NFPA 410
Standard on Aircraft Maintenance

1999 Edition

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

IMPORTANT NOTICE ABOUT THIS DOCUMENT

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

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

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

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

NOTICES

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

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

A statement, written or oral, that is not processed in accordance with Section 16 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

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

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

Licensing Policy

NFPA 410

Standard on

Aircraft Maintenance

1999 Edition

This edition of NFPA 410, *Standard on Aircraft Maintenance,* was prepared by the Technical Committee on Aircraft Maintenance Operations and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17–20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

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

This edition of NFPA 410 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 410

Work on an overall 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; NFPA 410B, *Recommendations on Aircraft Breathing Oxygen Systems Maintenance Operations,* was adopted in 1958; 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; NFPA 410E, *Recommended Safe Practice for Aircraft Welding Operations in Hangars,* was adopted in 1963; and NFPA 410F, *Recommendations on Safeguarding Aircraft Cabin Cleaning and Refurbishing Operations,* was adopted in 1963. The 1980 edition was a compilation of the 410 series, compiled 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. This edition is a partial revision.

Technical Committee on Aircraft Maintenance Operations

John R. Flynn, *Chair*
American Airlines, TX [U]

Nathaniel J. Addleman, Boeing Comm. Airplane, KS [U]
Joseph A. Behnke, Ansul Inc./Tyco, WI [M]
Rep. Fire Equipment Mfrs. Assn.
Jim DeWitt, Int'l Assn. of Machinists & Aerospace Workers, MO [L]
John J. O'Sullivan, British Airways, England [C]
Thomas M. Suehr, Wausau HPR Engr, WI [I]
Rep. The Alliance of American Insurers
Jack A. Treasure, University of Missouri, MO

Alternate

Brandon M. Pregler, American Airlines, OK [U]
(Alt. to J. R. Flynn)

Nonvoting

Jerome Lederer, Laguna Hills, CA
(Member Emeritus)

Mark T. Conroy, NFPA Staff Liaison

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

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

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

Contents

NFPA 410

Standard on

Aircraft Maintenance

1999 Edition

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

Information on referenced publications can be found in Chapter 9 and Appendix B.

Chapter 1 Administration

1-1 Scope.

1-1.1 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. The operations include maintenance of electrical systems; maintenance of oxygen systems; fuel tank repairing, cleaning, painting, and paint removal; welding operations in hangars; interior cleaning; and refurbishing operations.

1-1.2 This standard also covers requirements for fire protection of aircraft ramp areas.

1-2 Purpose. The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through requirements for aircraft maintenance based on sound engineering principles, test data, and field experience.

1-3 Definitions.

Air Ventilation. The passing of undiluted air (air not containing flammable vapors or inert gases) through an aircraft tank in order 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. It is recognized that, at some time during and possibly after air ventilation, the tank may 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.

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

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

Approved.* Acceptable to the authority having jurisdiction.

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

Bladder Tanks. See Fuel Tanks, Bladder.

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

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

Coating. Application of special-purpose materials such as anticorrosion and walkway paints.

Combustible Liquid. Any liquid having a flash point at or above 100°F (38°C). Classifications are in accordance with NFPA 30, *Flammable and Combustible Liquids Code.*

Electric Converters. Devices used to convert line voltage alternating current to the voltage and frequency, or direct current, suitable for the aircraft power system; rectifier units are also used to accomplish this task.

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) at 100°F (38°C).

Flight Deck. The area of the aircraft arranged for use of the flight crew in operating the aircraft. Berths, galleys, and lavatory facilities can be associated with the flight crew compartment but are not included in the term *flight deck.*

Fuel Tanks, Bladder.* Tanks that are both collapsible and self-sealing.

Fuel Tanks, Integral.* Fuel containers whose boundary composition is as nearly 100 percent primary structure as possible, the primary structure being the elements of the aircraft that carry the major stresses of flight, such as stressed skin spar caps, and spar webs.

Fuel Tanks, Metal. All types of metal fuel containers, including surge and vent tanks, that can be removed from the aircraft for shop or bench repair, but not including metal fuel containers that are an integral part of the aircraft and that, under certain major overhaul conditions, can be removed from the primary portion of the airframe.

Galley. An area of an aircraft used for storing, refrigerating, heating, and dispensing food and beverages. Such areas typically include areas for plastic trays, plastic dinnerware utensils, and paper napkins.

Hot Work. Operations including cutting, welding, Thermit welding, brazing, soldering, grinding, thermal spraying, thawing pipe, torch-applied roofing, or any other similar situation.

Inert Atmosphere. An atmosphere where combustion cannot occur.

Inert Gas. A nonflammable, nonreactive gas that renders the combustible material for the use intended incapable of supporting combustion.

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.

Integral Tanks. See Fuel Tanks, Integral.

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.

Maintenance. Aircraft overhaul, repair, and service operations as herein defined.

Major Painting. Complete or virtually complete surface finishing of the exterior, the interior, or both.

Metal Fuel Tanks. See Fuel Tanks, Metal.

