NFPA®

410

Standard on Aircraft Maintenance

2020

NFPA®

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ISBN: 978-145592382-3 (PDF)
ISBN: 978-145592383-0 (eBook)

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NFPA® 410

Standard on

Aircraft Maintenance

2020 Edition

This edition of NFPA 410, *Standard on Aircraft Maintenance*, was prepared by the Technical Committee on Aircraft Maintenance Operations. It was issued by the Standards Council on January 15, 2019, with an effective date of February 4, 2019, and supersedes all previous editions.

This edition of NFPA 410 was approved as an American National Standard on February 4, 2019.

Origin and Development of NFPA 410

Work on a project to develop recommendations on fire safety safeguards for aircraft maintenance was launched in 1955. NFPA 410A, *Recommendations on Safeguarding Aircraft Electrical System Maintenance Operations,* was adopted in 1958, as was NFPA 410B, *Recommendations on Aircraft Breathing Oxygen Systems Maintenance Operations.* NFPA 410C, *Recommendations on Safeguarding Aircraft Fuel System Maintenance,* was adopted in 1962; NFPA 410D, *Recommendations for Safeguarding of Aircraft Cleaning, Painting, and Paint Removal,* was adopted in 1965. Both NFPA 410E, *Recommended Safe Practice for Aircraft Welding Operations in Hangars,* and NFPA 410F, *Recommendations on Safeguarding Aircraft Cabin Cleaning and Refurbishing Operations,* were adopted in 1963. The 1980 edition of NFPA 410 was a compilation of the 410 series as a standard. The 1989 edition of the standard was completely revised. A chapter was added for the fire protection of ramp areas where aircraft can be parked.

The 1994 edition was a reconfirmation of the 1989 edition. The 1999 edition was a partial revision.

The 2004 edition of this standard included additional requirements for painting of aircraft within a hangar, and the fire protection requirements were consolidated into one chapter.

The 2010 edition removed unenforceable language to comply with the *Manual of Style for NFPA Technical Committee Documents* and reorganized Chapter 7 on aircraft external cleaning, painting, and paint removal to eliminate confusion and provide clarity.

The 2015 edition updated the portable extinguisher requirements to address the phase-out of Halon portables, as well as changes in the rating system for Class A and Class B portables.

The 2020 edition updates references and portable fire extinguisher requirements to reflect the most up-to-date extinguisher options.

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

Committee Scope: This Committee shall have primary responsibility for documents on fire safe practices during maintenance operations on aircraft including similar operations on aircraft during manufacture. This committee does not cover aircraft fuel servicing.

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NFPA 410

Standard on

Aircraft Maintenance

2020 Edition

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope. The scope of this standard is as follows:

(1) This standard covers the minimum requirements for fire safety to be followed during aircraft maintenance and does not include the health and safety requirements for personnel involved in aircraft maintenance.
(2) The operations covered include the following:
  (a) Maintenance of electrical systems
  (b) Maintenance of oxygen systems
  (c) Fuel tank repairing
  (d) Cleaning, painting, and paint removal
  (e) Welding operations in hangars
  (f) Interior cleaning
  (g) Refurbishing operations
(3) This standard also covers requirements for fire protection of aircraft ramp areas.

1.2 Purpose. The purpose of this standard is to provide a degree of protection for life and property from fire through requirements for aircraft maintenance based on engineering principles, test data, and field experience.

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

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

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

1.4* Units. In this standard, values for measurement are followed by an equivalent in SI units, but only the first value stated shall be regarded as the requirement because equivalent values in SI units might be approximate.

Chapter 2 Referenced Publications

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

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

NFPA 10, *Standard for Portable Fire Extinguishers,* 2018 edition.
NFPA 30, *Flammable and Combustible Liquids Code,* 2018 edition.
NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 2018 edition.
NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2019 edition.
NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* 2020 edition.
NFPA 70®, National Electrical Code®, 2020 edition.
NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair,* 2020 edition.
NFPA 407, *Standard for Aircraft Fuel Servicing,* 2017 edition.
NFPA 409, *Standard on Aircraft Hangars,* 2016 edition.

2.3 Other Publications.

Δ **2.3.1 CGA Publications.** Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151.

CGA Pressure Relief Device Standards, Part 1 — *Cylinders for Compressed Gases,* S-1.1, 2011.

2.3.2 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2014 edition.
NFPA 69, *Standard on Explosion Prevention Systems,* 2014 edition.
NFPA 408, *Standard for Aircraft Hand Portable Fire Extinguishers,* 2017 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

3.2.4 Shall. Indicates a mandatory requirement.

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

3.2.6 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1* Air Ventilation. The passing of undiluted air through an aircraft tank to render the atmosphere of the tank more suitable for human occupancy and to reduce the amount of flammable vapors in the tank to below the lower explosive limit of the fuel vapors involved.

3.3.2* Aircraft Breathing-Oxygen System. A system onboard an aircraft to provide breathing oxygen to occupants of the aircraft.

3.3.3 Aircraft Fuel Tank Inerting. The use of an inert gas to render the atmosphere of an enclosure nonexplosive or nonflammable, in effect, reducing the oxygen content of the air in the tank vapor space below the lowest point at which combustion can occur by replacing the oxygen in air with an inert gas.

3.3.4 Aircraft Maintenance. Aircraft overhaul, repair, and service operations.

3.3.5 Aircraft Overhaul. The major disassembly, inspection, repair, and reassembly of aircraft.

3.3.6 Aircraft Repair. The modification of an aircraft, rebuilding of structural damage, correction of a system malfunction, or replacement of a major component or subassembly that requires an aircraft to be in out-of-flying status.

3.3.7 Aircraft Storage and Servicing Area. The part of a hangar normally used for the storage and servicing of one or more aircraft, not including any adjacent or contiguous areas or structures, such as workshops, storage areas, and offices.

3.3.8 Airport Ramp. Any outdoor area at an airport, including aprons and hardstands, on which aircraft are normally fueled, defueled, stored, parked, maintained, or serviced.

3.3.9 Bladder Tank. See 3.3.14.1, Bladder Fuel Tank.

3.3.10 Cleaning.

3.3.10.1 ***Exterior Cleaning.*** The removal of soil from the complete aircraft exterior or from only localized areas where flammable or combustible solvents are used.

3.3.10.2 ***Interior Cleaning.*** The removal of soil from flight deck and cabin areas.

3.3.11 Coating. Application of special-purpose material such as an anticorrosion paint or a walkway paint.

3.3.12* Electric Converter. A device used to convert line voltage alternating current to the voltage and frequency, or direct current, suitable for the aircraft power system.

3.3.13* Flight Deck. The area of the aircraft arranged for use of the pilot and flight crew operating the aircraft. [**408**, 2017]

3.3.14 Fuel Tank.

3.3.14.1* ***Bladder Fuel Tank.*** A fuel container that is both collapsible and self-sealing.

3.3.14.2* ***Integral Fuel Tank.*** A fuel container whose boundary composition is as close to 100 percent of the primary structure as possible.

3.3.14.3 ***Metal Fuel Tank.*** A fuel container that includes all metal types, including surge and vent tanks, that can be removed from the aircraft for workshop or bench repair, but not including a metal fuel container that is an integral part of the aircraft and that, under certain major overhaul conditions, can be removed from the primary portion of the airframe.

3.3.15* Galley. An area of an aircraft used for storing, refrigerating, heating, and dispensing food and beverages.

3.3.16* Gaseous Oxygen. A colorless, tasteless, and nontoxic gas, comprising about 21 percent of normal air by volume, that is about 10 percent heavier than air.

3.3.17 Hot Work. Work involving burning, welding, or a similar operation that is capable of initiating fires or explosions. [**51B**, 2014]

3.3.18 Inert Atmosphere. An atmosphere in which combustion cannot occur.

3.3.19 Inert Gas. A gas that is noncombustible and nonreactive. [**69**, 2014]

3.3.20 Integral Tanks. See 3.3.14.2, Integral Fuel Tank.

3.3.21 Liquid.

3.3.21.1 ***Combustible Liquid.*** A liquid that has a closed-cup flash point at or above 37.8°C (100°F).

3.3.21.2 ***Flammable Liquid.*** Any liquid having a flash point under 100°F (38°C) closed cup and having a vapor pressure not exceeding 40 psia (2068.6 mm Hg) at 100°F (38°C).

3.3.22 Oxygen, Gaseous. See 3.3.16.

3.3.23 Paint Removal. The process of softening existing paint by applying appropriate solvents and spraying or brushing away the residue.

3.3.24 Purging. The removal of flammable vapor atmospheres or any residue capable of producing flammable vapors in the tank and connected distribution lines so that subsequent natural ventilation does not result in the reinstatement of a flammable atmosphere unless or until a flammable liquid is again introduced into the tank or its connected distribution lines.

3.3.25 Refurbishing. The replacement of aircraft interior fabrics, plastic headliners, rugs or synthetic flooring, sound-insulating materials, windows, doors, or paneling.

3.3.26 Service Operation. Routine service checks, correction of flight crew complaints, and minor repair and maintenance performed while the aircraft is routinely in out-of-flying status.

3.3.27 Tanks. See 3.3.14, Fuel Tank.

3.3.28 Unfueled Aircraft. An aircraft whose fuel system has had flammable or combustible liquid removed so that no tank, cell, or piping contains more than one-half percent of its volumetric capacity.

Chapter 4 Electrical Maintenance Operations

4.1 General.

4.1.1 Electrical system maintenance as used herein and in references to *NFPA 70* shall apply only to aircraft maintenance.

4.1.2 Electrical systems shall be de-energized during maintenance work other than where a live circuit is necessary to accomplish the required maintenance.

4.1.3 Where more than one maintenance operation is being carried out at the same time and an electrical system is energized, personnel working on the aircraft shall be informed that the system is energized.

4.1.4 Wherever possible, provisions shall be made to tag out or lock out de-energized circuits so that anyone attempting to energize the circuits is alerted to the resulting hazard to other maintenance operations.

4.2 Battery Charging and Equipment.

4.2.1 Wherever possible, aircraft batteries shall be disconnected or removed during maintenance operations in order to de-energize all electrical circuits.

4.2.2 The battery switch on the aircraft shall be in the OFF position before batteries are removed or installed.

4.2.3 Battery Removal.

4.2.3.1* When moving batteries, including during removal and replacement, precautions shall be taken to prevent the terminal prongs from contacting metal structures or objects.

4.2.3.2 During maintenance, extension cable used to provide power to the aircraft from batteries that are not in their normally installed location shall be equipped with standard aircraft battery connectors and integral fusible overload protection.

4.2.3.3 Fuses shall be the instantaneous type and sized no larger than 10 amperes above the maximum connected load.

4.2.4 Precautions.

4.2.4.1 When removing and replacing batteries, precautions shall be taken to prevent the electrolyte from spilling.

4.2.4.2 When replacing or adding electrolyte solutions in batteries, precautions similar to those required by 4.2.4.1 shall be taken.

4.2.5* Batteries in the aircraft shall be charged only where on-the-ground ventilation is provided.

4.2.6 Flexible cords used for charging shall be for the type of service used and approved for extra-hard usage.

4.2.7 Connectors shall have a rating not less than the current-carrying capacity of the cord.

4.2.8 Connectors to the battery terminals shall be of a positive type to prevent them from coming loose due to vibration, thereby causing arcs that might ignite gas from the batteries or other flammables or combustibles.

4.2.9 Tables, racks, trays, and wiring shall conform to the provisions of Article 480 of *NFPA 70* where storage batteries use acid or alkali as the electrolyte and consist of a number of cells connected in series with a nominal voltage in excess of 16 volts.

4.2.10 Mobile chargers shall carry at least one permanently affixed warning sign to read as follows:

WARNING: Keep 1.5 m (5 ft) Horizontally Clear of Aircraft Engines, Fuel Tank Areas, and Vents

4.2.11* Batteries shall be charged at a rate that does not produce a dangerous concentration of gas or excessive heat.

4.2.12 The battery manufacturer's instructions shall be followed with regard to segregation of nickel–cadmium battery-charging operations from lead–acid battery charging operations in order to prevent contamination.

4.2.13 Battery chargers and their control equipment, tables, racks, trays, and wiring shall be located or operated as follows:

(1) Not within any of the hazardous areas defined in 513.3(B) of *NFPA 70*
(2) Either in a separate building or in an area such as described in 513.3(D) of *NFPA 70*

4.2.14 Areas in which batteries are charged shall be well ventilated to ensure that the maximum gas–air mixture that is expected to be generated during charging is held below the lower explosive limits.

4.2.14.1 Where mechanical ventilation is required to accomplish the requirement of 4.2.14, it shall be of the type listed for use in Class 1, Group B atmosphere locations as defined in Article 500 of *NFPA 70* and shall be so interlocked as to ensure operation when batteries are on charge.

4.2.14.2 Exhaust ducts shall lead directly to the outside, above roof level, where gases cannot accumulate.

4.2.15 Access to battery rooms shall be limited to qualified personnel only.

4.2.16 Sources of Ignition.

4.2.16.1 Smoking shall be prohibited, and open flames, sparks, arcs, and other sources of ignition shall be kept away from the immediate vicinity of batteries that are being charged.

4.2.16.2 Warning signs shall be prominently displayed.

4.2.17 Brushes used to clean batteries shall have neither a metal frame nor wire bristles.

4.3 Ground Power Units.

4.3.1 Placement of ground power units in use shall comply with the requirements of 513.10 of *NFPA 70* and 5.6.1 and 5.6.2 of NFPA 407.

4.3.2 Proximity to Ignition Sources.

4.3.2.1 Ground power units shall be located away from fueling points, tank vents, tank outlet areas, fuel line drains, and wings.

4.3.2.1.1 Ground power units shall not be positioned within an 8 m (25 ft) horizontal radius of aircraft fuel system vent openings.

4.3.2.1.2 Ground power units shall not be used in areas in which adequate ventilation is not available or where they might constitute a fire hazard.

4.3.2.2 If used inside hangars, in addition to the requirements of 4.3.3, ground power units shall also be designed and mounted so that all electrical equipment, sparking contacts, hot surfaces, and any other possible ignition source shall be at least 457 mm (18 in.) above floor level.

4.3.2.3 At no time shall engine-driven generators be refueled within any aircraft maintenance or storage area within a hangar.

