydrant servicing, and bottom loading of tank vehicles use hoses or flexible connections of metal tubing or piping, and devices to permit temporary connection of fuel transfer lines.

(d) Potential sources of ignition which could present a hazard during aircraft fuel servicing include:

1. Static sparks.
2. Operating aircraft engines, auxiliary power units, and heaters.
3. Operating automotive or other internal combustion engine servicing equipment in the vicinity.
4. Arcing of electrical circuits.
5. Open flames.
6. Energy from energized radar equipment.
7. Lightning.

(e) The autoignition temperatures of turbine fuels [*see A-1-3.2.1(d)*] are such that the residual heat of aircraft turbine engines after shutdown or the residual heat of turbine aircraft brakes following hard use can ignite such fuels if they are spilled or sprayed on these surfaces before they have cooled to a temperature below the autoignition temperatures of the fuels.

(f) Aircraft fuel tank vents are usually located some distance above ground level. Under normal conditions fuel vapors from the vents are quickly dissipated and diluted safely. Fuel spilling from the vents if a tank is overfilled is a much more serious hazard. Spills resulting from leaks or equipment failure are also a hazard.

(g) Fire prevention measures in aircraft fuel servicing are principally directed toward:

1. Prevention of fuel spillage.
2. Elimination or control of potential ignition sources.

A-1-3 Fire Hazard Properties of Aviation Fuels. The fire hazard properties of aviation fuels may be best described by analyzing: I, Susceptibility to or ease of ignition; II, Fire severity after ignition; and III, Fire control factors.

I. Susceptibility to or Ease of Ignition.

(a) Flash Point.

1. The flash point of standard grades of aviation gasoline has been established at approximately minus 50°F (-46°C). at sea level by the Tag closed-cup method. The flash point of JET B turbine fuel is not regulated by specification but samples have been tested by the closed-cup method and found to be in the range of from minus 10°F to plus 30°F (-23°C to -1°C) at sea level. Most of the JET A (kerosine grade) turbine fuels have flash points in the range of plus 95°F to plus 145°F (+35°C to +63°C) (closed-cup) at sea level.

2. In an air saturation test method of utilizing upward propagation of flame, flash point determinations have produced figures significantly lower than those produced by the Tag closed-cup method. For instance, by this method, the flash points of aviation gasolines ranged from minus 75°F to minus 85°F (-59°C to -65°C) and JET B turbine fuel goes down to minus 60°F (-51°C).

3. From this information it may be observed that aviation gasoline and JET B turbine fuel at normal temperatures and pressures will give off vapors which are capable of forming ignitible mixtures with the air near the surface of the liquid or within the vessel in which the liquid is stored. Kerosine grades of turbine fuels (JET A) are out of this range at normal temperatures and pressures but where a JET A turbine fuel may be heated above its flash point, the vapors may be capable of forming ignitible mixtures. This condition may develop where ambient temperatures are in the 100°F (38°C) range for extended periods, such as in the tropics.

4. In evaluating the potential flammability of a fuel-air mixture in a tank under a given temperature condition, it should be remembered that the temperature of the fuel inside the tank may be quite different than the ambient temperatures being experienced.

(b) Flammability Limits.

1. The lower limit represents the minimum concentration while the upper limit defines the maximum amount of fuel vapors in air that will permit combustion. The generally accepted flammability range by volume for most gasolines is: 1.4 percent to 7.6 percent. The average figures for JET B turbine fuels are: 1.16 percent to 7.63 percent. The average figures for kerosine grade (JET A) turbine fuels are 0.74 percent to 5.32 percent.

2. There is relatively little significance in the varia-

tions indicated for the range between the lower and upper limits of these products as there is only about 2 percentage points variation between the least volatile fuel (JET A turbine fuel) and the most volatile (aviation gasoline).

3. More significant is the temperature range during which it may be possible to have such flammable vapor-air mixtures. At sea level in a storage tank this temperature range for aviation gasoline would be from about minus 50°F to plus 30°F (-46°C to -1°C); for JET B turbine fuels, the range would be from about minus 10°F to plus 100°F (-23°C to 38°C) and for the kerosine grades (JET A) turbine fuels from plus 95°F to plus 165°F (+35°C to +74°C). It can be seen that the JET B turbine fuels represent the most serious practical hazard under normal temperature conditions.