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

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

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

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 will 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.

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

Refurbishing. The types of refurbishing operations considered herein are the replacement of aircraft interior fabrics, plastic headliners, rugs or synthetic flooring, sound-insulating materials, windows, doors, or paneling.

Repair. The modification of aircraft, rebuilding of structural damage, correction of system malfunction, or replacment of a major component or subassembly that requires the aircraft to be in "out of flying" status.

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.

Shall. Indicates a mandatory requirement.

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

Tanks. See Fuel Tanks.

Touch-up Painting. The refinishing of only localized areas, exterior or interior, involving no more than 1 qt (1 L) of material by spray or 1 gal (4 L) by brush or roller.

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. Equivalent values in SI units shall not be considered as the requirement, since these values may be approximate.

Chapter 2 Electrical Maintenance Operations

2-1 General.

2-1.1 Electrical system maintenance as used herein and references to NFPA 70, *National Electrical Code®*, shall apply only to aircraft maintenance.

2-1.2 Electrical systems shall be de-energized during maintenance work except when a live circuit is necessary to accomplish the required maintenance.

2-1.3 Where more than one maintenance operation is being carried out at the same time and an electrical system is energized, steps shall be taken to inform personnel working on the aircraft that the system is energized.

2-1.4 Wherever possible, provision shall be made to effectively tag out or lock out de-energized circuits so that anyone attempting to energize them will be unmistakably alerted to the resulting hazard to other maintenance operations.

2-2 Battery Charging and Equipment.

2-2.1 Whenever possible, aircraft batteries shall be disconnected or removed during maintenance operations in order to de-energize all electrical circuits.

2-2.2 The battery switch on aircraft shall be in the off position before batteries are removed or installed.

2-2.3 Battery Removal.

2-2.3.1* When moving batteries, including removal and replacement, precautions shall be taken to prevent the terminal prongs from contacting metal structures or objects.

2-2.3.2 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. Fuses shall be the instantaneous type and sized no larger than 10 A above the maximum connected load.

2-2.4 When removing and replacing batteries, precautions shall be taken to prevent the electrolyte from spilling. Similar precautions shall be taken when replacing or adding electrolyte solutions in batteries.

2-2.5* Batteries in the aircraft shall be charged only where adequate on-the-ground ventilation is provided.

2-2.6 Flexible cords used for charging shall be suitable for the type of service used and approved for extra hard usage.

2-2.7 Connectors shall have a rating not less than the current-carrying capacity of the cord.

2-2.8 Connectors to the battery terminals shall be of a positive type to prevent them from coming loose due to vibration, causing arcs that might ignite gas from the batteries or other flammables or combustibles.

2-2.9 Tables, racks, trays, and wiring shall conform to the provisions of Article 480 of NFPA 70, *National Electrical Code,* 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 V.

2-2.10 Mobile chargers shall carry at least one permanently affixed warning sign to read as follows: "Warning — Keep 5 ft (1.5 m) Horizontally Clear of Aircraft Engines, Fuel Tank Areas, and Vents."

2-2.11* Batteries shall be charged at a rate that will not produce a dangerous concentration of gas or excessive heat.

2-2.12 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.

2-2.13 Battery chargers and their control equipment, tables, racks, trays, and wiring shall not be located or operated within any of the hazardous areas defined in 513-3(b) of NFPA 70, *National Electrical Code.* They shall preferably be located in a separate building or in an area such as described in 513-3(d) of NFPA 70.

2-2.14 Areas wherein batteries are charged shall be well ventilated to assure that the maximum gas–air mixture that may be generated during charging is held below the lower explosive limits. Where mechanical ventilation is required to accomplish this requirement, it shall be of the type listed for use in Class 1, Group B atmosphere locations as defined in Article 500 of NFPA 70, *National Electrical Code,* and shall be so interlocked as to ensure operation when batteries are on charge. Exhaust ducts shall lead directly to the outside, above roof level, where gases cannot accumulate.

2-2.15 Access to battery rooms shall be limited to qualified personnel only.

2-2.16 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. Appropriate warning signs shall be prominently displayed.

2-2.17 Brushes used to clean batteries shall have neither a metal frame nor wire bristles.

2-3 Ground Power Units.

2-3.1 Placement of ground power units in use shall comply with the requirements of Section 513-10 of NFPA 70, *National Electrical Code,* and 3-6.2 and 3-6.3 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

2-3.2 Proximity to Ignition Sources.

2-3.2.1 Ground power units shall be located as far as practical from fueling points, tank vents, tank outlet areas, fuel line drains, and wings. Ground power units shall not be positioned within a 25-ft (8-m) horizontal radius of aircraft fuel system vent openings. They shall not be used in areas wherein adequate ventilation is not available or where they may constitute a fire hazard.

2-3.2.2 If used inside hangars, in addition to the requirements of 2-3.3, ground power units shall also be so designed and mounted that all electrical equipment, sparking contacts, hot surfaces, and any other possible ignition source shall be at least 18 in. (457 mm) above floor level. At no time shall engine-driven generators be refueled within any aircraft maintenance or storage area within a hangar.