4.3.3 Electrical equipment in hangar floor pits used to store cables shall be of the type approved for Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

4.3.4 A protection system shall be provided to protect against undervoltage and overvoltage.

4.3.5 Ground power units shall always be operated at the prescribed voltage.

4.3.6* Battery Switch.

4.3.6.1 Other than as permitted in 4.3.6.2, the battery switch in the aircraft shall be turned to the OFF or GROUND POWER position when the ground power unit is connected to the aircraft.

4.3.6.2 The battery switch shall be permitted to remain in the ON position for troubleshooting that requires battery power.

4.3.7 In the event of extensive fuel spills or whenever similar hazardous conditions exist, ground power units in the vicinity that would constitute a fire hazard shall be left as is until the hazardous condition is corrected or withdrawn, if it is safe to do so.

4.3.7.1 If a portable ground power unit is to be moved under such hazardous conditions, the unit shall be de-energized before the cable is disconnected.

4.3.7.2 The cable shall be disconnected before the unit is moved.

4.3.8 Cables shall be stowed to prevent damage.

4.3.9 Strains on cables and connectors shall be avoided.

4.3.10 The ground power units shall be turned on only after the connector is installed in the aircraft receptacle.

4.3.11 When connected, the ground power unit shall be checked to determine whether it is operating at the prescribed voltage before supplying power to the aircraft.

4.3.12 The ground power units shall be de-energized before disconnecting, or anti-arcing provisions that interlock the load contactors with the aircraft electrical system shall be provided.

4.3.13 Portable ground power units shall be disconnected before they are moved.

4.4 Repair of Aircraft Electrical Systems.

4.4.1 Consideration shall be given to de-energizing the entire aircraft electrical system by disconnecting or removing the batteries and by disconnecting any outside power source.

4.4.1.1 The use of a "dummy" ground power plug shall be considered.

4.4.2 Whenever the entire aircraft electrical system is not de-energized, all personnel working on the aircraft shall be informed that the aircraft's electrical systems are energized.

4.4.3 Whenever the entire aircraft electrical system is not de-energized due to other work being performed, the electrical system being worked on shall be isolated by placing the circuit breaker in an OFF position or by pulling the fuse.

4.4.4 When an electrical system is to be isolated in order to work on it, the person assigned to work on the system shall place the circuit breaker in an OFF position or pull the fuse.

4.4.4.1 The person assigned to work on the system shall not rely on someone else to de-energize the system.

4.4.4.2 A positive test on the isolated circuit shall be made.

4.4.5 When two or more people are going to work on the same system, provisions shall be made to make one person responsible for energizing or de-energizing the system.

4.4.6 Circuit breakers shall be in the OFF position and fuses shall be pulled before removing and installing system units.

4.4.7* The use of a tag-out system, covering the switch with masking tape, or some other similar method shall be used to positively indicate that an electrical system is being worked on and that it shall not be energized except on the authorization of the supervisor.

4.4.8 When working on energized electrical systems in areas containing flammable fluid lines, the following precautions shall be taken:

(1)* Whenever working on any part of the aircraft, accidental contact of control cables, tools, or metal parts with energized electrical systems, components, or both shall be prevented.
(2) Adjacent terminals, electrical components and wiring, and flammable fluid lines shall be protected to prevent arcing and fire if accidental cross contact is made.

4.4.9 When troubleshooting, all wires shall be considered energized until proven otherwise.

4.4.10 Nonconductive or insulated tools shall be used for working on energized circuits.

4.4.11 The aircraft electrical circuit involved shall be de-energized whenever equipment or wiring is removed or installed.

4.4.12 New or repaired equipment shall be tested and checked for short circuits before being installed on an aircraft.

4.4.13 Aircraft wiring shall be secured to prevent chafing.

4.4.14 All loops provided in electrical cables to prevent flammable fluids from entering electrical connections or components shall be reformed so that they perform their intended functions.

4.4.15 Where dripshields, cables, sheaths, plug covers, or similar devices have been provided to prevent flammable fluids from contacting electrical components, they shall be reinstalled so that they perform their intended functions.

4.5 Repairs to Communications and Navigation Equipment. Radar and radio transmitting equipment shall not be operated, tested, or checked on the aircraft whenever any of the following operations are taking place within the distance limits outlined in 4.1.4 of NFPA 407 or within the distances of the manufacturer's prescribed limitations:

(1) Fueling
(2) Defueling
(3) Conducting tank repair operations when flammable vapor–air atmospheres are present
(4) Other similar hazardous operation

4.6 Cleaning of Electrical Components Installed on the Aircraft.

4.6.1 Electrical components shall not be energized and shall be isolated from power sources during cleaning operations.

4.6.2 Only nonflammable solvents shall be used for cleaning electrical components.

4.7 Testing of Electrical Equipment During and Following Repair Operations.

4.7.1 Testing of electrical equipment installed on aircraft shall be held to a minimum.

4.7.2 Wherever possible, testing shall be done at a bench or in a workshop away from the aircraft.

4.7.3 Equipment shall be checked for continuity of circuitry and resistance before power is applied.

4.8 Energizing and De-Energizing Electric Circuits During Complete Engine Change.

4.8.1 The aircraft manufacturer's recommended procedures for static grounding shall be followed.

4.8.2 Magneto circuits shall be bonded to the aircraft where they are disconnected at the engine firewall.

4.8.3 The electrical systems involved in an engine removal shall be de-energized prior to removal of the engine and remain de-energized until any hazard of flammable vapors in the area has been removed.

4.8.4 Pertinent electrical systems shall be de-energized prior to installation of the engine and remain de-energized until all flammable fluid system connections are completed and no flammable vapors exist in the area.

4.8.5 Personnel performing an engine change shall be advised when the electrical systems are de-energized and re-energized following the principles in 4.1.4 and 4.4.5.

4.8.6 The de-energized circuits shall be tagged out or locked out so that persons attempting to energize them are made aware that others could be endangered by their action.

4.8.7 Electrical disconnects shall be protected against accidental contact, dirt, and moisture during the disconnect period by tight-fitting blind plugs, tape wrapping, or both.

4.9 Electrical Equipment Mounted on Fixed Workstands.

4.9.1 Electric wiring, outlets, and equipment, including lamps on or attached to fixed docks and stands that are located or likely to be located in hazardous areas as defined in 513.3 and 513.4 of *NFPA 70* shall conform to the requirements for Class I, Group D, Division 2 locations.

4.9.2 Where docks and workstands are not located or likely to be located in hazardous areas as defined in 4.9.1, wiring and equipment shall conform to 513.7 of *NFPA 70*.

4.9.3 Receptacles and attachment plugs shall be of the locking type that do not break apart.

4.10 Electrical Equipment Mounted on Movable Stands. Movable docks and workstands with electrical equipment conforming to 4.9.2 shall carry at least one permanently affixed warning sign to read as follows:

WARNING: Keep 1.5 m (5 ft) Horizontally Clear of Aircraft Engines, Fuel Tank Areas, and Vents

Chapter 5 Aircraft Breathing-Oxygen Systems

5.1 Oxygen System Charging Operations and Safeguards.

5.1.1* Because of the possibility of fire or explosion involving oxygen, the person choosing the site for oxygen charging operations shall consider items such as exposure of other aircraft, vehicles, structures, utilities, and people in the vicinity as well as the accessibility of the aircraft to fire-fighting equipment.

5.1.2 Where it is necessary to conduct gaseous oxygen system recharging in a hangar or building, it shall be done under controlled conditions.

5.1.3 Bulk liquid oxygen recharging shall not be conducted indoors under any conditions.

5.1.3.1 A separation of at least 15 m (50 ft) shall be maintained between a filling point and other aircraft, vehicles, and structures.

5.1.3.2* Liquid oxygen charging operations shall not be performed within range of any drainage system elements, such as catch basins, through which a liquid oxygen spill could enter the drainage system.

5.1.4 Good housekeeping practices, particularly where combustibles such as grease, lubricating oil, and asphalt are found, shall be maintained in the vicinity of oxygen charging operations.

5.1.5 Open flames and smoking shall be prohibited within 15 m (50 ft) of oxygen charging operations.

5.1.6 Safeguards shall be taken while performing aircraft servicing or maintenance operations such as fueling, repair of fuel and hydraulic systems, use of cleaning fluids or de-icing fluids, or operation of electrical equipment that can inherently or accidentally introduce ignition sources or combustibles concurrent with oxygen charging operations.

5.1.7 Only charging equipment and containers suitable for the specific aircraft breathing-oxygen system shall be used.

5.1.7.1 Each container shall be identified by its marking before it is connected to the aircraft system.

5.1.7.2 Equipment intended or used for other gases shall not be interchanged with oxygen equipment.

5.1.7.3 High-pressure commercial containers, 12.4 MPa (1800 psi) or higher, shall be connected through a high-pressure regulator specified for oxygen service to service low-pressure aircraft systems.

5.1.7.4 Oxygen charging hoses shall be kept clean, capped when not in use, and clearly marked or tagged "For Oxygen Use Only."

5.1.8 Oil, grease, or other combustible substances shall not be permitted to come in contact with oxygen containers, valves, regulators, fittings, or any other part of the aircraft oxygen system or charging equipment.

5.1.8.1 Oxygen equipment shall not be handled with oily gloves or tools.

5.1.8.2 Charging operations shall not be performed while wearing oily or greasy clothing.

5.1.8.3 Protective caps shall be kept on equipment as long as possible and replaced as soon as possible.

5.1.8.4 Before charging, all connections shall be inspected for cleanliness.

5.1.8.5 If dust, dirt, grease, or any other contaminant is found, it shall be removed with detergent or solvent approved for oxygen service.

5.1.8.6 A small amount of oxygen shall be bled through hose or valve outlets before connecting to the fill fitting in order to eliminate foreign material that escapes external inspection.

5.1.8.7 The hose or valve outlet shall be aimed away from the body and equipment, and only necessary valves shall be cracked open.

5.1.8.8 A clean, dry container shall be available to collect any liquid oxygen discharge that might escape.

5.1.9 Only lubricating and thread compounds specifically approved for oxygen service under the pressures and temperatures involved shall be permitted to be used.

5.1.10 Only valve packing and transfer hose gaskets that are suitable for oxygen service shall be used.

5.1.11 Damage to oxygen containers, hoses, or converters shall be avoided.

5.1.12 Equipment shall be secured so that it cannot fall or roll.

5.1.13 Tampering with safety devices, identifying markings, symbols, and nameplates shall be prohibited.

5.1.14 Valve outlets or controls that become clogged with ice shall be thawed with warm, not boiling, water.

5.1.15 Gaseous oxygen shall not be directed at the body or clothing, and liquid oxygen shall not be permitted to contact the body or clothing because of the possibility of both fire and personal injury.

5.1.16 Where desiccant cartridges are required to ensure that only dry oxygen is introduced, only fresh desiccant cartridges with filters shall be used.

5.1.17 Threaded fittings on regulators, container valve outlets, and hoses shall properly mate with each other.

5.1.17.1 Connectors that do not fit shall not be forced.

5.1.17.2 Fittings with worn or damaged threads shall be replaced.

5.1.18 After connecting containers or charging hoses to the oxygen system fill fitting, the following checks shall be made:

(1) The connection shall be checked for gastightness by audible and visual means.
(2) Leak testing shall be done with a solution specifically approved for that particular gaseous, chemical, or liquid oxygen service.

5.1.19 Charging equipment discharge valves shall be closed when charging is completed.

5.2* Specific Cautions Applicable to Gaseous Breathing Oxygen.

5.2.1 Opening Valves.

5.2.1.1 Container charging valves shall be opened slowly to minimize fast discharge of oxygen into the aircraft oxygen system, which can cause dangerous heating and result in a fire or explosion.

5.2.1.2 Container valves shall be fully opened to prevent leakage around the valve stem.

5.2.2 Method of Opening Valve.

5.2.2.1 Wrenches, hammers, or other tools shall not be used to force container valves.

5.2.2.2 If a container valve cannot be hand operated, it shall be considered defective and taken out of service.

5.2.3 The aircraft oxygen system shall be charged to the established pressure after setting the supply regulating valve to the proper setting.

5.2.4 Where the aircraft oxygen system does not have filler valves and it is necessary to remove the aircraft containers for recharging, the container valve shall be closed and all oxygen in the lines shall be released to atmosphere before attempting container removal.

5.2.5 Before removing the container from the aircraft, the container valve outlet shall be disconnected and capped and all distribution lines shall be plugged.

5.3* Specific Cautions Applicable to Liquid Breathing Oxygen.

5.3.1 Liquid oxygen shall not be permitted to contact any part of the body or clothes.

5.3.2 Personnel shall wear approved protective clothing and equipment while handling liquid oxygen equipment.

5.3.3 If liquid oxygen is spilled on clothing, the clothing shall be removed immediately and aired before reuse.

5.3.4 Personnel who have handled liquid oxygen shall refrain from smoking for at least 15 minutes after leaving the charging area.

5.3.5 If it is necessary to remove moisture from the system, any of the following shall be used before the introduction of liquid oxygen:

(1) Dry, oil-free air
(2) Gaseous oxygen
(3) Nitrogen

5.3.6 Construction Materials.

5.3.6.1 Because of its low temperature, liquid oxygen shall be handled in equipment constructed of materials suitable for the service.

5.3.6.2 Ordinary rubber or plastic hoses, gaskets, or seals shall not be used.

5.3.7 When it is necessary to transfer liquid oxygen from one container to another, splashing shall be avoided.

5.3.7.1 To avoid breakage, the receiving container shall be cooled gradually.

5.3.7.2 Glass containers shall not be reused, and containers used shall be clean.

5.3.8 Valves.

5.3.8.1 When transferring liquid oxygen, valves shall not be left completely open.

5.3.8.2 To prevent the valves from freezing in the open position, they shall be fully opened and then immediately closed one-quarter turn.

5.3.9 Pressure relief devices shall be installed on all lines in which liquid oxygen could be trapped between closed valves and on closed containers.

5.3.10 Drip pans shall be used where pavement surfaces could be combustible or contaminated with dirt, oils, or similar materials that could ignite on contact with any spilled liquid oxygen.

5.3.10.1 If a spill does occur, the flow of liquid shall be stopped where possible and the area involving the liquid spill shall be evacuated for the time necessary for liquid oxygen to evaporate.

5.3.10.2 Personnel shall not walk on or move equipment through a liquid oxygen spill.

5.3.11* The equipment manufacturer's instructions shall be followed when transferring liquid oxygen from the supply tank to the aircraft system.