4. As vented tanks are drained, air enters and during such periods the flammable vapor conditions may change drastically. The same change occurs in aircraft which descend from altitude. These facts are important in assessing the degree of hazard which may exist in a tank containing any of these volatile products during or after such air mixing.

5. Under aircraft crash impact conditions where "fuel mists" are created following tank failures, all of the fuels are readily ignitible. Under these conditions, fuel in "mist" form presents a hazard equal to fuel in vapor form as far as reaching the flammability limits of the fuel are concerned.

(c) Vapor Pressure.

1. The vapor pressure of these fuels is the pressure of the vapor at any given temperature at which the vapor and liquid phases of the substance are in equilibrium in a closed container. Such pressures vary with the temperature but, most commonly, information on hydrocarbon mixtures is given by the Reid method where the pressures are measured at 100°F (38°C) (ASTM D323-72). The Reid vapor pressures of average grades of aviation gasoline range from 5.5 to 7.0 lb./sq in. (38 to 48 kPa) absolute. For JET B turbine fuels, the Reid vapor pressure is between 2.0 and 3.0 lb./sq in. (14 to 21 kPa) absolute. JET A (kerosine grade) turbine fuels are about 0.1 lb./sq in. (0.7 kPa) absolute.

2. The practical significance of this characteristic of the three grades of fuel is that the standard grades of aviation gasoline do give off flammable vapors in ignitible amounts at normal temperatures and pressures, but when these vapors are confined the vapor air mixture over the liquid surface most frequently is too rich to be ignited by sparks (being above the upper flammability limit). With JET B turbine fuel, due to its relatively low vapor pressure, the vapor air mixture above the liquid surface under normal temperature and pressure conditions most frequently will be within the flammability range. This means that ignition of JET B turbine fuel vapors either within or exterior to a tank may cause violent combustion within the confined space if flame enters. The JET A (kerosine grade) turbine fuels do not give off flammable vapors in ignitible amounts unless the fuel temperature is above its flash point.

(d) Autoignition Temperature.

1. The autoignition temperature is the minimum temperature of a substance required to initiate or cause self-sustained combustion independently of any sparks or other means of ignition.

2. Under one set of test conditions standard grades of aviation gasoline have ignition temperatures approximating 840°F (449°C). Turbine fuels have ignition temperatures among the lowest found for hydrocarbons and considerably lower than those for aviation gasoline. For instance, the autoignition temperature of a JET B turbine fuel was measured using the same test procedure at approximately 480°F (249°C). A JET A (kerosine grade) turbine fuel under the same test method was found to have an autoignition temperature approximating 475°F (246°C). Temperatures in this range may exist for a considerable period in turbine engines after shutdown or on brake surfaces following hard use.

3. Under another set of test conditions the ignition temperatures for aviation gasolines ranged from about 825°F to 960°F (440°C to 516°C), for JET B about 470°F (243°C), and for JET A (kerosine grade) from about 440°F to 470°F (227°C to 243°C).

4. It should be remembered that these figures are derived from reproducible laboratory test procedures, whereas, in actual field conditions, these ignition temperatures may be higher.

(e) Distillation Range.

1. The initial and the end boiling points of standard grades of aviation gasoline are approximately 110°F and 325°F (43°C and 163°C). The initial boiling point of JET B turbine fuels is about 135°F (57°C) and the end point is 485°F (252°C). The only marked difference in the distillation ranges of the three fuels under consideration concerns the JET A (kerosine grade) of turbine fuels which have initial boiling points of about 325°F (163°C) and end points of about 450°F (232°C).*

2. This factor, along with the flash points and vapor pressures of the fuels, indicates the relative volatility of the fuels; the initial and end boiling points show the overall volatility of a fuel through its entire distillation range; the flash point and vapor pressures measure the initial tendency of the fuel to vaporize. It can be seen that aviation gasoline and JET B turbine fuels have wider ranges.