2-3.3 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, *National Electrical Code.*

2-3.4 A protection system shall be provided to protect against undervoltage and overvoltage.

2-3.5 Ground power units shall always be operated at the prescribed voltage.

2-3.6* 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.

Exception: The battery switch shall be permitted to remain in the on position for troubleshooting that requires battery power.

2-3.7 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 withdrawn or left as is until the hazardous condition is corrected. 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, and the cable shall be disconnected before the unit is moved.

2-3.8 Cables shall be stowed properly to prevent damage.

2-3.9 Strains on cables and connectors shall be avoided.

2-3.10 The ground power units shall be turned on only after the connector is installed in the aircraft receptacle. When connected, the unit shall be checked to determine whether it is operating at the prescribed voltage before supplying power to the aircraft.

2-3.11 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.

2-3.12 Portable ground power units shall be disconnected before they are moved.

2-4 Repair of Aircraft Electrical Systems.

2-4.1 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. The use of a "dummy" ground power plug shall be considered.

2-4.2 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.

2-4.3 Whenever the entire aircraft electrical system is not de-energized due to other work being accomplished, the electrical system being worked on shall be isolated by placing the circuit breaker in an off position or pulling the fuse.

2-4.4 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. That person shall not rely on someone else to do this. A positive test on the isolated circuit shall be made.

2-4.5 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.

2-4.6 Circuit breakers shall be in the off position and fuses shall be pulled before removing and installing system units.

2-4.7* 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. *(See Figure A-2-4.7.)*

2-4.8 When working on energized electrical systems in areas containing flammable fluid lines, the following precautions shall be taken:

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

(b) An extinguisher having a rating of not less than 20-B and a minimum capacity of 15 lb (6.8 kg) of agent shall be located within 50 ft (15.2 m) of the work operation.

2-4.9 When troubleshooting, all wires shall be considered "hot" until proven otherwise.

2-4.10 Nonconductive or insulated tools shall be used for working on hot circuits.

2-4.11 The aircraft electrical circuit involved shall be de-energized whenever equipment or wiring is removed or installed.

2-4.12 New or repaired equipment shall be thoroughly tested and checked for short circuits before being installed on an aircraft.

2-4.13 Aircraft wiring shall be properly secured to prevent chafing.

2-4.14 All loops provided in electrical cables to prevent flammable fluids from entering electrical connections or components shall be re-formed so that they will perform their intended functions.

2-4.15 When dripshields, cables, sheaths, plug covers, or similar devices have been provided to prevent flammable fluids from contacting electrical components, care shall be taken to see that they are reinstalled so that they effectively perform their intended function.

2-5 Repairs to Communications and Navigation Equipment.

2-5.1 Radar and radio transmitting equipment shall not be operated, tested, or checked on the aircraft whenever fueling, defueling, conducting tank repair operations when flammable vapor–air atmospheres are present, or any other similar hazardous operation is taking place within the distance limits outlined in Section 2-9 of NFPA 407, *Standard for Aircraft Fuel Servicing,* or within the distances of the manufacturer's prescribed limitations.

2-5.2 Such operation, testing, or checking shall be permitted to be made at any time if a dummy load, which prevents the energizing of the antenna, is used. In addition, the precautions outlined in 2-4.10 through 2-4.15 shall be followed.

2-6 Cleaning of Electrical Components Installed on the Aircraft.

2-6.1 Electrical components shall not be energized and shall be isolated from other power sources during cleaning operations.

2-6.2 Only nonflammable solvents shall be used for cleaning electrical components.

2-7 Testing of Electrical Equipment During and Following Repair Operations.

2-7.1 Testing of electrical equipment installed on aircraft shall be held to a minimum. Whenever possible, testing shall be done at a bench or in a shop away from the aircraft.

2-7.2 Equipment shall be checked for continuity of circuitry and resistance before power is applied.

2-8 Energizing and De-Energizing Electric Circuits During Complete Engine Change.

2-8.1 Standard aircraft static-grounding procedures shall be followed.

2-8.2 Magneto circuits shall be grounded when disconnected at the fire wall.

2-8.3 The electrical systems involved in an engine installation 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.

2-8.4 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.

2-8.5 Personnel performing an engine change shall be advised when the electrical systems are de-energized and re-energized following the principles expressed in 2-1.4 and 2-4.5.

2-8.6 The de-energized circuits shall be tagged out or locked out so that persons attempting to energize them will be definitely aware that others could be endangered by their action.

2-8.7 Electrical disconnects shall be protected against accidental contact, dirt, and moisture during the disconnect period, by tight-fitting blind plugs, tape wrapping, or both.

2-9 Electrical Equipment Mounted on Fixed Work Stands.

2-9.1 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, *National Electrical Code,* shall conform to the requirements for Class I, Group D, Division 2 locations.