5.4* Specific Cautions Applicable to Oxygen Generator Systems.

5.4.1* During maintenance operations that require the removal of the generator from its aircraft position, a safety cap shall be installed on the oxygen generator primer.

5.4.2 If the generator is inadvertently activated outside of its aircraft position, it shall immediately be placed on a noncombustible surface.

5.4.3 If the generator is inadvertently activated in its aircraft position, it shall be left in its protected location.

5.5 Aircraft Breathing-Oxygen System Test and Repair Operations and Safeguards.

5.5.1* When flow testing the aircraft system, the minimum amount of oxygen necessary to check the system shall be used.

5.5.2 Distribution lines within the aircraft shall be periodically inspected in accordance with the aircraft manufacturer's recommendations.

5.5.3 Pressure shall be released before attempting to tighten or loosen fittings unless the containers incorporate self-opening and self-venting valves.

5.5.4 When making pressure tests of oxygen distribution lines, the valves isolating the supply containers shall be closed.

5.5.4.1 The system shall be tested in accordance with the specific instructions for the particular application.

5.5.4.2 Oil or grease shall not be permitted to come in contact with escaping oxygen.

5.5.4.3 Only leak-testing solutions specifically approved for the purpose shall be used.

5.5.4.4 All solutions shall be cleaned off the system following the test.

5.5.5 A periodic inspection shall be done on the vacuum available on all vacuum-insulated liquid oxygen tanks, and the manufacturer's instructions shall be followed.

5.5.6 When oxygen regulators or other oxygen system components on the pressure side of shutoff valves are removed for repair or replacement, the oxygen in the lines shall be released in the same manner as specified for container replacement in 5.2.4, and all disconnected lines shall be plugged or capped.

5.6* Fire Emergencies. In the event of a fire, the oxygen supply to the fire shall be shut off and the fire shall be extinguished in the same manner as a fire in a normal air atmosphere.

5.7* Breathing-Oxygen Cylinder Storage (DOT Gaseous Oxygen Cylinders and DOT-Type 4L Cylinders of Liquid Oxygen).

5.7.1 Cylinders shall be stored in an approved assigned location and protected against tampering by unauthorized individuals.

5.7.2 Only oxygen cylinders scheduled to be installed on an aircraft shall be stored in aircraft maintenance areas.

5.7.3 Designated storage areas shall be provided for liquid oxygen.

5.7.4 Oxygen storage areas shall be placarded "Oxygen — No Smoking — No Open Flames."

5.7.5 Oxygen cylinders shall not be stored near flammable or combustible materials such as petroleum products or other combustible substances, or in the same area as compressed combustible gases.

5.7.5.1 Empty and full cylinders shall be stored separately.

5.7.5.2 Empty cylinders shall be marked.

5.7.6 Aviator's Breathing Oxygen.

5.7.6.1 Each cylinder of aviator's breathing oxygen shall be marked to indicate its content.

5.7.6.2 Aviator's breathing oxygen shall be stored separately from all other oxygen cylinder supplies.

5.7.7 Cylinder Storage Temperature.

5.7.7.1 Cylinders shall be stored so that they are never allowed to reach a temperature exceeding 52°C (125°F).

5.7.7.2 When stored in the open, cylinders shall be protected against direct rays of the sun in localities where extreme temperatures prevail, from snow and ice where necessary, and from the ground beneath to prevent rusting.

5.7.8 Protection.

5.7.8.1 Cylinders shall be protected against abnormal mechanical shock that could damage the cylinder, valve, or safety devices.

5.7.8.2 When cylinders are not connected, valve protection caps shall also be used on those cylinders designed for such caps.

5.7.9* When moving cylinders, care shall be exercised to prevent them from being dropped.

5.7.9.1 Lifting magnets, slings of rope or chain, or any other hoisting device, which the cylinders themselves form a part, shall not be used for hoisting oxygen cylinders.

5.7.9.2 When being transported, cylinders shall be secured in an upright position.

5.7.10 Department of Transportation (DOT) regulations regarding hydrostatic testing of DOT Specification 3A or 3AA cylinders shall be followed.

5.8* Liquid Breathing-Oxygen Storage (in Other Than DOT-Type 4L Cylinders).

5.8.1 Liquid oxygen containers shall be stored outdoors or in a detached, noncombustible structure in accordance with NFPA 55 if the oxygen quantities fall within the scope of that standard.

5.8.2 Smaller quantities shall be located outdoors in a detached, noncombustible structure or in a cutoff room, provided that the cutoff room has ventilation and doorways protected by fire doors with ramps or curbs to prevent entrance of flammable liquids and exit of liquid oxygen.

5.8.3 Designated storage areas shall be provided for liquid oxygen storage and shall be placarded "Oxygen — No Smoking — No Open Flames."

5.8.4 In outdoor areas, valves and safety devices shall be protected from ice and snow accumulations.

5.9* Gaseous Oxygen Equipment.

5.9.1* Gaseous oxygen cylinders shall meet the following criteria:

(1) Conform with DOT regulations
(2) Have a shutoff valve
(3) Have a frangible disc safety device that meets the requirements of CGA Pressure Relief Device Standards, Part 1 — *Cylinders for Compressed Gases*, S-1.1
(4) Connect to a common header by suitable pigtails strong enough to safely withstand full cylinder pressure
(5) Fastened securely to the transportation unit

5.9.2 Manifolds.

5.9.2.1 Manifolds shall be designed and constructed to withstand full cylinder pressure.

5.9.2.2 Manifolds shall be equipped with a valve connection for use in filling the cylinders and a valved outlet connection to which the regulator is attached.

5.9.3* An approved spring-loaded relief valve shall be provided to protect the hose and other equipment that is attached to the outlet of the manifold.

5.9.4 A frangible disc shall be provided in the system, downstream of the manifold outlet, to function in the event that the safety relief valve malfunctions.

5.9.5* Regulators.

5.9.5.1 Regulators and components shall be approved for oxygen service.

5.9.5.2 Seats used in regulators shall be of a material chosen for maximum resistance to ignition in an oxygen atmosphere and the physical characteristics needed to maintain a gastight seal.

5.9.5.3 Regulators shall be provided with a filter to prevent foreign particles from entering their inlet chambers.

5.9.5.4* Regulators shall be provided with a means for dissipating heat of recompression resulting from admission of high-pressure oxygen to the regulator that might otherwise cause the regulator high-pressure seat to ignite.

5.9.5.5 Regulators shall be equipped with gauges indicating cylinder and discharge pressures.

5.9.6* Orifice.

5.9.6.1 Where a flow-restricting orifice is used, the orifice plate shall be constructed of approved material and shall be provided with a hole small enough to restrict the flow of oxygen to the equipment being filled in order to prevent development of excessive temperature in such equipment.

5.9.6.2 A pressure gauge shall be provided downstream of the orifice as a means of indicating the pressure in the aircraft oxygen system being filled.

5.9.7 Dehumidifiers or Dryers.

5.9.7.1 Any drying agent used shall be approved for use with oxygen.

5.9.7.2 Construction Material.

5.9.7.2.1 The container housing the drying agent shall be constructed of an approved material and shall be strong enough to withstand the pressure to which it could be subjected.

5.9.7.2.2 If steel is used, it shall be protected from corrosion.

5.9.7.3 Gasket materials used shall be approved for use with oxygen.

5.9.8 Hose.

5.9.8.1 Hose shall be approved for use with oxygen.

5.9.8.2 Hose shall be strong enough to withstand any pressure to which it might be subjected.

5.9.8.3 Hose connections shall be secured to prevent loosening.

5.9.8.4 The outlet end of the hose shall be equipped with a shutoff valve.

5.9.8.5 The valve outlet shall be attachable to the system fill receptacle and shall be secured to prevent loosening.

5.9.9 Precautions.

5.9.9.1 Oil, grease, or other such combustible material shall not be permitted to come in contact with the equipment.

5.9.9.2 Thread-sealing compounds, when used, shall be approved for use with oxygen.

5.9.9.3 All parts of the equipment shall be cleaned of oil or grease before being assembled.

5.9.9.4 The transport unit manifold outlet valve immediately upstream of the regulator shall be in the closed position before the cylinder valves are opened.

5.9.9.5 Oxygen valves shall be opened slowly to avoid rapid pressure rise.

5.9.9.6 After the cylinder valves on the transportation unit are opened, the manifold outlet valve shall not be opened for 60 seconds to allow heat to dissipate.

5.9.9.7 Where the regulator is not the self-relieving type, the regulator shall be relieved of pressure before the manifold outlet valve to the regulator is opened.

5.9.9.8 Before disconnecting, the valve at the end of the fill hose shall be closed to avoid whipping.

5.10 Miscellaneous Requirements.

5.10.1 Oxygen shall not be used as a substitute for compressed air to operate pneumatic tools or for pressurizing containers, paint spraying, or blowing out pipelines.

5.10.2 Gases shall not be mixed in an oxygen container.

Chapter 6 Aircraft Fuel System Maintenance

6.1 Fuel Transfer Equipment and Operations.

6.1.1* General.

6.1.1.1 The requirements of this section shall apply to aircraft fuel transfer operations during aircraft maintenance and overhaul operations.

6.1.1.2 The fuel transfer operations shall include the following:

(1) Transferring fuel from one tank to another within an aircraft while that aircraft is on the ground preparatory to maintenance
(2) Transferring fuel between a tank in an aircraft and a tank in ground equipment to achieve a maintenance objective
(3) Transferring fuel for the purpose of performing tank repairs, replacement of tank accessories, or balancing of fuel loads

6.1.2 Aircraft fuel transfer operations shall be conducted outdoors if the aircraft tanks contain gasoline, Jet B fuel, or fuels used having a flash point under 37.8°C (100°F).

6.1.3 A fixed fuel transfer piping system shall be used where fuel transfer operations are conducted on a routine basis.

6.1.3.1 A limited-capacity self-contained trailer having a closed liquid transfer system shall be permitted to be used.

6.1.3.2 Self-propelled fuel servicing vehicles shall be permitted to be used.

6.1.4 Where a fixed fuel transfer piping system specified in 6.1.3 is used, it shall meet the requirements of Section 4.4 of NFPA 407.

6.1.4.1* Where fuel transfer piping extends into a hangar for aircraft fuel servicing operations, the portion of the piping located inside the hangar shall meet the requirements of 4.4.6 of NFPA 407.

6.1.5 Self-Propelled Fuel Servicing Vehicles.

6.1.5.1 Where self-propelled fuel servicing vehicles specified in 6.1.3.2 are used, they shall meet the requirements of Section 4.3 of NFPA 407.

6.1.5.2 The fuel servicing vehicles shall not be permitted inside the hangar and shall be positioned outside the hangar so as to be readily movable.

6.1.6 Each fuel transfer operation shall be tailored to the fuel system design features of each type of aircraft and shall be performed only after the detailed procedures have been approved by the AHJ.

6.1.7 Where multiple aircraft occupy one aircraft storage and servicing area, the location used for fuel transfer operations shall be identified.

6.1.8 During each fuel transfer operation, a trained and qualified person shall be assigned to specifically oversee the fire safety of the procedures used, including the handling of the fire protection equipment provided, spill emergency precautions, and ventilation techniques.

6.1.9 Any fueling hose used shall be continuous, without intermediate couplings, and shall conform to and be maintained in accordance with the requirements of Section 4.2 of NFPA 407.

6.1.10 Nozzles shall comply with the requirements of 4.3.16.2 and 4.3.16.3 of NFPA 407.

6.1.11 Only one aircraft shall undergo fuel transfer operations at any one time in a single aircraft storage and servicing area.

6.1.12 Any other simultaneous maintenance operation on an aircraft undergoing fuel transfer operations or within 7.6 m (25 ft) of the aircraft fuel system vents, fuel tank openings, or fuel servicing vehicle, if used, that could constitute a source of ignition of vapors that could be released during an operation shall not be permitted.

6.1.13 Personnel selected for fuel transfer operations shall have a thorough knowledge of the fuel system of the aircraft involved and the handling of flammable and combustible liquids and shall be familiar with the operation and limitations of the fire-extinguishing equipment available.

6.1.14 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and not operated during the fuel transfer operations.

6.1.15 Electrical equipment used in the vapor hazard area shall be listed for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.1.16 Prior to making any fueling connection to the aircraft, the fueling equipment shall be bonded to the aircraft by use of a cable, thus providing a conductive path to equalize the potential between the fueling equipment and the aircraft.

6.1.16.1 The bond shall be maintained until fueling connections have been removed, thus allowing separated charges that could be generated during the fueling operation to reunite.

6.1.16.2 Grounding during aircraft fueling shall not be permitted.

6.1.17 Internal combustion engine–powered equipment shall not be operated within 7.6 m (25 ft) of the aircraft fuel system vents or fuel tank openings prior to the start of and during fuel transfer operations.

6.1.18 When transferring fuel from an aircraft tank by suction using an external pump or fuel servicing truck, sufficient personnel shall be assigned to accomplish the operation, to prevent overfilling, and to guard against hose slippage and any flammable or combustible liquid spillage.

6.1.19 Aircraft radio, radar, strobe lights, and electronic transmitting equipment shall not be operated during fuel transfer operations.

6.1.20 When removing fuel from an aircraft tank by gravity, free fall of the fuel shall not be permitted and a positive electrical bond shall be provided between the fuel tank and the receiving container.

6.1.21 Any spillage of fuel shall be handled in accordance with the requirements of Section 5.2 of NFPA 407.

6.1.22 When transferring aircraft fuels by hose into a tank or drum, the hose shall be extended and fixed below the liquid level of the receiving tank to reduce the hazard of liquid surface electrostatic generation.

6.2* Air Ventilation.

6.2.1 Air mover equipment used to secure air ventilation shall not create fire hazards.

6.2.2 Air movers designed to operate by expansion of compressed air or steam shall be used.

6.2.3 Compressed air shall not be introduced directly into aircraft fuel tanks for air ventilation purposes.

6.2.4 Where electrical equipment is used, the appliances shall conform to the types specified by Article 513 of *NFPA 70*.

6.2.5 A safety factor shall be included wherein the lower flammable limit (LFL) is the criterion and 20 percent of the limits shown in Table 6.2.5 shall be considered the maximum allowable concentration of fuel vapor.