(f) Electrostatic Susceptibility.

1. The degree to which a static charge is acquired and built up by aviation fuels depends on many factors such as fuel type, amount and type of impurity, linear velocity, type and condition of charge separating surface and presence of extraneous materials like water, air, sludge, tank scale and treating reagents.

2. JET B and JET A turbine fuels by their very nature generally are more prone to aquire a static charge than aviation gasolines.

*Initial and end boiling points as determined by ASTM Method D86-67 (1972).

II. Fire Severity After Ignition.

(a) Heat of Combustion.

1. The net heat of combustion of gasoline is normally quoted as about 19,000 Btu/lb (44.19 KJ/kg). For JET B turbine fuels the average is roughly 18,700 Btu/lb (43.50 KJ/kg), while for the JET A (kerosine grades) of turbine fuels it is approximately 18,600 Btu/lb (43.26 KJ/kg).

2. From these figures it can be readily seen that there is little difference in the heat of combustion between these various hydro-carbons which would be of significance from the fire safety point of view.

(b) Rate of Flame Spread.

1. Where quiescent pools of spilled fuel exist, there is a marked difference in the rates of flame spread over pools of JET A (kerosine grades) of turbine fuels as compared with the other two types. Under these conditions, a direct relationship exists between the rate of flame spread and the vapor pressures of the materials; for instance, aviation gasolines and JET B turbine fuels have been calculated to have a rate of flame spread of between 700 feet to 800 feet (213 m to 244 m) per minute, whereas the rate of flame spread for JET A turbine fuels under the same conditions is substantially lower and is less than 100 feet (30 m) per minute. A recent report dated October 1973 entitled "An Evaluation of the Relative Fire Hazards of JET A and JET B for Commercial Flight" (N74-10709), available from the National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA 22151, states: "the rate for JP-4 (JET B) is about 30 times greater than for aviation kerosene (JET A) at the temperatures most often encountered." This is an important factor in evaluating the severity of the fire hazard encountered under these conditions and is also a factor which would affect the ease of fire control under similar conditions.

This slower rate of flame propagation for JET A (kerosine grade) turbine fuels does not hold, however, where the fuel is released as a "fuel mist" as is frequently the result of aircraft impact accidents, or where the fuels are heated to or above their flash point. If a flammable or combustible liquid is in "mist" form or is at a temperature above its flash point, the speed of flame spread in the "mist" or vapor will be essentially the same regardless of the liquid spilled.

III. Fire Control Factors.

(a) Specific Gravity.

1. The specific gravity of a material is commonly expressed as related to water at 60°F (16°C). All these fuels are lighter than water; the specific gravity of aviation gasolines is normally quoted at about 0.70, JET B turbine fuels at about 0.78, and the JET A (kerosine grade) fuels at about 0.81.

2. This means, as far as fire control is concerned, that all of the fuels will float on water. This may be a handicap during fire fighting operations under certain conditions where sizable quantities of spilled fuel may be involved.

(b) Solubility in Water.

1. All three of the fuels are essentially nonsoluble in water. Fires involving all three fuels can be handled with regular foam concentrates (as opposed to alcohol types). U.S. specifications* on all the various aviation fuels are such that control is established over the additives making it possible to use regular foam concentrates without concern for abnormal foam breakdown because of anti-icing or defoaming constituents in the fuel.

2. The amount of water that may be entrained in the fuel due to water contamination is not particularly significant from a fire hazard viewpoint except that the amount of water increases the static generation hazard of the fuel.

A-1-4.2 Deadman Controls. Deadman controls should be designed so that the operator can comfortably use them while wearing gloves and for the time required to complete the operation. A pistol grip deadman device which is squeezed to operate is better than a small button that must be held by a thumb or finger.

A-1-4.2 Standard Grades of Aviation Fuels. Standard grades of aviation fuels include:

(a) Aviation gasoline (AVGAS) means all gasoline grades of fuel for reciprocating engine powered aircraft of any octane rating. It has the general fire hazard characteristics of ordinary automotive gasoline.