2-9.2 Where docks and work stands are not located or likely to be located in hazardous areas as defined in 2-9.1, wiring and equipment shall conform to 513-5 and 513-6 of NFPA 70, *National Electrical Code.* Receptacles and attachment plugs shall be of the locking type that will not break apart readily.

2-10 Electrical Equipment Mounted on Movable Stands. Movable docks and work stands with electrical equipment conforming to 2-9.2 shall carry at least one permanently affixed warning sign to read: "Warning — Keep 5 ft (1.5 m) Horizontally Clear of Aircraft Engines, Fuel Tank Areas, and Vents."

Chapter 3 Aircraft Breathing-Oxygen Systems

3-1 Oxygen System Charging Operations and Safeguards.

3-1.1* Because of the possibility of fire or explosion involving quantities of oxygen, the person choosing the site for oxygen charging operations shall consider such items as exposure of other aircraft, vehicles, structures, utilities, and people in the vicinity and the accessibility of the aircraft to fire-fighting equipment.

3-1.2 Where it is necessary to conduct gaseous oxygen system recharging or filling in a hangar or building, it shall be done under controlled conditions.

3-1.3 Liquid oxygen recharging shall not be conducted indoors under any conditions. A separation of at least 50 ft (15.2 m) shall be maintained between a filling point and other aircraft, vehicles, and structures. 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, since such systems could contain combustible material that could be extremely hazardous in contact with liquid oxygen in the confined space.

3-1.4 Good housekeeping practices, particularly with combustibles such as grease, lubricating oil, and asphalt, shall be maintained in the vicinity of oxygen charging operations.

3-1.5 Open flames, including smoking, shall be prohibited within 50 ft (15.2 m) of charging equipment.

3-1.6 Safeguards shall be taken while performing aircraft servicing or maintenance operations such as fueling, fuel and hydraulic system repairs, use of cleaning fluids or deicing fluids, or operation of electrical equipment that can inherently or accidentally introduce ignition sources or combustibles concurrent with oxygen charging operations.

3-1.7 Only charging equipment and containers suitable for the specific aircraft breathing-oxygen system shall be used. Each container shall be identified by its marking before connecting it to the aircraft system. Equipment intended or used for other gases shall not be interchanged with oxygen equipment. High-pressure commercial containers, 1800 psi (12.4 MPa) or higher, shall be connected through a high-pressure regulator specified for oxygen service to service low-pressure aircraft systems. Oxygen charging hoses shall be kept clean, capped when not in use, and clearly marked or tagged "For Oxygen Use Only."

3-1.8 Oil, grease, or other readily combustible substances shall not be permitted to come in contact with containers, flasks, valves, regulators, fittings, or any other part of the aircraft oxygen system or charging equipment. Oxygen equipment shall not be handled with oily gloves or tools. Charging operations shall not be performed while wearing oily or greasy clothing. Protective caps shall be kept on equipment as long as possible and replaced as soon as possible. Before charging, all connections shall be inspected for cleanliness. If dust, dirt, grease, or any other contaminant is found, it shall be removed with detergent or solvent approved for oxygen service. 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 may escape external inspection.

The hose or valve outlet shall be aimed away from the body and equipment, and only necessary valves shall be cracked open. A clean, dry container shall be available to collect any liquid oxygen discharge that might accidentally escape.

3-1.9 Only lubricating and thread compounds specifically approved for oxygen service under the pressures and temperatures involved shall be used. Other lubricants shall not be used.

3-1.10 Only valve packing and transfer hose gaskets that are suitable for oxygen service shall be used.

3-1.11 Damage to oxygen containers, hoses, flasks, or converters shall be avoided. Equipment shall be secured so that it cannot fall or roll.

3-1.12 Safety devices, identifying markings, symbols, and nameplates shall not be tampered with.

3-1.13 Valve outlets or controls that become clogged with ice shall be thawed with warm, not boiling, water.

3-1.14 Gaseous oxygen shall not be directed at the body or clothing, and liquid oxygen shall not be allowed to contact the body or clothing because of the possibility of both fire and personal injury.

3-1.15 Desiccant cartridges may be required to ensure that only dry oxygen is introduced, and, where required, only fresh desiccant cartridges with filters shall be used.

3-1.16 Threaded fittings on regulators, container valve outlets, and hoses shall properly mate with each other. Connectors that do not fit shall not be forced. Fittings with worn or damaged threads shall be replaced.

3-1.17 After connecting containers or charging hoses to the oxygen system fill fitting, the connection shall be checked for gastightness by audible and visual means. Leak testing shall be done with a solution specifically approved for that particular gaseous, chemical, or liquid oxygen service.

3-1.18 Charging equipment discharge valves shall be closed when charging is completed.

3-2* Specific Cautions Applicable to Gaseous Breathing Oxygen.

3-2.1 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. Container valves shall be fully opened to prevent leakage around the valve stem.

3-2.2 Wrenches, hammers, or other tools shall not be used to force container valves. If a container valve cannot be hand operated, it shall be considered defective and taken out of service.

3-2.3 The aircraft oxygen system shall be charged to the established pressure after properly setting the supply regulating valve to the proper setting.