6.2.6 Instruments.

6.2.6.1 Instruments used to measure the LFL shall be used only by qualified personnel.

6.2.6.2 Instruments shall be calibrated for the type of vapors present and checked periodically against standard samples to ensure maintenance of calibration.

6.2.6.3 Sampling tubes shall be impervious to absorption of the vapors.

6.2.6.4 Instruments dependent on electrical power, if not designed for use in Class I, Group D, Division 1 atmospheres as defined in *NFPA 70* or certified as intrinsically safe because of their low-energy design, shall be operated only in nonhazardous locations.

6.2.7 Personnel selected to conduct air ventilation work shall have knowledge of and experience in handling flammable liquids and a knowledge of the aircraft fuel system.

6.2.8 Aircraft shall be defueled in accordance with Section 6.1.

Table 6.2.5 Lower Flammable Limits (LFLs) of Aviation Fuels

	Lower Flammable Limit (LFL)	
Fuel	**Percent by Volume**	**Parts per Million**
Aviation gasoline (all grades)	1.4	14,000
Type A (kerosene) turbine fuel	0.6	6,000
Type B (gasoline–kerosene blend)	0.8	8,000

6.2.9* Aircraft undergoing fuel tank ventilation procedures shall be segregated or isolated from other aircraft when the flash point of the fuel is less than 37.8°C (100°F) or until a flammable vapor concentration of 20 percent of the LFL is maintained.

6.2.10 When air ventilation is performed in an enclosed hangar, and where a closed ventilating system to discharge vapors from tanks to outside the hangar is not used and tank vapors are discharged into the hangar, tests shall be conducted to determine that the presence of such fuel vapor–laden air in the enclosed hangar does not constitute a hazard under the worst conditions that can normally be anticipated.

6.2.10.1 Any flammable vapor concentration over 20 percent of the LFL downwind from any discharge point of a tank shall result in emergency revisions of procedures.

6.2.11 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and shall not be operated during the ventilation procedures.

6.2.12 Electrical equipment used in the vapor hazard areas shall be listed for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.2.13 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank shall utilize equipment as specified in Section 5.15 of NFPA 409.

6.2.13.1 Exhaust equipment and the aircraft to be ventilated shall be electrically bonded and grounded.

6.2.13.2 If ducting is used, a static bonding wire from each exhaust hose nozzle shall be connected to the aircraft before the fuel tank(s) is opened.

6.2.14 Aircraft electrical circuits that are in vapor-hazardous areas shall be de-energized.

6.2.15 Aircraft radar operations shall be controlled as required in 4.1.4 of NFPA 407.

6.2.16 Warning signs shall be placed in locations around the aircraft to indicate that tank ventilation is in progress until a flammable vapor concentration less than 20 percent of the LFL is maintained.

6.2.17 Negative Pressure.

6.2.17.1 Where air exhaust only is used, precautions shall be taken to prevent building up a negative pressure, which might result in tank collapse.

6.2.17.2 Where a blower is used, the volume and pressure of air introduced and discharged shall be balanced so that no pressure differential arises that might have an adverse effect on the tank structure.

6.2.18 The following equipment shall be required to accomplish air ventilation of aircraft fuel tanks:

(1) An air mover (exhaust) and, if circumstances dictate, a blower
(2) When air ventilation is conducted in an enclosed hangar and conditions warrant, an exhaust system designed to discharge the vapors to the outside of the hangar
(3)* Calibrated instruments that are designed to take readings of fuel and solvent vapor and oxygen concentrations within the tank volume being treated and gas-sampling tubing

6.3 Repair of Fuel Tanks.

6.3.1 Prior to conducting work on tanks, if it is necessary to defuel the tank(s) to be repaired or inspected, such defueling operation shall be done in accordance with the requirements contained in Section 6.1.

6.3.2 Residual fuel that cannot be withdrawn by normal defueling procedures shall be drained from the tanks by removal of tank access plates.

6.3.2.1 With the opening of the tanks, air ventilation procedures shall be immediately instituted.

6.3.2.2 Residual fuel shall be retrieved in the safest possible manner and the fuel prevented from excessively wetting the undersurface of the wing or dripping to the ground or ramp to form pools.

6.3.2.3 The residual fuel shall be siphoned out of the tank or manually sponged or mopped up from tank low points or where trapped by baffles or other internal structural members.

6.3.3 Prior to entering the tank or the start of any repairs, tests shall be conducted to determine that a flammable vapor concentration less than 10 percent of the LFL exists.

6.3.4 Where repairs are to be made to integral tanks that are interconnected to other integral or bladder tanks that do not require work, steps, such as plugging or taping interconnector openings, vent openings, or vent manifolds, shall be taken to prevent vapors from entering the tank or the section undergoing repairs.

6.3.5 Personnel selected to perform fuel tank repair shall be trained in the hazardous characteristics of the work environment and the materials present.

6.3.6 The supervisor in charge of the operation shall have a knowledge of the operation.

6.3.7 Where tank repair work is performed in an enclosed hangar and tank vapors are discharged into the hangar, tests shall be conducted to determine that the presence of such fuel vapor–laden air does not constitute a hazard under the worst conditions that can normally be anticipated.

6.3.7.1 Any flammable vapor concentration over 20 percent of the LFL anywhere in the hangar shall result in a cessation of work until the concentration falls below 20 percent.

6.3.8 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and shall not be operated during the repair operations.

6.3.9 Electrical equipment used in the vapor hazard area shall be listed for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.3.10 Static Electricity.

6.3.10.1 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank in accordance with Section 5.4 of NFPA 407 shall be followed, and the equipment as specified in Section 5.15 of NFPA 409 shall be utilized.

6.3.10.2 Apparel worn by personnel shall be made of material that does not accumulate static charges.

6.3.11 When tank repairs are in progress, steps shall be taken to prevent all electrical and manual controls to the affected tank from being activated or energized.

6.3.12 Aircraft electrical circuits that are in vapor hazard areas shall not be energized.

6.3.13 Portable electrical lights used in tank repair operations shall be listed for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.3.14 If flashlights are used within integral fuel cells, they shall be listed for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.3.15 Containers used to transport flammable solvents used in effecting compound removal within the fuel tanks shall be equipped with positive closing or antispill lids to prevent solvent spills while entering the fuel tank.

6.3.16 Electrical heating units used in tank repair operations shall be approved for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.3.17 Blowers having electrical components used to accelerate cure time of sealant or to warm tank interiors shall be listed for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.3.18* Additional Requirements for Repair of Integral Fuel Tanks.

6.3.18.1* Removal of existing sealant shall be accomplished with nonsparking metallic or hardwood scrapers.

6.3.18.2 Plastic or other scrapers constructed of conducting materials that tend to accumulate a static electric charge shall not be used.

6.3.18.3 Repairs necessitating structural rework shall be accomplished with compressed air-driven tools.

6.3.18.4* During top coating of fuel tank sealant base materials, ignition sources shall be eliminated.

6.3.19* Additional Requirements for Repair of Bladder Tanks.

6.3.19.1* Fuel cell repair areas shall be ventilated and segregated from other maintenance or assembly areas.

6.3.19.2 During application of coats of solvent and sealer over and under the patch, ignition sources shall be eliminated.

6.3.19.3 Upon reinstallation of the fuel cell, air ventilation procedures shall be started again and maintained until the fuel cell is closed.

6.3.20* Additional Requirements for Repair of Metal Tanks.

6.3.20.1 Required procedures for the safe removal of flammable vapors from metal tanks shall be as specified in NFPA 326.

6.3.20.2 In addition to the precautions contained in NFPA 326, the following special precautions shall also be followed:

(1) Each compartment in a container having two or more compartments shall be treated in the same manner, regardless of which compartment is to be repaired.
(2) All tanks that have been cleaned and tested shall be stenciled and tagged with the following:
    (a) Phrase such as "Safe for Welding or Cutting"
    (b) Signature of the person so certifying
    (c) Date

6.4 Pressure Testing of Aircraft Fuel Systems.

6.4.1 The requirements of this section shall apply to aircraft fuel system pressure testing using a test fluid or fuel to ensure integrity of the fuel system.

6.4.2 Aircraft fuel system pressure testing shall be conducted outdoors if the aircraft tanks contain gasoline, Jet B fuel, or fuels used having a flash point under 37.8°C (100°F).

6.4.3 Dump valve tests involving fuel discharge shall also be done out of doors.

6.4.4 Fuel transfer operations conducted in conjunction with aircraft fuel system pressure testing shall comply with the requirements specified in Section 6.1.

6.4.5 Each fuel system pressure testing operation shall be tailored to the fuel system design features of each type of aircraft and shall be performed only after the detailed procedures have been approved by the authority having jurisdiction.

6.4.6 Emergency Aircraft Removal.

6.4.6.1 An aircraft undergoing fuel system pressure testing shall be located in the hangar so that it or adjacent aircraft, unless on jacks or otherwise immobilized, can be rapidly withdrawn from the hangar in an emergency.

6.4.6.2 Provisions shall be made to tow aircraft using preplanned techniques so that emergency fire control procedures can be undertaken.

6.4.7 Hangar doors shall be opened when weather conditions allow and, if closed, unlatched and in a condition such that in an emergency they can be opened.

6.4.8 The amount of test fluid or fuel transferred shall be the minimum considered essential to each pressure testing operation.

6.4.9 The area used for fuel system pressure testing operations shall be placarded with warning signs.

6.4.10 During each fuel system pressure testing operation, a trained and qualified person shall be assigned to specifically oversee the fire safety of the procedures used, including the handling of the fire protection equipment provided, spill emergency precautions, and ventilation techniques.

6.4.11 Any fueling hose used shall be continuous, without intermediate couplings, and shall conform to and be maintained in accordance with Section 4.2 of NFPA 407.

6.4.12 Nozzles shall comply with the requirements of 4.3.16.2 and 4.3.16.3 of NFPA 407.

6.4.13 Only one aircraft shall undergo fuel system pressure testing at any one time in a single aircraft storage and servicing area.

6.4.14 Any simultaneous maintenance operation that constitutes a source of ignition of vapors, which might be released during the pressure testing operation, shall not be permitted within 7.6 m (25 ft) of the aircraft fuel system including vents and fuel tank openings.

6.4.15 Personnel selected for fuel system pressure testing operations shall have a thorough knowledge of the fuel system of the aircraft involved and the handling of flammable and combustible liquids and shall be familiar with the operation and limitations of the fire-extinguishing equipment available.

6.4.16 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and shall not be operated during the ventilation procedure.

6.4.17 Electrical equipment used in the vapor hazard area shall be approved for use in Class I, Group D, Division 1 hazardous locations as defined by *NFPA 70*.

6.4.18 Static Electricity.

6.4.18.1 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank shall utilize equipment as specified in Section 5.15 of NFPA 409.

6.4.18.2 Apparel worn by personnel shall be made of material that does not accumulate static charges.

6.4.19 Internal combustion engine–powered equipment shall not be operated within 8 m (25 ft) of the aircraft fuel system vents or fuel tank openings prior to the start of fuel system pressure testing.

6.4.20 Ground power units, which are essential when employing the aircraft fuel booster pump for the fuel system pressure testing work, shall not be located within 8 m (25 ft) of the aircraft fuel system vents or fuel tank openings.

6.4.21 When transferring fuel from one aircraft tank to another by means of an aircraft fuel booster pump, sufficient personnel shall be assigned to accomplish the operation, prevent overfilling and overpressurizing, and detect possible leakage.

6.4.21.1 Where fuel transfer operations in accordance with 6.4.21 cannot be done utilizing the internal aircraft fuel system plumbing, sufficient personnel shall perform the functions outlined in 6.4.21, with particular attention given to the integrity of the external plumbing arrangement.

6.4.22 Aircraft radio, radar, strobe lights, and electronic transmitting equipment shall not be operated during fuel system pressure testing.

6.4.23 Caution shall be exercised to prevent intermixing of test fluids or different grades of fuel.

6.4.24 Any spillage of fuel shall be handled in accordance with the requirements given in Section 5.2 of NFPA 407.

Chapter 7 Aircraft External Cleaning, Painting, and Paint Removal

7.1 General.

7.1.1 Cleaning, painting, or paint removal operations using flammable or combustible materials shall be conducted in accordance with the requirements of this chapter.

7.1.2 The spray application of flammable and combustible liquids on components and subassemblies that are removed shall be conducted in accordance with NFPA 33.

7.1.3 Where the components are not removed from the aircraft, these operations shall be conducted in accordance with Section 7.2.

7.1.4* In selecting materials for cleaning, painting, and paint removal purposes, materials with the highest flash point available shall be used.

7.2 Operational Sites and Precautions.

7.2.1* When conducting cleaning, painting, or paint removal operations, the major consideration in choosing a location shall be that of good general ventilation and ease of cleanup.

7.2.2 Aircraft, Major Aircraft Assemblies, and Aircraft Subassemblies.

7.2.2.1 When cleaning, painting, or paint removal operations are being conducted directly on an aircraft in a hangar, the application shall be limited to a maximum of 7.4 m^2 (80 ft^2) within a 2-hour period. No concurrent, hazardous operations shall be conducted within 15.2 m (50 ft) of the work operation.

7.2.2.2 Where cleaning, painting, and paint removal operations exceed the specified area and time limitations outlined in 7.2.2.1, the operations shall be conducted in a paint hangar meeting the requirements of NFPA 409, or in accordance with the requirements for a paint room meeting the requirements of NFPA 33.

7.2.3 Ramp areas used for the maintenance procedures specified in 7.2.2.1 shall be servicing ramps not subject to public access.

7.2.3.1 A minimum of 6.1 m (20 ft) clearance shall be maintained to reduce the hazard to adjacent aircraft or structures and to ensure access by fire-fighting equipment.

7.2.3.2 The aircraft being worked on shall not be in the path of other normal aircraft movements on the ramp.

7.2.4 Air Movement.

7.2.4.1 Air movement shall be provided to prevent flammable vapor concentrations at the work area, at floor level, in floor pits and drains, and in the aircraft compartments from reaching 20 percent of the LFL of material used.

7.2.4.2 Managing the flammable vapor concentrations shall be accomplished by opening the hangar doors and additional doors not on the same wall as the main hangar door, or by portable ventilation equipment rated for the area and service or conducted in a paint hangar meeting the requirements of NFPA 409.