(b) JET A and JET A-1 means kerosine grades of fuel for turbine engine-powered aircraft, whatever the trade name or designation. JET A has a minus 40°F (-40°C) freezing point (maximum); JET A-1 incorporates special low temperature characteristics for certain operations having a minus 58°F (-50°C) freezing point (maximum). JP-8 (identical with JET A-1) and JP-5 (slightly less volatile than either JET A or JET A-1) are used by certain U.S. military forces. These fuels are known in the United Kingdom as AVTUR (AVCAT in the UK is a high flash point kerosine primarily for military aircraft).

(c) JET B means all blends of gasoline and kerosine grades of fuel for turbine engine powered aircraft, whatever the trade name or designation, having the general fire hazard characteristics as described herein. JET B is a relatively wide boiling range volatile distillate having a minus 60°F (-51°C) freezing point (maximum). JP-4 is one grade of JET B fuel as used by the U.S. military forces; JP-4 has identical specifications with JET B as they relate to fire hazards. This fuel is known in the United Kingdom as AVTAG.

A-2-2 Handling Fuel Spills. In the event of a fuel spill the following actions may be appropriate, although each spill will have to be treated as an individual case because of such variables as the size of the spill, type of flammable or combustible liquid involved, wind and weather conditions, equipment arrangement, aircraft occupancy, emergency equipment and personnel available, etc.

*As published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, especially ASTM Specifications D910-70 and D1655-72.

(a) *Stop the Flow of Fuel if Possible.* If the fuel is discovered leaking or spilling from fuel servicing equipment or hoses, operate the emergency fuel shutoff at once. If the fuel is discovered leaking or spilling from the aircraft at the filler opening, vent line or tank seams during fueling operations, stop fueling immediately. Evacuation of the aircraft should be ordered when necessary. The aircraft must then be thoroughly checked for damage or entrance of flammable liquid or vapors into any concealed wing or fuselage area before being placed in normal operational service.

(b) *Notify the Airport Fire Crew* if the spill presents a fire hazard. The only normal exceptions are for small spills. Supervisory personnel should be notified to assure that operations in progess may either be continued safely or halted until the emergency is past and that corrective measures can be taken to prevent recurrence of a similar accident.

(c) *Small Priming Spills* involving an area less than 18 inches (457 mm) in any dimension are normally of minor consequence although ramp personnel manning ramp fire extinguishers during start-up procedures should stand by until the aircraft is dispatched. Occasionally such small spills will ignite from engine exhaust fumes or heat but the amount of fuel is so small as not to require application of an extinguishing medium unless the spill is in close proximity to ramp personnel or equipment which might be endangered.

(d) *Other Small Spills* of not over 10 feet (3 m) in any dimension or not over 50 square feet (5 m^2) in area and not of a continuing nature should have a fire guard posted. The fire guard should be provided with at least on ramp fire extinguisher. If the spill is not ignited, either absorbent cleaning agents (such as diatomaceous earth) or emulsion compounds or rags may be used to absorb the spilled fuel. The use of absorbent cleaning agents or emulsifiers is preferred to rags as they can be applied with less personnel hazard. This is particularly true in the case of spills of aviation gasoline and similar low flash point fuels. Contaminated absorbents and fuel soaked rags should be placed in metal containers with self-closing lids until they can be disposed of by burning at a sale location. An exception to this method may be authorized if the spill occurs in an area where no operations are in progress or will be conducted until ample opportunity is provided for volatile fuels to evaporate harmlessly. In such an event, the area should be roped off to prevent unauthorized entry. Fuels that will not evaporate in air readily (such as kerosine) must be removed by one of the methods indicated above and note should be taken of the fact that some types of ramp surfacing are adversely affected by liquid fuel contact.

(e) *Larger spills* of over 10 feet (3 m) in any dimension and over 50 square feet in area or of a continuing nature normally require handling by the airport fire brigades or local fire department. They should be summoned immediately. Anyone in the spill hazard area should leave it at once. Only general guidance can be given, but the following procedures should be considered in the event of this type of spill following the alerting of the responsible fire brigade or department.