3-2.4 Where the aircraft oxygen system does not have filler valves and it is necessary to remove the aircraft containers themselves for recharging, the container valve shall be closed and all oxygen in the lines released to atmosphere before attempting container removal. Before removing the container from the aircraft, the container valve outlet shall be disconnected and capped and all distribution lines shall be plugged.

3-3* Specific Cautions Applicable to Liquid Breathing Oxygen.

3-3.1 Liquid oxygen shall not be permitted to contact any part of the body or clothes.

3-3.2 Personnel shall wear approved protective clothing and equipment while handling liquid oxygen equipment.

3-3.3 If liquid oxygen is spilled on clothing, the clothing shall be removed immediately and thoroughly aired before reuse.

3-3.4 Personnel who have handled liquid oxygen shall refrain from smoking for at least 15 minutes after leaving the charging area.

3-3.5 If it is necessary to remove moisture from the system, dry, oil-free air, gaseous oxygen, or nitrogen shall be used before the introduction of liquid oxygen.

3-3.6 Because of its low temperature, liquid oxygen shall be handled in equipment constructed of materials suitable for the service. Ordinary rubber or plastic hoses, gaskets, or seals shall not be used.

3-3.7 When it is necessary to transfer liquid oxygen from one container to another, splashing shall be avoided. To avoid breakage, the receiving container shall be cooled gradually. Glass containers shall not be reused, and containers used shall be clean.

3-3.8 When transferring liquid oxygen, valves shall not be left completely open. To prevent the valves from freezing in the open position, they shall be opened wide and then immediately closed one-quarter turn.

3-3.9 Pressure relief devices shall be installed on all lines in which liquid oxygen could be trapped between closed valves and on closed containers.

3-3.10 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. 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. Personnel shall not walk on or move equipment through a liquid oxygen spill.

3-3.11* The equipment manufacturer's instructions shall be followed when transferring liquid oxygen from the supply tank to the aircraft system.

3-4* Specific Cautions Applicable to Oxygen Generator Systems.

3-4.1 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, since, when activated, it will generate temperatures up to 500°F (260°C).

3-4.2 If the generator is inadvertently activated, it shall immediately be placed on a noncombustible surface. However, if the generator is inadvertently activated in its aircraft position, it shall be left in its protected location.

3-5 Aircraft Breathing-Oxygen System Test and Repair Operations and Safeguards.

3-5.1* When flow testing the aircraft system, the minimum amount of oxygen necessary to check the system shall be used.

3-5.2 Distribution lines within the aircraft shall be inspected periodically in accordance with the aircraft manufacturer's recommendations.

3-5.3 Pressure shall be released before attempting to tighten or loosen fittings unless the containers incorporate self-opening and self-venting valves.

3-5.4 When making pressure tests of oxygen distribution lines, the valves isolating the supply containers shall be closed. The system shall be tested in accordance with the specific instructions for the particular application. Oil or grease shall not be permitted to come in contact with escaping oxygen. Only leak testing solutions specifically approved for the purpose shall be used. All solutions shall be carefully cleaned off the system following the test.

3-5.5 A close check shall be kept on the vacuum available on all vacuum-insulated liquid oxygen tanks, and the manufacturer's instructions shall be closely followed.

3-5.6 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 for container replacement specified in 3-2.4, and all disconnected lines plugged or capped.

3-6 Fire Protection.

3-6.1* In case of a fire, the oxygen supply to the fire shall be shut off and the fire extinguished in the same manner as a fire in a normal air atmosphere.

3-6.2 An extinguisher having a rating of not less than 20-B and a minimum capacity of 15 lb (6.8 kg) of agent shall be located within 50 ft (15.2 m) of the work operation.

3-7* Breathing-Oxygen Cylinder Storage (DOT Gaseous Oxygen Cylinders and DOT-Type 4L Cylinders of Liquid Oxygen).

3-7.1 Cylinders shall be stored in a definitely assigned location and protected against tampering by unauthorized individuals. Oxygen cylinders other than cylinders scheduled to be installed on the aircraft shall not be stored in aircraft servicing and maintenance areas of aircraft hangars.

3-7.2 Storage areas shall be reserved for liquid oxygen storage alone.

3-7.3 Oxygen storage areas shall be clearly placarded "Oxygen — No Smoking — No Open Flames" or equivalent.

3-7.4 Oxygen cylinders shall not be stored near flammable or combustible materials such as petroleum products, other readily combustible substances, or in the same area as compressed combustible gases. Empty and full cylinders shall be stored separately, and empty cylinders shall be clearly marked.

3-7.5 Each cylinder of aviator's breathing oxygen shall be clearly marked to indicate its content. Aviator's breathing oxygen shall be separately stored from all other oxygen cylinder supplies.

3-7.6 Cylinders shall be stored so that they are never allowed to reach a temperature exceeding 125°F (51.7°C). When stored in the open, they 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.