7.2.5 Electrical Equipment.

7.2.5.1 Electrical equipment shall conform to Articles 513 and 516 of *NFPA 70*.

7.2.5.2 Temporary lighting used for general illumination during cleaning, painting, or paint removal operations shall not be located in direct range of any flammable sprays or liquids or in any “overspray” areas or shall be listed for use in Class I, Group D hazardous locations.

7.2.6 Heat Lamps.

7.2.6.1* Heat lamps shall be permitted where approved procedures are in place that limit the surface temperature of the painted area.

7.2.6.2 Heat lamps shall not be used where spraying operations are being conducted within 15.2 m (50 ft).

7.2.7 Where cleaning or paint removal agents are applied through a spray nozzle under pressure, the nozzle shall be of the self-closing type so that, when the hand of the operator is removed from the nozzle, the nozzle automatically closes.

7.2.8 Aircraft electrical systems with components exposed to flammable or combustible liquids or vapors shall be deenergized during cleaning, painting, and paint removal operations.

7.3 Control of Flammable and Combustible Liquids.

7.3.1 Storage of paints, thinners, and solvents shall be as follows:

(1) Located in a separate building or segregated from the aircraft maintenance and servicing areas of hangars by a 1–hour fire-rated partition with openings that shall be protected by an approved and listed 1–hour rated fire door
(2) Conforming to the requirements of NFPA 30

7.3.2 Only an operational supply of paints and flammable solvents, limited to not more than a 1-day supply, shall be maintained in a hangar.

7.3.2.1 The materials specified in 7.3.2 shall be in containers that comply with NFPA 30.

7.3.2.2 Flammable and combustible liquid dispensing operations shall be conducted in accordance with NFPA 30.

7.3.3 Maximum solvent or paint container size in the hangar shall be 113.5 L (30 gal) in paint hangars complying with NFPA 409 and 20 L (5 gal) in all other locations.

7.4 Housekeeping and General Safeguards.

7.4.1 Upon completion of each operation, and at least once each day during the progress of the operation, stripped paint waste, all waste solvents, wiping waste, used masking tape, and wastepaper shall be collected and disposed of in accordance with this section.

7.4.1.1 Flammable liquids or painting materials shall not be dumped into sanitary or storm drains.

7.4.1.2 Industrial waste shall be properly disposed of.

7.4.1.3 Waste shall be removed regularly from floor pits and trenches and from aircraft holds and recesses.

7.4.1.4 Until disposed of, liquid and stripped paint waste shall be kept in covered, liquid-tight containers compatible with the material being sorted.

7.4.1.5* Rags and other solid materials contaminated with flammable and combustible liquids shall be kept in a separate container and not in containers used to keep other waste materials.

7.4.1.6* Spills shall be cleaned up as they occur.

7.4.2 Spray Equipment Cleaning.

7.4.2.1 Spray equipment shall not be cleaned in the aircraft storage and servicing area.

7.4.2.2 Spray equipment shall be cleaned in accordance with NFPA 30 and NFPA 33.

7.4.3* Static Electricity.

7.4.3.1 To reduce the hazards associated with static electricity, aircraft shall be electrically grounded when parked in aircraft hangars.

7.4.3.2 The aircraft manufacturer's description and maintenance instructions shall be followed regarding the location of grounding points on the aircraft and the number of grounding cables required.

7.4.4* Smoking shall be prohibited in hangars or aircraft servicing ramps used for cleaning, paint removal, or painting operations.

7.4.5* Footwear with metal cleats or tacks shall not be permitted to be worn.

7.4.6 Open flames shall not be permitted in a paint hangar and shall be prohibited within 15.2 m (50 ft) of cleaning, painting, and paint removal operations using flammable and combustible liquids.

7.5 Inspection and Preventive Maintenance.

7.5.1 Electrical equipment shall be periodically inspected and properly maintained.

7.5.2 Grounding or bonding equipment shall be inspected, maintained, and used properly.

7.5.3 Pumps, faucets, and pressure relief vents of containers used for flammable liquids or solvents shall be kept leak-free and functioning.

7.5.4 Any damage to containers, structure, seals, or flame arrestors shall be promptly repaired.

7.5.5 Cleaning solution spray equipment, paint removal equipment, paint spray equipment, and other applicators shall be maintained in a safe condition.

7.5.6 Stands, docks, floors, filters, scaffolds, staging, and drop curtains shall be maintained to keep them sound and free from combustible accumulations.

7.5.7 Floors, roof trusses, light fixtures, and overhead equipment shall be regularly inspected for paint overspray and dust accumulation and cleaned when necessary.

Chapter 8 Aircraft Welding Operations

8.1 General.

8.1.1* Aircraft welding operations shall conform to the requirements of this chapter.

8.1.2 Only gas-shielded arc welding shall be performed on aircraft.

8.1.3 Only qualified welders, trained in the technique and familiar with the hazards involved, shall be permitted to perform aircraft welding operations.

8.1.4* A written, special welding permit for each welding operation conducted on an aircraft shall be obtained from an individual designated by management as responsible for authorizing welding operations.

8.1.5 Checklist.

8.1.5.1 A welding fire safety checklist shall also be specifically developed to cover the individual hazards of each type of operation.

8.1.5.2 If a hazard is encountered that is not covered on the checklist, work shall be stopped until the individual designated by management as responsible for authorizing welding operations provides any needed additional guidance.

8.1.6 Welding shall not be conducted, and welding equipment shall not be brought to the work area, until a permit has been issued.

8.1.7 Other work shall not be permitted within a 7.6 m (25 ft) radius of the location of any gas-shielded arc-welding operation.

8.1.8 If other aircraft are located adjacent to the welding operation, the person responsible for each aircraft shall be notified in advance that welding is to be conducted.

8.2 Flammable Vapors.

8.2.1 Welding shall not be performed on an aircraft while work is in progress on any system or component of the aircraft that contains, or has contained, fuel or other flammable or combustible liquids.

8.2.2 Welding shall not be performed on an aircraft while work is in progress on the fuel systems on any other aircraft within 15.2 m (50 ft) from the point of welding.

8.2.3 Fuel Tanks.

8.2.3.1 Fuel tank access plates and any fuel tank openings shall be closed on all aircraft within 15.2 m (50 ft) from the point of any welding.

8.2.3.2 All fuel lines, valves, manifolds, and other fuel components on the aircraft on which welding is being performed shall be in place, secured, or capped prior to the start of welding operations and remain so throughout welding operations.

8.2.4* All fuel tank vents on the aircraft being worked on and the vents of other aircraft within a 15.2 m (50 ft) radius of the welding operation shall be plugged or covered prior to the start of welding operations and remain so throughout welding operations.

8.2.5 Flammable Vapors.

8.2.5.1 Where welding is being performed in the vicinity of sources of flammable vapors, a qualified person shall use a combustible gas analyzer to check, prior to the start of welding and at least every 15 minutes during the welding operation, that flammable vapors do not reach 20 percent of the LFL.

8.2.5.2 Floor drains in the area of a welding operation conducted in a hangar shall be checked in the manner of 8.2.5.1.

8.3 Equipment.

8.3.1 Welding generating equipment shall be placarded as follows:

WARNING: Keep 1.5 m (5 ft) Horizontally Clear of Aircraft Engines, Fuel Tank Areas, and Vents

8.3.2 In aircraft hangars housing other than unfueled aircraft, welding equipment shall have no electrical components other than flexible lead cables within 457 mm (18 in.) of the floor.

8.3.2.1 The ground leads shall be as close to the area to be welded as possible, and clamps used on such ground leads shall be of the C clamp type only.

8.3.2.2* Components that could produce arcs, sparks, or hot metal under any condition of operation shall be of the totally enclosed type or shall have guards or be located outside the electrically classified areas in compliance with the requirements of Article 513, Hazardous (Classified) Locations, of *NFPA 70*, as shown in Figure 8.3.2.2.

8.3.3 The inert gas cylinder shall be fastened to prevent tipping, and the regulator and gauge shall be in proper working condition.

8.3.4 In aircraft hangars housing unfueled aircraft, standard welding practices as specified in NFPA 51B shall be followed with regard to separation from combustible materials and flammable and combustible liquids.

8.4 Fire Protection.

8.4.1 Any welding performed shall take into consideration the type of automatic fire detection equipment installed in the hangar to avoid false alarms or accidental actuation of the fire protection equipment provided.

8.4.2 The specific location where the welding is being done shall be roped off or otherwise segregated by a physical barrier to prevent unintended entry into the welding area.

8.4.3 A placard reading "Welding Operations in Progress" shall be displayed.

8.4.4 Good housekeeping shall be maintained in the welding area.

8.4.5 Fire Watch.

8.4.5.1 A fire watcher shall be assigned to operate the welding equipment and shall monitor the entire welding operation.

8.4.5.2 In the event a hazardous condition develops, the fire watcher shall have the authority to stop the welding operation.

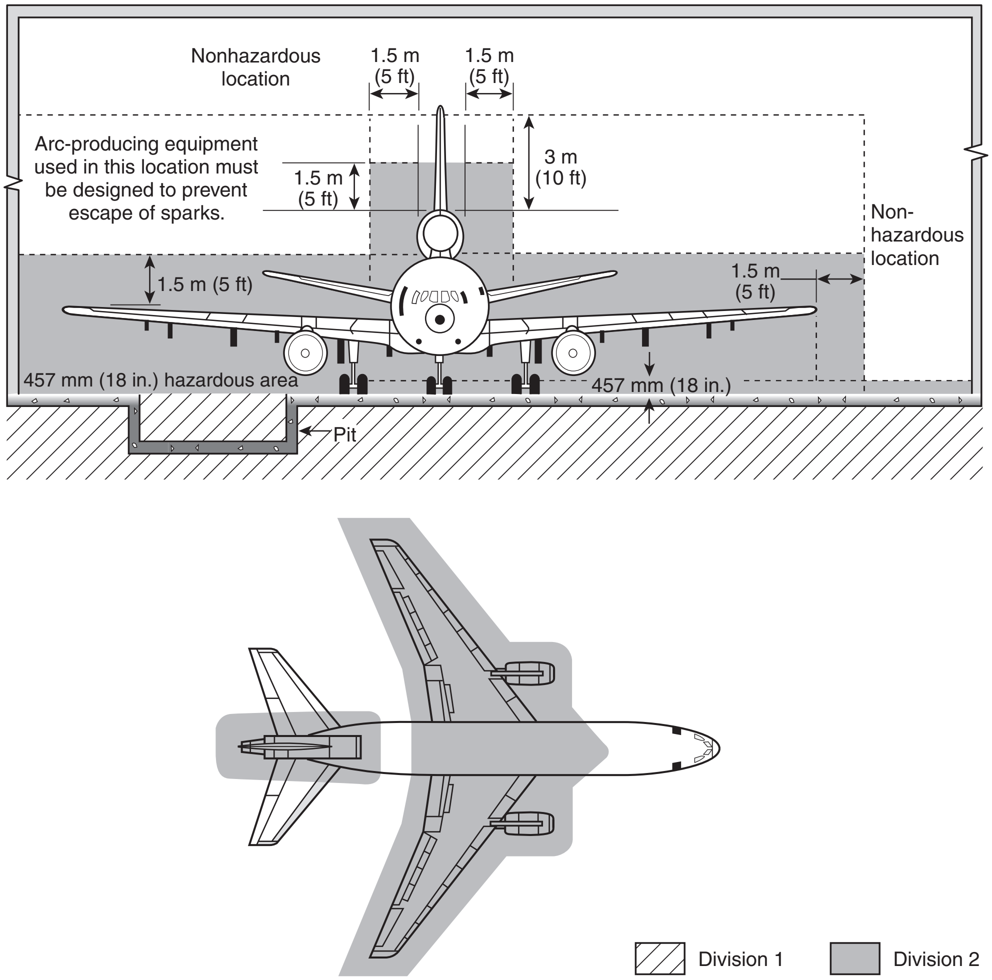

FIGURE 8.3.2.2 Area Classification in Aircraft Hangars.

Chapter 9 Interior Cleaning and Refurbishing Operations

9.1 General.

9.1.1 Flammable liquid cleaning agents shall not be used for the cleaning of aircraft interiors, such as the seats, walls, carpets, and overhead storage compartments. *(See Annex D.)*

9.1.1.1 Flammable liquid solvents or cleaning agents shall be permitted for interior aircraft cleaning when the aircraft interiors have been removed from the aircraft, including the seats, walls, carpets and overhead storage compartments.

9.1.1.2 Combustible liquid cleaning agents shall be permitted to be used.

9.1.1.3* Flammable liquid solvents or cleaning agents shall not exceed 500 ml (~1 pt) containers.

9.1.1.4 Combustible liquid solvents or cleaning agents shall not exceed 1.0 L (~1 qt) containers.

9.1.2* Aircraft cleaning or refurbishing operations using flammable or combustible liquids shall be conducted in accordance with this chapter.

9.2 Precautions for Flammable or Combustible Liquid Cleaning Agents.

9.2.1 Flammable and combustible liquids shall be stored and controlled in accordance with the provisions of NFPA 30.

9.2.2 Container storage areas shall be segregated from the aircraft maintenance and servicing area of hangars by a 1-hour fire rated partition with openings protected by listed 1-hour rated fire doors or located in a separate building.

9.2.3 Flammable and combustible liquid containers shall be appropriately marked or labeled.

9.2.4 Ventilation. Aircraft interiors shall be provided with ventilation at all times to prevent the accumulation of flammable or combustible vapors.

9.2.4.1 To comply with 9.2.4, aircraft doors shall be open to provide maximum natural ventilation.

9.2.4.2 Where available natural ventilation is insufficient, listed mechanical ventilation equipment shall be provided and used to prevent the accumulation of flammable or combustible vapors from reaching 20 percent of the LFL of the particular vapor being used.

9.2.4.3 Electrically powered mechanical ventilation equipment shall meet the requirements of 9.2.6.

9.2.5 All open flame- and spark-producing equipment or devices that are brought within the vapor hazard area shall be shut down and shall not be operated during the period when flammable or combustible vapors exist.

9.2.6 Electrical equipment of a hand-portable nature used within a vapor hazard area shall be of the type approved for use in Class I, Group D hazardous locations as defined by *NFPA 70*.

9.2.7 Temporary lighting used outside the hazard area for general illumination within an interior during cleaning and refurbishing operations shall be listed for use in Class I, Group D hazardous locations.