1. It may be necessary to evacuate the aircraft if the spill is such as to pose a serious fire exposurve it at once.

Only general guidance can be given, but the following procedures should be considered in the event of this type of spill following the alerting of the responsible fire brigade or department.

1. It may be necessary to evacuate the aircraft if the spill is such as to pose a serious fire exposure to the aircraft or its occupants. Do not permit anyone to walk through the liquid area of the fuel spill. If any person has been sprayed with fuel or had his clothing soaked with fuel, he should go to a place of refuge, remove his clothing and wash his body. Individuals whose clothing may be ignited should be told or forced to roll on the ground. A dry chemical extinguisher may be used to extinguish such a fire.

2. Mobile fueling equipment and all other mobile equipment should be withdrawn from the area or left "as is" until the spilled fuel is removed or made safe. No fixed rule can be made as fire safety will vary with circumstances. "Shutting down" equipment or moving vehicles may provide a source of ignition if no fire immediately results from the spillage.

3. Neither any idle aircraft nor any idle automotive or spark producing equipment in the area should be started before the spilled fuel is removed or made safe. If a vehicle engine is running at the time of the spill, it is normally good practice to drive it from the hazard area unless the hazard to personnel is judged too severe. Fuel servicing vehicles in operation at the time of the fire should not be moved until a check is made that any fuel hose which may have been in use or connected between the vehicle and the aircraft is safely stowed.

4. If any aircraft engine is operating at the time of the spill, it is normally good practice to move the aircraft from the hazard area unless air currents set up by operating power plants would aggravate the extent or the nature of the vapor hazard existing.

5. If circumstances dictate that operating internal combustion engined equipment within a spill area which has not ignited should be "shut down," engine speeds should be reduced to "idle" prior to cutting ignition in order to prevent backfire.

6. The volatility of the fuel may be a major factor in the initial severity of the hazard created by a spill. Aviation gasoline and other low flash point fuels at normal temperatures and pressures will give off vapors which are capable of forming ignitible mixtures with the air near the surface of the liquid, whereas this condition does not normally exist with kerosine fuels (JET A or JET A-1) except where ambient temperatures are in the 100°F (38°C) range the liquid, or both, has been heated to a similar temperature.

7. Spills of aviation gasoline (AVGAS) and low flash point turbine fuels (JET B) greater than 10 feet (3 m) in any dimension and covering an area of over 50 square feet (5 m^2) or which are of a continuing nature should be blanketed or covered with foam. The spills should then be washed from critical areas with water and allowed to evaporate before the site is again used for normal operations. The nature of the ground surface and the exposure conditions existing will dictate the exact method to be followed. Such fuels should not normally be washed down sewers or drains unless no alternative is available or unless exposure conditions are such that this would obviously be

the safest procedure. If such action is taken, the decision to do so should be restricted to the chief of the airport fire brigade or the fire department. If fuels do enter sewers, either intentionally or unintentionally, large volumes of water should be introduced to flush such undergrounds as quickly as possible to dilute, to the maximum possible extent, the flammable liquid content of the underground. Normal operations involving ignition sources (including aircraft and vehicle operations) should be prohibited on surface areas adjacent to open drains or manholes from which flammable vapors may issue due to the introduction of liquids into the sewer system until it can be established that no flammable vapor air mixture is present in the proximity.

NOTE: See NFPA 415, *Standard on Aircraft Fueling Ramp Drainage*, for further information on aircraft fueling ramp drainage designs to control the flow of fuel which may be spilled on a ramp and to minimize the resultant possible danger therefrom.

8. Spills of kerosine grades of aviation fuels (JET A or JET A-1) greater than 10 feet (3 m) in any dimension and covering an area of over 50 square feet (5 m^2) or which are of a continuing nature and which have not ignited, may be blanketed or covered with foam if there is danger of ignition. If there is no danger of ignition, an absorbent compound or an emulsion type cleaner may be used to clean the area. The emulsified residue can be safely flushed away with water. Kerosine does not evaporate readily at normal temperatures and must be cleaned up. Smaller spills may be cleaned up using an approved, mineral-type, oil absorbent.