3-7.7 Cylinders shall be protected against abnormal mechanical shock that could damage the cylinder, valve, or safety devices. Valve protection caps shall also be used when cylinders are not connected, providing that cylinders are designed for protection caps.

3-7.8 When moving cylinders, care shall be exercised to prevent their being dropped, which could cause injury to the cylinder, valve, or safety devices. Lifting magnets, slings of rope or chain, or any other device in which the cylinders themselves form a part of the carrier shall not be used for hoisting oxygen cylinders. When on hand or power trucks or tractors, cylinders shall be secured in an upright position.

3-7.9 Department of Transportation (DOT) regulations regarding hydrostatic testing of DOT Specification 3A or 3AA cylinders shall be followed.

3-8* Liquid Breathing-Oxygen Storage (in Other Than DOT-Type 4L Cylinders).

3-8.1 Liquid oxygen containers shall be stored outdoors or in a detached, noncombustible structure in accordance with NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites,* if the oxygen quantities fall within the scope of that standard. Smaller quantities shall be located outdoors in a detached noncombustible structure or in a cutoff room provided the cutoff room has effective ventilation and necessary doorways protected by fire doors with ramps or curbs to prevent entrance of flammable liquids and exit of liquid oxygen.

3-8.2 Storage areas shall be reserved for liquid oxygen storage alone and shall be clearly placarded "Oxygen — No Smoking — No Open Flames" or equivalent.

3-8.3 In outdoor areas, valves and safety devices shall be protected from ice and snow accumulations.

3-9* Gaseous Oxygen Equipment.

3-9.1* Gaseous oxygen cylinders shall conform with DOT regulations; shall be equipped with a shutoff valve; shall be equipped with a frangible disc safety device that meets the requirements of CGA Pressure Relief Device Standards, Part 1 — *Cylinders for Compressed Gases,* S-1.1; shall be connected to a common header by suitable pigtails strong enough to safely withstand full cylinder pressure; and shall be securely fastened to the cart.

3-9.2 Manifolds shall be constructed with sufficient strength to safely withstand full cylinder pressure. 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.

3-9.3 An approved spring-loaded relief valve, preferably equipped with a metal seat, shall be provided to protect the hose and other equipment that may be attached to the outlet of the manifold.

3-9.4 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.

3-9.5* Regulators.

3-9.5.1 Regulators and components shall be approved for oxygen service.

3-9.5.2 Seats used in regulators shall be of a material chosen for maximum resistance to ignition in an oxygen atmosphere and for having the required physical characteristics needed to maintain a gastight seal.

3-9.5.3 Regulators shall be provided with a suitable filter to prevent foreign particles from entering their inlet chambers.

3-9.5.4* 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.

3-9.5.5 Regulators shall be equipped with gauges for indicating cylinder and discharge pressures.

3-9.6* Orifice.

3-9.6.1 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 this equipment.

3-9.6.2 A pressure gauge shall be provided downstream of the orifice as a means of indicating the pressure in the aircraft oxygen system being filled.

3-9.7 Dehumidifiers or Dryers.

3-9.7.1 Any drying agent used shall be approved for use with oxygen.

3-9.7.2 The container housing the drying agent shall be constructed of an approved material and shall be strong enough to safely withstand the pressure to which it could be subjected. If steel is used, it shall be protected from corrosion.

3-9.7.3 Gasket materials used shall be approved for use with oxygen.

3-9.8 Hose.

3-9.8.1 Hose shall be approved for use with oxygen. It shall be strong enough to safely withstand any pressure to which it might be subjected.

3-9.8.2 Hose connections shall be secured to prevent loosening.

3-9.8.3 The outlet end of the hose shall be equipped with a shutoff valve.

3-9.8.4 The valve outlet shall be attachable to the system fill receptacle and shall be secured to prevent loosening.

3-9.9 Precautions.

3-9.9.1 No oil, grease, or other such combustible material shall be allowed to come in contact with the equipment.

3-9.9.2 Thread-sealing compounds, when used, shall be approved for use with oxygen.

3-9.9.3 All parts of the equipment shall be thoroughly cleaned of oil or grease before being assembled.

3-9.9.4 The cart manifold outlet valve immediately upstream of the regulator shall be in the closed position before the cylinder valves on the cart are opened.

3-9.9.5 Oxygen valves shall be opened slowly to avoid rapid pressure rise.

3-9.9.6 After opening cylinder valves on the cart, the manifold outlet valve shall not be opened for 60 seconds in order to permit heat of recompression to dissipate.

3-9.9.7 The regulator shall be relieved of pressure (if the regulator is not the self-relieving type) before the manifold outlet valve to the regulator is opened.

3-9.9.8 Before disconnecting, the valve at the end of the fill hose shall be closed to avoid whipping.

3-10 Miscellaneous Requirements.

3-10.1 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.

3-10.2 Gases shall not be mixed in an oxygen container.

Chapter 4 Aircraft Fuel System Maintenance

4-1 Fuel Transfer Equipment and Operations.