9.2.8 Switches to aircraft interior lighting and to the aircraft electrical system components within the interior area shall not be worked on or switched on or off during cleaning operations where flammable vapors exist.

Chapter 10 Fire Protection

10.1 General. All aircraft hangars where maintenance is performed shall be constructed and protected in accordance with the requirements of NFPA 409.

10.2* Fire Extinguishers. In addition to extinguishers required by NFPA 409, extinguishers shall be provided for aircraft maintenance operations in accordance with NFPA 10, as required by the AHJ for the following operations:

(1) Electrical maintenance
(2) Oxygen system
(3) Fuel transfer
(4) Air ventilation
(5) Fuel tank repair
(6) Pressure testing operations of aircraft fuel systems
(7) Aircraft cleaning, paint removal, or painting operations
(8) Welding operations
(9) Cleaning and refurbishing operations
(10) Ramp operations

10.2.1 Portable extinguishers shall be located in the immediate vicinity of aircraft maintenance operations, but no farther than 15 m (50 ft) away.

10.2.2 Electrical maintenance operations shall have an extinguisher having a minimum listed rating of 10-B:C and a minimum agent capacity of 6.8 kg (15 lb) located in the immediate vicinity.

10.2.3 Oxygen system test and repair operations shall have an extinguisher having a minimum listed rating of 10-B:C and a minimum agent capacity of 6.8 kg (15 lb) located in the immediate vicinity.

10.2.4 Fuel transfer operations shall have at least two dry chemical extinguishers, each having a minimum 9.1 kg (20 lb) agent capacity and agent discharge flow rate of 0.45 kg/sec (1 lb/sec), located in the immediate vicinity.

10.2.5 Air ventilation operations shall have an extinguisher having a minimum listed rating of 10-B:C and a minimum agent capacity of 6.8 kg (15 lb) located in the immediate vicinity.

10.2.6 Fuel tank repair operations shall have an extinguisher having a minimum listed rating of 10-B:C and a minimum agent capacity of 6.8 kg (15 lb) located in the immediate vicinity.

10.2.7 Pressure testing operations of an aircraft fuel system shall have at least two dry chemical extinguishers, each having a minimum 9.1 kg (20 lb) agent capacity and agent discharge flow rate of 0.45 kg/sec (1 lb/sec), located on each side of the aircraft undergoing maintenance.

10.2.8 Aircraft cleaning, paint removal, and painting operations shall have at least one extinguisher having a minimum listed rating of 10-B:C and a minimum agent capacity of 6.8 kg (15 lb) located in the immediate vicinity of the operation and available for immediate use and an additional extinguisher having a minimum listed rating of 80-B:C within the service area.

10.2.9 Welding operations shall have at least one extinguisher having a minimum listed rating of 10-B:C and a minimum agent capacity of 6.8 kg (15 lb) located in the immediate vicinity of the welding operation and available for immediate use and an additional extinguisher having a minimum listed rating of 80-B:C within the service area.

10.2.10 Cleaning and refurbishing operations in an aircraft outside or inside of the hangar shall have at least one portable fire extinguisher having a minimum listed rating of 2-A:10-B:C and a minimum agent capacity of 6.8 kg (15 lb) at the cabin entrance.

10.2.11* Ramp operations shall have at least one wheeled extinguisher having a minimum listed rating of 80-B provided at each gate or stand or at intervals of 61 m (200 ft) along the length of aircraft ramps.

10.3 Training.

10.3.1* All personnel performing aircraft maintenance shall be given training on action to take in case of fire.

10.3.2 This training shall include the use of portable and wheeled extinguishers.

10.4 Materials to Access Aircraft. Scaffolding, work platforms, or other means used to access aircraft during maintenance operations shall be of noncombustible materials.

Annex A Explanatory Material

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

A.1.4 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). One unit (liter) outside of but recognized by SI is commonly used in international fire protection. For additional information, see IEEE/ASTM-SI-10, *Standard for Use of the International System of Units (SI): The Modern Metric System.*

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

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

A.3.2.3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1 Air Ventilation. Undiluted air is air that does not contain flammable vapors or inert gases. It is recognized that, at some time during and possibly after air ventilation, the tank might contain a flammable vapor–air mixture. During such periods, a fire and explosion hazard exists that requires the elimination of ignition sources within the vapor-hazardous areas.

A.3.3.2 Aircraft Breathing-Oxygen System. Such systems do not include equipment used for or with either gaseous or liquid oxygen when used for any purpose other than for breathing. Such systems also do not include equipment used for the storage and handling of breathing oxygen and charging equipment outside of operations directly associated with breathing-oxygen systems.

A.3.3.12 Electric Converter. Rectifier units are also used to accomplish line voltage conversion.

A.3.3.13 Flight Deck. Berths, galleys, and lavatory facilities can be associated with the flight crew compartment but are not included in the term *flight deck.* [**408**, 2017]

A.3.3.14.1 Bladder Fuel Tank. The bladders themselves are of a special synthetic rubber and fabric material. Normally, these cells have a fairly low melting point and change pliability with relatively small changes in temperature. Pliability is a crucial quality in the fuel cell material. A plasticizing agent is compounded into the synthetic rubber to keep it pliable. Fuel tends to extract the plasticizing agent; however, this is not detrimental, since fuel itself keeps the material pliable.

A.3.3.14.2 Integral Fuel Tank. Integral fuel tanks can be part of either the wing or the fuselage. Integral fuel tanks are confined to the types that are basically without gasket materials installed in the seams, and the structural cavities are made fuel-tight by the installation of a sealing material after the completion of fabrication of the unit where the tank is located. The primary structure is the elements of the aircraft that carry the major stresses of flight, such as stressed skin spar caps and spar webs.

A.3.3.15 Galley. Such areas typically include places for plastic trays, plastic dinnerware utensils, and paper napkins.

A.3.3.16 Gaseous Oxygen. Above its critical temperature of −118°C (−180.4°F), oxygen can exist only as a gas regardless of the pressure exerted on it.

A.4.2.3.1 A short across these terminals can burn or weld metal, and resultant arcs can cause an explosion if the short circuit occurs in the presence of a flammable vapor. Wrenches and other hand tools should be used carefully to avoid short circuits. Rings, wristwatches, bracelets, and so forth, should not be worn while working near battery terminals because a short circuit could cause an arc or result in a severe burn.

A.4.2.5 Most aircraft have battery compartments designed for in-flight ventilation only, and if batteries are charged in such compartments while the aircraft is on the ground, an explosive gas–air mixture could be trapped in the battery compartment.

A.4.2.11 Lead–acid batteries can release hydrogen gas during charging, and any sulfuric acid vapors released are corrosive. Vented nickel–cadmium batteries can release oxygen and hydrogen if overcharged. Sealed nickel–cadmium batteries can swell, vent, or rupture if charged at a rate greater than recommended or if excessively overcharged.

A.4.3.6 The provisions of this section are extremely important, because in some aircraft the battery switch has a midposition, and if the switch is in that position and the batteries have not been removed or disconnected, the batteries will be charged in the aircraft battery compartment, giving off excessive heat, hydrogen gas, or both.

A.4.4.7 See Figure A.4.4.7.

A.4.4.8(1) No fewer than two people should work on energized electrical systems in areas containing flammable fluid lines.

A.5.1.1 For information on bulk storage of oxygen, see Annex B, NFPA 53, and NFPA 55.

A.5.1.3.2 Liquid oxygen charging operations are not performed within range of any drainage system elements, such

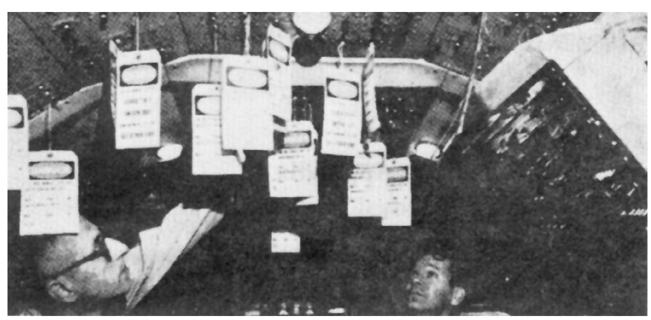

FIGURE A.4.4.7 Use of a Tag-Out System. ***(Courtesy of American Airlines, Inc.)***

as catch basins, through which a liquid oxygen spill could enter the drainage system, since such systems could contain combustible material that could be extremely hazardous in contact with liquid oxygen in the confined space.

A.5.2 Low-pressure breathing-oxygen systems are fixed systems that utilize compressed gaseous oxygen stored in containers having a maximum service pressure of about 2.76 MPa to 3.10 MPa (400 psi to 450 psi). A typical system consists of one or more containers manifolded to suitable oxygen distribution piping, check valves to isolate individual containers, relief devices to prevent container overpressure from overcharging or heating, a pressure gauge to indicate quantity of oxygen available, a manual shutoff valve, valves to isolate portions of the system, a fill fitting to allow charging the system, and one or more of the types of regulators previously described.

High-pressure breathing-oxygen systems are fixed systems that utilize compressed gaseous oxygen stored in containers having a maximum service pressure of about 12.4 MPa to 15.2 MPa (1800 psi to 2200 psi). A typical system is quite similar to low-pressure systems except that fill fittings are sometimes not provided. (In such systems, the entire container is replaced with a full container as needed.)

Portable equipment ("walk-around bottles") utilize compressed gaseous oxygen in either the low- or high-pressure containers. A typical system is composed of either a demand or continuous flow regulator, a pressure reducer, a quick-disconnect fill fitting equipped with a check valve for charging, a container pressure gauge, and a snap-in connection for mask fittings.

A.5.3 Liquid breathing-oxygen converter systems are fixed systems that utilize liquid oxygen stored in highly insulated containers that can be vented to the atmosphere or operated under low or moderate pressure. A typical system utilizes demand or continuous flow regulators, and the liquid oxygen is passed through tubing where it vaporizes and then through a warm-up coil (heat exchanger) to raise the temperature of the gaseous oxygen to a comfortable breathing level. A pressure-operated control valve maintains the desired delivery pressure and volume. Overpressure relief devices vent excessive pressures overboard. Other components include a cockpit oxygen quantity indicator, a fill fitting, and the necessary distribution piping and check valves. Some liquid oxygen containers are spherical in shape and are surrounded by integral vaporizer tubing. Others have the vaporizer tubing separate from the container. Liquid breathing-oxygen charging operations are not regarded as more hazardous than gaseous breathing-oxygen charging operations; however, a spill of liquid oxygen introduces a new hazard that should be specifically safeguarded.

A.5.3.11 The following recommendations outline procedures considered typical; however, variances in design between aircraft systems and charging equipment might require deviations and the equipment manufacturer's instructions should always be observed:

(1) Before transferring liquid oxygen from the supply tank to the aircraft system, be sure that the pressure relief valve on the supply tank is operating.
(2) To develop the desired pressure to effect transfer, close the vent valve and open the pressure build-up valve slowly.
(3) Allow the pressure to reach the desired level, then close the pressure build-up valve.
(4) Attach the transfer hose to the tank and open the fill-drain valve.
(5) Purge the transfer hose in accordance with the specific instructions of the manufacturer, then close the fill-drain valve.
(6) After purging, attach the hose to the fill fitting in the aircraft oxygen system and open the fill-drain valve slowly.
(7) Fill the aircraft converter until a steady flow of liquid (caught in a clean, dry container specifically reserved for this purpose) comes from the converter vent line, decreasing the built-up pressure in the supply tank as the converter approaches the full condition by opening the supply tank vent valve.
(8) When the aircraft converter is full, close the fill-drain valve on the tank and release pressure in the transfer hose by opening the pressure relief valve; if necessary, operate the pressure relief valve several times until there is no further pressure rise.
(9) Disconnect the transfer hose from the aircraft fill fitting.
(10) Replace the cap on the aircraft fill fitting and set the build-up and vent valves in accordance with the manufacturer's instructions.

Liquid oxygen might contain trace quantities of dissolved hydrocarbon impurities. Repeated recharging of containers from which oxygen is withdrawn as a gas, without periodically warming the containers sufficiently to volatilize and clean out impurities, can concentrate impurities to an objectionable degree. Normally this will not be a problem if the system is warmed and purged at each major aircraft overhaul period.

A.5.4 Oxygen generator systems utilize a generator with a chemical core. Chemical reaction is initiated by an electrically fired squib or a firing pin. Upon initiation, the generator supplies oxygen to the masks. The generator systems are installed on some turbine aircraft to supply emergency oxygen to the passengers and interior attendants in the event of loss of interior pressure.

A.5.4.1 It is necessary to install a safety cap because, when activated, generators generate temperatures up to 260°C (500°F).

A.5.5.1 If available, breathing air, rather than oxygen, can be used for this purpose.

A.5.6 If liquid oxygen is involved in a fire, it is normally desirable to allow the fire to burn until the liquid oxygen present in the fire area has evaporated. The combustible materials ignited should be attacked with the appropriate agent. Oxygen can combine with a number of combustible materials and cause an explosion. Liquid oxygen, as a vigorous oxidizing agent, cannot be effectively blanketed by extinguishing agents.

A.5.7 Gaseous breathing oxygen is generally received in high-pressure [12.4 MPa to 20.7 MPa (1800 psi to 3000 psi)] containers. The containers can be conventional commercial cylinders, in which case they are stored and transported to the charging site where they are used to charge the aircraft system storage containers. In some instances the aircraft system storage containers themselves might be received, in which case they are stored and transported to the charging site and interchanged with the empty containers in the aircraft system.

Liquid breathing oxygen is generally received in a tank car or truck and is transferred to a storage vessel. It is then transferred as needed to a mobile charging vehicle and transported to the charging site where it is used to charge the converter in the aircraft system.

In general, the applicable provisions of NFPA 51 and NFPA 55 should be followed. NFPA 51 is applicable to cylinder storage in smaller quantities. NFPA 55 is applicable to larger systems that utilize both gaseous and liquid oxygen.

A.5.7.9 Dropping a cylinder could cause injury to the cylinder, valve, or safety devices.

A.5.8 In the United States, liquid oxygen storage containers either are fabricated from materials meeting the impact test requirements of Paragraph UG-84 of the ASME *Boiler and Pressure Vessel Code,* Section VIII, "Rules for Construction of Pressure Vessels," or meet the specifications of DOT for 4L cylinders. Vessels (other than DOT 4L cylinders) operating at pressures above 103 kPa gauge (15 psig) are designed in accordance with the further appropriate provisions of the ASME code. A gastight, carbon steel jacket generally encloses the liquid-holding container, the annular space is filled with noncombustible insulation, and a high vacuum is maintained in the space. Containers used for this purpose should be painted and legibly marked "Aviator's Breathing Oxygen" in a manner similar to that described in A.5.9.