9. With either type of fuel it may be possible to wash the fuel with water spray nozzles to a safe location, but caution should be used since ground surface contamination is normally of considerable concern in the proximity of aircraft operations.

10. Aircraft on which fuel has been spilled should be thoroughly inspected to assure that no fuel or fuel vapors have accumulated in flap well areas or internal wing sections not designed for fuel tankage. Any cargo, baggage, express, mail sacks or similar items that have been wetted by fuel should be decontaminated before being placed aboard any aircraft.

A-2-2.9 Transferring fuel from one tank vehicle to another which is servicing an aircraft is prohibited because of the inherent danger of a spill from overfilling the servicing tank vehicle.

A-2-3 Bonding and Grounding. An aircraft is similar to any other rubber-tired vehicle, such as an automobile or truck, with regard to its ability to build up a static charge when in movement on the ground or at rest (*see Section 5-5 of Chapter 5 of NFPA 77, Recommended Practice on Static Electricity*). The difference is principally one of magnitude because of the greater "plate area" of an aircraft. Charges may be generated by the movement of the aircraft with the generation at the point of separation of the tires from the pavement and by air currents passing over aircraft surfaces, particularly when such currents carry particles of dust, dry snow or ice crystals. The movement of air over the metallic surface of an aircraft insulated from ground (as by rubber tires or while on nonconductive ground surfaces) is normally of little concern from a fire hazard viewpoint except where flammable vapors may be present. Some ground maintenance operations provide sources of flammable vapors requiring subsequent caution. Generation of static charges will usually be found greater when low relative humidity conditions prevail in the atmosphere. The sudden discharge of a highly electrified cloud by a lightning stroke in the vicinity might suddenly release any "bound" charges which might be present on an aircraft insulated from the ground. The charge thus freed might produce an arc of sufficient intensity to be potentially hazardous in the presence of any flammable vapors. Certain maintenance operations can produce static charges which constitute a fire hazard in the presence of flammable vapors. Fueling and replenishing of flammable liquid tanks, fuel filtering processes, spraying, buffing, cleaning and paint stripping are examples.

The bonding connection recommended herein assumes that all adjoining aircraft structural (plate) surfaces of metal covered aircraft are bonded so that a single point bond will satisfactorily equalize all static charges on adjoining surfaces.

The bond between the nozzle and the aircraft is most essential and is to be maintained throughout the fueling operation — until after the fuel tank filler cap has been closed.

During overwing fuel servicing operations, the almost unavoidable presence of flammable vapors in the air in the immediate proximity of open fuel intakes may create a fire hazardous condition. Any leakage or spillage increases the area of the hazard. Protection against electrostatic spark ignition of such flammable vapor-air mixtures as may be created at fuel intakes during this fuel servicing necessitates control over the accumulation of such charges and good practice dictates the draining of any electrostatic charges that have accumulated on the aircraft or the fuel dispenser. A bonding cable between the fueling nozzle and the airframe will minimize the possibility of a static spark at the fill opening. With underwing servicing, the fill opening is closed until the filler nozzle is properly connected. The mechanical metal-to-metal contact between the aircraft fitting and the nozzle eliminates the need for a separate bonding connection at this point.

If a protective covering is provided on bonding cables to minimize the danger of hand injury, it may be loose fitting or bonded to the cable during manufacture. Preformed cable reduces the risk of hand injury without requiring a covering.

A-2-3.4 Ordinary plastic funnels or other nonconducting materials can increase static generation. The use of chamois as a filter is extremely hazardous.

NOTE: See also Section 5-10 on the importance of electrostatic bonding of filter separators.

A-2.3.9 Maximum Resistance and Grounding Electrodes. Although a resistance as high as 10,000 ohms is acceptable in a static grounding electrode, it will usually be found that a much lower resistance is readily attainable. Grounding electrodes, consisting of pipes or rods ½-inch to ¾-inch (13 mm to 19 mm) in diameter, of galvanized iron, steel or copperweld steel, driven into the ground to reach below the permanent ground moisture