4-1.1* The requirements of this section shall apply to aircraft fuel transfer operations during aircraft maintenance and overhaul operations. The fuel transfer operations shall include the following:

(1) Transferring fuel from one tank to another within an aircraft while on the ground preparatory to maintenance
(2) Transferring fuel from a tank in an aircraft to a tank in ground equipment or vice versa in order to achieve a maintenance objective

(3) Transferring fuel for the purpose of performing tank repairs, replacement of tank accessories, or balancing of fuel loads

4-1.2 Aircraft fuel transfer operations shall use one of the systems as required by 4-1.4. Where fuels used have a flash point under 100°F (37.8°C), fuel transfer operations shall be conducted only out of doors.

4-1.3 Fuel transfer operations shall be conducted only out of doors if the aircraft tanks contained gasoline or JET B fuels during the preceding 20 flying hours.

4-1.4 A fixed fuel transfer piping system shall be used where fuel transfer operations are conducted on a routine basis.

4-1.4.1 A limited-capacity self-contained trailer having a closed liquid transfer system shall be permitted to be used.

4-1.4.2 Self-propelled fuel servicing vehicles shall be permitted to be used.

4-1.5 Where a fixed fuel transfer piping system specified in 4-1.4 is used, it shall meet the requirements of Section 2-4 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-1.5.1* 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 2-4.6 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-1.6 Where self-propelled fuel servicing vehicles specified in 4-1.4.2 are used, the fuel servicing vehicles shall meet the requirements of Section 2-3 of NFPA 407, *Standard for Aircraft Fuel Servicing.* In addition, the fuel servicing vehicles shall not be permitted inside the hangar and shall be so positioned outside the hangar as to be readily movable.

4-1.7* All hangars used for these fuel transfer operations shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars.*

4-1.8 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 authority having jurisdiction.

4-1.9 Where multiple aircraft occupy one aircraft storage and servicing area, the location used for fuel transfer operations shall be identified.

4-1.10 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.

4-1.11 Any fueling hose used shall be continuous, without intermediate couplings, and shall conform to and be maintained in accordance with the requirements of Section 2-2 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-1.12 Nozzles shall comply with the requirements of 2-3.15.2 and 2-3.15.3 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-1.13 Only one aircraft shall undergo fuel transfer operations at any one time in a single aircraft storage and servicing area.

4-1.14 Any other simultaneous maintenance operation on that aircraft or within 25 ft (7.6 m) 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.

4-1.15 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.

4-1.16 At least two extinguishers, each with a minimum rating of at least 80-B:C and a minimum capacity of 125 lb (57 kg) of agent, shall be located within a 50-ft (15-m) distance, one on each side of the aircraft undergoing maintenance.

4-1.17 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.

4-1.18 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, *National Electrical Code.*

4-1.19 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank, the procedures of Section 3-4 of NFPA 407, *Standard for Aircraft Fuel Servicing,* shall be followed, and the equipment as specified in Section 2-15 of NFPA 409, *Standard on Aircraft Hangars,* shall be utilized. Apparel worn by personnel shall be made of material that will not accumulate static charges.

4-1.20 Internal combustion engine–powered equipment shall not be operated within 25 ft (7.6 m) of the aircraft fuel system vents or fuel tank openings prior to the start of fuel transfer operations.

4-1.21 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.

4-1.22 Aircraft radio, radar, strobe lights, and electronic transmitting equipment shall not be operated during fuel transfer operations.

4-1.23 Any fuel transfer hose nozzle used during these operations shall be electrically bonded to the aircraft. These bonding connections shall be made prior to the start of operations and maintained until after the fuel transfer operations have been completed.

4-1.24 When removing fuel from an aircraft tank by gravity, free fall of the fuel shall be avoided and a positive electrical bond shall be provided between the fuel tank and the receiving container.

4-1.25 Any spillage of fuel shall be handled in accordance with the requirements of Section 3-2 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-1.26* 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.

Exception: This requirement does not apply to siphoning operations where a system is provided with bonding to reduce the hazard of liquid surface electrostatic generation. (Also, see 4-3.2)

4-2* Air Ventilation.

4-2.1 Air mover equipment used to secure air ventilation shall not create fire hazards.

4-2.2 Air movers designed to operate by expansion of compressed air or steam shall be used.

4-2.3 Compressed air shall not be introduced directly into aircraft fuel tanks for air ventilation purposes.

4-2.4 Where electrical equipment is used, the appliances shall conform to the types specified by Article 513 of NFPA 70, *National Electrical Code*.

4-2.5 A safety factor shall be included wherein the lower flammable limit is the criterion and 20 percent of the limits shown in Table 4-2.5 shall be considered the maximum allowable concentration of fuel vapor.

Table 4-2.5 Lower Flammable Limits of Aviation Fuels

	Lower Flammability Limit	
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

4-2.6 Instruments used to measure the lower flammable limit shall be used only by qualified personnel and shall be calibrated accurately for the type of vapors present and checked periodically against standard samples to assure maintenance of calibration. Sampling tubes shall be of a type that will be impervious to absorption of the vapors. Instruments depending on electrical power, if not designed for use in Class I, Group D, Division 1 atmospheres as defined in NFPA 70, *National Electrical Code*, or certified as intrinsically safe because of their low energy design, shall be operated only in nonhazardous locations.