A.5.9 In the United States, DOT regulations govern the type and capacity of containers in which commercial oxygen as a nonflammable compressed gas can be transported and stored *(see A.5.8).* In Canada, specifications issued by the Board of Transport Commissioners apply. In other countries, similar rules are generally issued by the appropriate governmental agencies. In the United States, commercial oxygen at a pressure in excess of 276 kPa (40 psi) absolute [approximately 171 kPa (25 psi) gauge] at 21.1°C (70°F) is most commonly packed and shipped in seamless steel cylinders constructed to DOT Specification 3A or 3AA.

Commercial oxygen container valve outlet and inlet connections should conform to standards that have been prepared by the Compressed Gas Association, Inc., and adopted by both the American and Canadian standards associations.

Most oxygen cylinders are required by DOT to be equipped with safety devices. Usually, this provision is accomplished by using a frangible disc, a fusible metal core, or a combination thereof on the cylinder valve, designed to release the gas in the event the cylinder is subjected to an abnormally high temperature, as in a fire.

Each DOT 3A and 3AA cylinder is marked with a service pressure, and filling of the cylinder at 21.1°C (70°F) must not exceed 110 percent of the service pressure if the cylinder is marked with a plus sign following the last test date and if the cylinder valve is fitted with a frangible disc (without fusible metal) safety device. If not so marked and fitted, the filling must not exceed the marked service pressure.

DOT cylinders are required to have the DOT specification number followed by the service pressure (e.g., DOT3A2015); a serial number and identifying symbol (registered with the Bureau of Explosives) of the purchaser, user, or maker; the inspector's official mark and the date of the test to which the cylinder was subjected in manufacture; and the word "Spun" or "Plug" when an end enclosure is made by the spinning process or effected by plugging. In addition, cylinders used in this service should be painted and legibly marked "Aviator's Breathing Oxygen" as recommended by CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers.*

A.5.9.1 The conventional equipment consists of a wheeled cart on which is mounted a number of high-pressure cylinders with an attached manifold. A pressure-reducing device, such as a regulator, installed on the manifold is provided with an outlet connection to which the hose used to fill the aircraft oxygen system is attached. A dehumidifier, used to dry the oxygen, is sometimes interposed between the regulator outlet and the filling hose.

A.5.9.3 An approved spring-loaded relief valve should preferably be equipped with a metal seat.

A.5.9.5 The following three basic types of aircraft breathing-oxygen regulators are supplied from fixed or portable oxygen systems *(see A.5.2, A.5.3, and A.5.4)*:

(1) A continuous flow-type regulator, automatic or manual, is a means for increasing the flow with altitude. With this regulator, the breathing-oxygen flow is fixed for any given adjustment and does not vary automatically to suit work or rest conditions.
(2) A demand-type regulator allows breathing oxygen to flow only when a suction is applied, as by inhaling through a mask or tube. This regulator might feed only pure breathing oxygen, or the diluter demand-type regulator might have automatic means for mixing air with the pure breathing oxygen to maintain the partial pressure of oxygen in the lungs at a preset, low-altitude condition up to some predetermined altitude. An emergency valve for eliminating the dilution of pure breathing oxygen is normally provided.
(3) A pressure breathing demand-type regulator, when used with the proper mask, imposes a predetermined pressure upon the lungs at certain altitudes [usually above 9,000 m (30,000 ft)]. Below that altitude, the regulator functions as an ordinary diluter demand-type regulator.

A.5.9.5.4 Such means can be a dead-end chamber directly connected to the inlet passage of the regulator or some other heat-absorbing device.

A.5.9.6 Pressure reduction can also be achieved through the use of a flow-restricting orifice installed at the manifold outlet valve or in the line between the outer valve and the cylinder to be filled. This arrangement, unlike the one employing a regulator, requires the presence of an operator to shut off the gas supply from the manifold when the aircraft oxygen system comes up to specified pressure.

A.6.1.1 See NFPA 407 for aircraft fuel transfer operations not associated with aircraft maintenance or overhaul operations.

A.6.1.4.1 While Chapter 5 of NFPA 407 does not permit fuel transfer piping to be located in a building, NFPA 407 does not apply to aircraft fuel system maintenance operations. *(See Section 1.1 of NFPA 407.)* This document, NFPA 410, covers aircraft fuel system maintenance, and the provisions of 6.1.4.1 permit the fuel transfer piping to extend into a hangar for aircraft fuel system maintenance operations provided that it is protected as stated.

A.6.2 See Annex C.

A.6.2.9 Where such facilities are available and practical, hangar docks (open-faced structures) are preferable to enclosed hangars for the balance of the air ventilation procedure.

A.6.2.18(3) Warning! The reliance placed on combustible vapor detectors requires great care in the selection of the proper instrument and thorough knowledge of its capabilities and limitations. Expert maintenance is normally required. Only persons specially trained in the use of the instruments selected and in interpreting the measurements secured should be relied on to perform the required tests.

A.6.3.18 See Annex C.

A.6.3.18.1 Removal of sealant and cleanup of the area to be resealed often requires considerable agitation of the solvent or stripper. When flammable solvents or strippers are used for this operation, it becomes imperative that extreme caution be exercised to eliminate all possible ignition sources. To minimize this type of hazard, nonflammable solvents should be used whenever possible, recognizing, however, that nonflammable solvents might be more toxic.

A.6.3.18.4 Application of top coating by spray method is not recommended.

A.6.3.19 See Annex C.

A.6.3.19.1 It is recommended that aircraft be segregated or isolated during the time fuel cells are being removed.

A.6.3.20 The term *metal tanks* applies to all types of metal fuel containers, including surge and vent tanks that can be removed from the aircraft for workshop or bench repair, but it does not include metal fuel containers that are an integral part of the aircraft that can, under certain major aircraft overhaul conditions, be removed from the primary portion of the airframe.

A.7.1.4 Polyurethane paint systems consisting of an epoxy coat and a polyurethane topcoat have been widely used in the aerospace industry. One phase of the aircraft surface conditioning requires solvent wipe-down just before the epoxy primer is applied. This solvent could be one of several flammable solvents, including methyl ethyl ketone, methyl propyl ketone, acetone, or aliphatic naphtha, all of which have low flash points and require safeguards of proper ventilation and control of ignition sources to reduce the incidence of fire.

Walkway coatings are applied to internal and external areas of aircraft that are normally walked upon frequently. Such coatings are used to protect the metal surface and to provide a safe footing for personnel. This paint system is suitable for brush or roller application, but the thinner most commonly used is xylene with a flash point less than 38°C (100°F), which requires the appropriate fire hazard safeguards. In the aerospace industry, the low-flash-point paint removers have largely been replaced by self-extinguishing water-based type with a low fire hazard.

Some paint stripping chemicals utilize methylene chloride as a major component. Although this is generally a noncombustible liquid, certain toxicity issues exist with this particular material that might need to be addressed by industrial hygiene personnel.

Newer-technology paint removal processes are currently being used for both aircraft interior and exterior applications. These processes involve the use of different types of media that are shot against the surface from which the paint is to be removed, much like sandblasting. The different media types used include carbon dioxide (dry ice), wheat starch, sponge laden with aluminum oxide (sponge jet), and a variety of plastic beads. In many aspects, these media blast systems are safer and create fewer environmental concerns than many of the chemical paint removal products currently being used. However, additional hazards associated with combustible dusts can be introduced, such as with the wheat starch media, that require careful consideration and analysis.

A.7.2.1 All areas used for paint finishing should be provided with mechanical ventilation discharging to the outside atmosphere of such capacity to allow between 20 and 30 air changes per hour by volume. Exhaust from spray booths should be of such capacity as to provide an airflow of not less than 76.2 m/min (250 linear ft/min). Air exhausted from spraying operations should not be circulated. Exhaust ducts should pass directly through the nearest outside wall or through the roof. Ducts should not pass through fire walls or the floor. Air intake should be from the outside atmosphere (through steam blast coils where necessary). Air intake should be from other areas provided the atmosphere does not contain flammable vapor or residue. Air intake openings should be protected with automatic dampers that close in the event of a fire. Hangar ventilation reduces human respiratory hazard, but skin hazard, eye hazard, and other protective health measures should also be considered. See also NFPA 90A and NFPA 91.

A.7.2.6.1 The intent of this section is to prevent the temperature from reaching 50 percent of the paint's autoignition temperature in degrees F.

A.7.4.1.5 This requirement is intended to prevent spontaneous combustion.

A.7.4.1.6 Hangar and workshop floors should be protected from fuel, oil, and other spillage through the use of drip trays or collection containers.

A.7.4.3 Where aircraft maintenance platforms are used in the painting operation, they should be bonded to the aircraft. Cables used for grounding painting equipment such as metal tables, racks, tanks, and maintenance stands, should be attached in such a manner that they cannot be disconnected or broken if the equipment is accidentally moved.

A.7.4.4 Personnel in such areas should not carry cigarette lighters or matches.

A.7.4.5 Footwear with metal cleats or tacks can cause sparks when scuffed along the floor.

A.8.1.1 Chapter 8 covers the welding of aircraft by the gas-shielded arc method. Welding operations other than those on aircraft should conform to NFPA 51, NFPA 51B, and ANSI Z49.1, *Safety in Welding and Cutting*.

Occasionally, it is necessary to stress-relieve certain portions of the aircraft engines or structures by normalizing through the use of an oxyacetylene flame. Silver soldering is also required on certain electrical connections and fluid lines. The same basic precautions outlined herein should apply to those operations.

NFPA 51B gives the basic rules for cutting and welding processes using electric arcs or oxy-fuel flames.

NFPA 51 applies to the installation and operation of all gas welding and cutting systems. Structural welding in hangars should follow the procedures outlined in NFPA 51 and NFPA 51B. It is recommended that any contract to perform structural or general welding in a hangar take special note of the hazard to the contents. Aircraft should be removed wherever possible and the precautions herein applied as applicable.

A.8.1.4 See Figure A.8.1.4(a) and Figure A.8.1.4(b).

A.8.2.4 Streamers should be attached to covered vents and promptly removed after completion of the welding operation.

A.8.3.2.2 The engine and fuel tank locations indicated in Figure 8.3.2.2 are for illustration only. Aircraft manufacturers' or operators' technical information should be consulted for specific locations in individual aircraft types.

A.9.1.1.3 The total aggregate amount of flammable or combustible liquid inside an aircraft should not exceed 7.58 L (2 gal), because the resulting fire would be shielded from the fire protection system.

A.9.1.2 Refer to the manufacturer's Safety Data Sheet (SDS) for fire hazard properties of liquid products.

A.10.2 Multipurpose dry chemical (ammonium phosphate) fire-extinguishing agent is known to cause corrosion to aircraft components and should not be used. Although the agent is capable of extinguishing fires on or near aircraft, it is likely that the agent will spread to other, uninvolved aircraft, causing damage from corrosion. Bicarbonate-based dry chemicals do not melt onto hot surfaces like ammonium phosphate–based dry chemicals and therefore are easier to clean from aircraft parts and the recommended option. Clean agents are an option for the protection of various hazards and will meet minimum ratings requirements for sections that do not require dry chemical.

Welding Permit
Required for Each Welding Operation

Aircraft Type: ____________ No.: ________

Part to Be Worked On: ____________

____

Specify in detail, e.g., “Inlet Vanes on No. 3 Engine”

Location of Work: ____________

Name of Mechanic: ____________

Name of Fire Watcher: ____________

Date of Work: ________ Approvals: ________

Shift: ________ Foreman: ________

Fire Watcher ____________

FIGURE A.8.1.4(a) Typical Welding Permit.

Attach to Welding Permit — Display at Job Site
Gas-Shielded Arc Welding

	YES	NO
Safeguarding Fuel Systems		
Fuel system closed on aircraft being welded	❏	❏
Portions of fuel system on adjacent aircraft within 30 m (100 ft) from welding point closed	❏	❏
Fuel tank access plates in place	❏	❏
Fuel tank fill and vent openings closed, covered, or plugged	❏	❏
Fuel lines, valves, manifolds in place, secured or capped	❏	❏
Streamers attached to covered fuel vents	❏	❏
Pressure removed from fuel systems	❏	❏
Area, including hangar floor drains, checked with combustible gas analyzer	❏	❏
Ramp area work location checked for sources of flammable/combustible vapors	❏	❏
Safeguarding Other Work		
All other work suspended within 6 m (20 ft) of welding point	❏	❏
Area placarded: “Welding Operations in Progress”	❏	❏
Adjacent workers notified prior to start of operations	❏	❏
Housekeeping		
Area cleaned where weld is to be made	❏	❏
Combustible materials removed in surrounding area	❏	❏
Area cleared of any oil or fuel spills	❏	❏
Drains checked in area for oil contamination	❏	❏
Welding Equipment		
Generators 1.5 m (5 ft) clear of aircraft engine, fuel tanks	❏	❏
Electrical equipment 457 mm (18 in.) (minimum) off floor	❏	❏
Ground leads clamped to grounding plug	❏	❏
Gas cylinder securely fastened to prevent tipping	❏	❏
Regulators, gauges working properly	❏	❏
Mobility of Aircraft		
Aircraft parking brakes off and wheels chocked	❏	❏
Tug available — tow bar attached	❏	❏
Hangar doors open	❏	❏
Path cleared to permit towing aircraft outside	❏	❏
Qualified tow operator available and alerted	❏	❏
Fire Protection		
Fire extinguisher [minimum 10-B:C rating and minimum 6.8 kg (15 lb) agent capacity] immediately adjacent	❏	❏
Fire extinguisher (minimum 80-B:C rating) wheeled, within 30 m (100 ft)	❏	❏
Automatic sprinkler protection operable	❏	❏
Fire watcher assigned, on duty	❏	❏

Approved Fire Watcher

Date: ________ Supervisor: ____________

Δ FIGURE A.8.1.4(b) Aircraft Welding Fire Safety Checklist.

A.10.2.11 At least one portable extinguisher having a rating of not less than 10-B and a minimum capacity of not less than 6.8 kg (15 lb) should be provided on mobile service equipment, including the following:

(1) Air-conditioning units
(2) Aircraft tractors
(3) Air starter units
(4) Cabin service trucks
(5) Catering trucks
(6) Container loaders
(7) Deicer trucks
(8) Engine-driven passenger loading steps
(9) Ground power units
(10) Mobile lounges

In those vehicles classified in (4), (5), (7), (8), and (10), consideration should be given to placing an extinguisher on both the chassis and the elevated section of the vehicle.

At least one portable extinguisher having a rating of not less than 5-B and a minimum capacity of 1.5 kg (3 lb) should be provided on other miscellaneous motorized vehicles that operate within an 8 m (25 ft) radius of any part of the aircraft.

A.10.3.1 When an aircraft lands with a suspected fire or smoke warning in a cargo hold, the fire department should be informed immediately and a full passenger evacuation of the aircraft should be carried out before any hold door is opened. Hold doors should not be opened until the fire department is in attendance at the aircraft.

Failure to observe this recommendation could result in an in-rush of air into the hold, which could cause the fire to erupt, creating danger if passengers or crew are still onboard the aircraft.

Annex B Aircraft Breathing-Oxygen Systems

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

B.1 General. Current aircraft breathing-oxygen systems can utilize either gaseous or liquid oxygen or a chemical-oxygen generator.

B.1.1 Gaseous Oxygen. Gaseous oxygen is colorless, odorless, tasteless, and nontoxic. It comprises about 21 percent of normal air by volume and is about 10 percent heavier than air. Above its critical temperature of −118°C (−180.4°F), oxygen can exist only as a gas, regardless of the pressure exerted on it.

B.1.2 Liquid Oxygen. Liquid oxygen is a light blue, transparent liquid that flows like water. It boils at −183°C (−297°F) at standard atmospheric pressure. The gaseous oxygen formed at room temperature [21°C (70°F)] and standard atmospheric pressure [760 mm (29.92 in.) of mercury] by vaporization of liquid oxygen will occupy a volume about 862 times that occupied by the original liquid. If a volume of liquid oxygen is confined and allowed to warm to room temperature, the attempt of the vaporizing oxygen to expand will result in the attaining of extremely high pressures [in the order of 276 MPa (40,000 psi)]. For this reason, liquid oxygen containers must be fitted with safety relief devices or vented to the atmosphere.

B.2 Oxygen General Information. Both gaseous and liquid oxygen are stable materials and are nonflammable. Combustible materials ignite more readily in an oxygen-enriched atmosphere. The intensity of a fire increases in the presence of oxygen. This property makes it very important to keep concentrations of oxygen separated from combustibles and from any source of ignition. Therefore, the highest standards of housekeeping are essential in areas where oxygen is stored or serviced. Physical damage to or failure of oxygen containers, valves, or plumbing can result in an explosive rupture in oxygen system components with resultant danger to life, limb, and property.

Combustible materials, particularly easily ignitable flammable liquids and lubricating oil, are especially hazardous when present inside the aircraft breathing-oxygen systems where oxygen concentrations are high. There have been several incidents where explosive rupture of system components has resulted under these circumstances.

In addition to aggravating the fire hazard, liquid oxygen causes severe burns (frostbite) when in contact with the skin because of its low temperature. Since oxygen-enriched atmospheres accelerate the corrosion process, only materials approved for oxygen service should be used.

Annex C Ventilation of Aircraft Fuel Tanks

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

C.1 Air Ventilation.

C.1.1 General. Air ventilation of aircraft fuel tanks is recommended for the sole purpose of rendering the atmosphere in an aircraft fuel tank more suitable for personnel to enter the tank area for inspection or work purposes. Rendering the atmosphere suitable for personnel basically requires reducing the fuel tank vapors to below a predetermined toxic threshold (unless respiratory protection is provided) and below the predetermined LFLs of the flammable vapors and then maintaining this condition throughout the period of inspection or work. Air ventilation is not a method of inerting an aircraft fuel tank, and this distinction must be clearly understood.

Air ventilation should be accomplished by exhausting the fuel tank atmosphere of toxic and flammable concentrations of fuel vapors through a specified vapor exhaust system with or without a blower designed to augment the sweeping of the fuel vapors from the tank. The design of the air ventilation system used on any particular aircraft must be tailor-engineered to satisfy the requirements of the aircraft in question, and detailed specifications will be required for each fuel tank configuration to properly achieve these objectives.

When using air ventilation procedures, there might be times when the fuel vapor–air mixture in the tank will be within the flammable range. During such periods, a fire and explosion hazard exists. It is thus vitally important that there be no ignition sources within the tank or within reach of the vapors being discharged from the tank.

Successful use of air ventilation depends heavily on the following three basic factors:

(1) Complete drainage of the fuel tank to be treated, including siphoning, sponging, or mopping up of fuel residues that might be trapped in the tank. During the latter operations, extreme caution is necessary to prevent accidental ignition of the vapors that will be present. Fuel vapor

concentrations must be maintained below 20 percent of LFL.

(2) Establishment of adequate air circulation through the tank to ensure that the air movement rids the entire tank volume of hazardous quantities of fuel vapors. This requires tests on each tank configuration to establish the correct tank openings required, the rate of air movement, and the time needed. Such tests should include combustible vapor measurements of the entire tank volume to ensure that no hazardous vapor pockets remain, especially in tank corners that might not be properly air ventilated if the air currents established by the exhaust and/or blower systems are ineffective.

(3) Continuation of air ventilation during the entire period that the tanks are open and any work is being done.

Under some conditions (particularly in integral-type fuel tanks having sealing compounds at tank joints and in baffled tanks where drainage through baffles might not be efficient), it is possible to reinstate a flammable fuel vapor–air concentration after initial ventilation has secured a satisfactory condition. Where flammable solvents are used to remove or replace sealant or where fuel vapors are released by the breaking of sealing compound blisters, a localized toxic or flammable vapor atmosphere can be created. To minimize this type of hazard, nonflammable solvents should be used wherever possible. Periodic checks should be made with a combustibles detector or other appropriate instrument in the area of work to ensure the maintenance of a safe tank atmosphere.

The purpose of periodic checks is to examine any unusual conditions that might develop and to help maintain a fire safety consciousness among employees involved in fuel tank maintenance work.

C.1.2 Example Procedure (Enclosed Aircraft Hangar). This example procedure is illustrative of one method only and can be altered as required for different situations and conditions. However, these principles should be followed.

Place the aircraft in the proper position in the hangar with fuel tanks drained, residual fuel mopped up, and the proper underwing tank plates removed; where possible, air ventilation should have been started outdoors and a satisfactory combustible instrument reading indicating a nonhazardous tank atmosphere secured.

Guard against static spark hazards by electrically bonding and grounding exhaust equipment and the aircraft to be ventilated. If ducting is used, connect a static bonding wire from each exhaust hose nozzle to the aircraft before opening the fuel tank(s).

When a closed ventilating system *(see 6.2.10)* is used, connect the prearranged exhaust system to an explosionproof exhaust fan designed to extract air at a specific rate. (Airflow must be calibrated for each tank volume and configuration to ensure effective fuel vapor removal.)

Note that it cannot be assumed that a high rate of airflow through a tank will be more efficient than a moderate rate. Complete sweeping of the tank volume is desired without bypassing corners or creating excessive turbulence.

When portable air movers or blowers are used, place this equipment in position, secure the equipment, and, for exhaust systems, seal around tank attachment. When ducting is used with air-moving equipment to help sweep vapors from the tank, bond the ducting (if conductive) to the aircraft and pressurize the ducting before making a tight connection around attachment openings. Having a positive pressure in the ducting should prevent any flammable vapors from entering the ducting that might ignite by a source of ignition in the air-moving equipment. The air introduced into the tank through the ducting should be clean and should not contain any entrained dust, moisture, or flammable vapors. When exhaust ducts are used, the air should be exhausted to a location not containing any ignition source and to a point outside the hangar or building.

Maintain the ventilation for the time prescribed to achieve a safe atmosphere within the tank *(see 6.2.5)* and during all tank maintenance work. Check the actual conditions periodically with the combustibles detector.

Halt tank maintenance operations when any unsafe condition develops, and do not resume operations until a safe condition is restored. *(See 6.2.10.)*

When work has been completed, remove ventilating equipment. When ducts are used, remove the exhaust nozzles from the tank(s), leaving the exhaust fan operating and static bonding wire(s) attached. Replace tank caps or plates. Allow the exhaust fan to run for 3 or 4 minutes to permit removal of all vapors from the ducts. Disconnect the static bond wires from the aircraft and turn off the exhaust fan.

C.2 Integral Fuel Tank.

C.2.1 General. The designation "integral fuel tank" is confined to fuel containers whose boundaries are made up of as nearly 100 percent primary structure as possible, primary structure being the elements of the aircraft that carry the major stresses of flight, such as stressed skin, spar caps, and spar webs. Integral fuel tanks can be part of either the wing or the fuselage. Integral fuel tanks discussed in this section are confined to the types that are basically without gasket materials installed in the seams, the structural cavities being made fueltight by the installation of a sealing material after fabrication of the unit where the tank is located is complete.

C.2.2 Example Procedure. The example procedure detailed herein might have to be altered under certain conditions depending on aircraft design factors and the fuel tank configuration.

Place the aircraft in the proper position in the hangar dock or hangar building with fuel tanks, fuel lines, and cross-feed system drained as required. Consideration should be given to cross-feed and selector valve positions to obtain the desired isolation of fuel within the system.

Place suitable warning signs in conspicuous locations around the aircraft to indicate that tank repairs and air ventilation are in progress.

Guard against static spark hazards by electrically grounding the aircraft to be repaired.

Attach air movers or blowers to the exhaust system, seal around tank attachments, and electrically bond to the aircraft. For the blower system, remove the necessary tank door and insert the exhaust hose nozzle, bond, and ground as necessary to guard against static spark hazards.

Maintain ventilation for the time prescribed to achieve a safe atmosphere within the tank and during all tank repair work. Check the actual conditions periodically with the combustible gas detector and maintain frequent verbal contact with personnel within tanks. *(See Section 6.2.)*

Remove additional tank access doors when necessary to effect repairs. Such removal can expose additional quantities of trapped or residual fuel. When such is the case, applicable precautions, as outlined in the text, should be followed.

C.3 Bladder Fuel Tank.

C.3.1 General. The designation “bladder tank” includes both collapsible and self-sealing tanks. The bladders themselves are of a special synthetic rubber and fabric material. Normally these cells have a fairly low melting point and change pliability with relatively small changes in temperature. Pliability is a critical quality in the fuel cell material. A plasticizing agent is compounded into the synthetic rubber to keep it pliable. Fuel tends to extract the plasticizing agent; however, this property is not detrimental since fuel itself keeps the material pliable.

C.3.2 Example Procedure. The example procedure detailed herein might have to be altered under certain conditions depending on aircraft design factors and the type of bladders being repaired.

Place the aircraft in the proper position in the hangar dock or hangar building with fuel tanks, fuel lines, and cross-feed system drained. Consideration should be given to cross-feed and selector valve positions to obtain the desired isolation of fuel within the system.

Suitable warning signs should be placed in conspicuous locations around the aircraft to indicate that fuel system repairs and air ventilation are in progress.

Guard against static spark hazards by grounding the aircraft.

Remove the access doors and open the fuel cells.

Attach the ventilation system and maintain for the time prescribed to achieve a safe atmosphere within the tank and until the cell is ready for removal. Check the actual conditions periodically with a combustible gas detector. *(See Section 6.2.)*

It should be noted that turbine-powered aircraft are most frequently fueled with Type A (kerosene) fuel. The use of a combustible vapor detector can be recommended only to detect the possible mixtures of lower flash point Type B turbine fuels or aviation gasoline.

Prior to detaching the cell from the fuel cell cavity, remove all of the equipment, pumps, lines, and so forth, and siphon out or manually sponge or mop up from cell low points any residual fuel remaining in the cell.

Collapse the cell and remove from the aircraft.

After removal of the cell, the cell cavity should be checked with a combustible gas detector to be certain that a safe condition exists.

Transport the cell to the repair area and preserve in accordance with the manufacturer's recommendations.

Annex D Nonflammable Agents and Solvents

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

D.1 Selection. In selecting nonflammable agents and solvents, care should be exercised to ensure that a toxicity hazard is not introduced that cannot be effectively controlled by practical protective means under normal working conditions. While health hazards are outside the scope of this standard, a number of effective nonflammable cleaning agents (e.g., carbon tetrachloride) do present a serious toxicity problem. Industrial hygienists and safety professionals as well as fire protection engineers should be consulted before selecting any cleaning agent or solvent for this use. Nonflammable agents and solvents are categorized as follows:

(1) Detergents and soaps
(2) Alkaline cleaners
(3) Acid solutions
(4) Deodorizing or disinfecting agents
(5) Abrasives
(6) Drycleaning agents

D.1.1 Detergents and Soaps. These cleaning agents have widespread application for most aircraft cleaning operations involving fabrics, headliners, rugs, windows, and similar surfaces that are not easily damaged by water solutions because they are colorfast and nonshrinkable. Care should be taken to prevent leaching of water-soluble fire-retardant salts that might have been used to treat such materials in order to reduce their flame spread characteristics.

D.1.2 Alkaline Cleaners. Most of these agents are water soluble and thus have no fire hazard properties. They can be used on fabrics, headliners, rugs, and similar surfaces in the same manner as detergent and soap solutions, with only minor added limitations resulting from their inherent caustic characteristics that might increase their efficiency as cleaning agents but result in somewhat greater deteriorating effects on certain fabrics and plastics.

D.1.3 Acid Solutions. A number of proprietary acid solutions are available for use as cleaning agents. They are normally mild solutions that are designed primarily to remove carbon smut or corrosive stains. As water-based solutions, they have no flash point but should require more careful and judicious use, not only to prevent damage to fabrics, plastics, or other surfaces, but also to protect the skin and clothing of those using the materials.

D.1.4 Deodorizing or Disinfecting Agents. A number of proprietary agents useful for aircraft interior deodorizing or disinfecting are nonflammable. Most are designed for spray application (aerosol type) and have a nonflammable pressurizing agent, but this should be checked carefully, because some might contain a flammable compressed gas for pressurization.

D.1.5 Abrasives. Some proprietary nonflammable mild abrasive materials are available for rejuvenating painted or polished surfaces. They present no fire hazard.