4-2.7 Personnel selected to conduct air ventilation work shall have considerable knowledge of and experience in handling flammable liquids and a thorough knowledge of the aircraft fuel system.

4-2.8 Aircraft shall be defueled in accordance with Section 4-1.

4-2.9* Aircraft undergoing fuel tank ventilation procedures shall be segregated or isolated from other aircraft when the flash point of the fuel is less than 100°F (37.8°C) or until a flammable vapor concentration of 20 percent of the lower flammable limit is maintained.

4-2.10 When air ventilation is done 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. Any flammable vapor concentration over 20 percent of the lower flammable limit downwind from any discharge point of a tank shall result in emergency revisions of procedures.

4-2.11 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and not operated during the ventilation procedures.

4-2.12 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, *National Electrical Code*.

4-2.13 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank shall utilize equipment as specified in Section 2-15 of NFPA 409, *Standard on Aircraft Hangars*. Exhaust equipment and the aircraft to be ventilated shall be electrically bonded and grounded. If ducting is used, a static bonding wire from each exhaust hose nozzle shall be connected to the aircraft before opening the fuel tank(s).

4-2.14 Aircraft electrical circuits that are in vapor-hazardous areas shall be de-energized.

4-2.15 Aircraft radar operations shall be controlled as required in 2-1.4 of NFPA 407, *Standard for Aircraft Fuel Servicing*.

4-2.16 Suitable warning signs shall be placed in conspicuous locations around the aircraft to indicate that tank ventilation is in progress until a flammable vapor concentration less than 20 percent of the lower flammable limit is maintained.

4-2.17* Aircraft hangars in which this work is conducted shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars*.

4-2.18 At least one extinguisher having a rating of not less than 20-B and a minimum capacity of 15 lb (6.8 kg) of agent shall be located within 50 ft (15.2 m) of the aircraft undergoing air ventilation.

4-2.19 When air exhaust only is used, precautions shall be taken to prevent building up a negative pressure, which might result in tank collapse. Where a blower is used, the volume and pressure of air introduced and discharged shall be so balanced that no pressure differential arises that might have an adverse effect on the tank structure.

4-2.20 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) *Properly calibrated instruments that are designed to take readings of fuel and solvent vapor and oxygen concentrations within the tank volume being treated and appropriate gas sampling tubing

4-3 Repair of Fuel Tanks.

4-3.1 Prior to conducting work on tanks, if it is necessary to defuel the tank or tanks to be repaired or inspected, such defueling operation shall be done in accordance with the requirements contained in Section 4-1.

4-3.2 Residual fuel that cannot be withdrawn by normal defueling procedures shall be drained from the tanks by removal

of tank access plates. With the opening of the tanks, air ventilation procedures shall be immediately instituted. 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. 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.

4-3.3 Prior to entry into 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 lower flammable limit exists.

4-3.4 When repairs are to be made to integral tanks that are interconnected to other integral or bladder tanks that do not require work, steps shall be taken to prevent vapors from entering the tank or the section undergoing repairs by plugging or taping interconnector openings, vent openings, or vent manifolds.

4-3.5 Personnel selected to perform fuel tank repair shall be trained in the hazardous characteristics of the work environment and the materials present.

4-3.6 The supervisor in charge of the operation shall have a thorough knowledge of the operation.

4-3.7 Aircraft hangars in which tank repair work is being conducted shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars*.

4-3.8 When tank repair work is done 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. Any flammable vapor concentration over 20 percent of the lower flammable limit anywhere within the hangar shall result in emergency revision of procedures.

4-3.9 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and not operated during the repair operations.

4-3.10 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, *National Electrical Code*.

4-3.11 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank, the procedures of Section 3-4 of NFPA 407, *Standard for Aircraft Fuel Servicing,* shall be followed and the equipment as specified in Section 2-15 of NFPA 409, *Standard on Aircraft Hangars,* shall be utilized. Apparel worn by personnel shall be made of material that will not accumulate static charges.

4-3.12 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.

4-3.13 Aircraft electrical circuits that are in vapor hazardous areas shall not be energized.

4-3.14 At least one extinguisher having a rating not less than 20-B and a minimum capacity of 15 lb (6.8 kg) of agent shall be located within 50 ft (15.2 m) of the aircraft.

4-3.15 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, *National Electrical Code*.

4-3.16 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, *National Electrical Code*.

4-3.17 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.

4-3.18 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, *National Electrical Code*.

4-3.19 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, *National Electrical Code*.

4-3.20* Additional Requirements for Repair of Integral Fuel Tanks.

4-3.20.1* Removal of existing sealant shall be accomplished with nonsparking metallic or hardwood scrapers. Plastic scrapers that tend to accumulate a static electric charge shall not be used.

4-3.20.2 Repairs necessitating structural rework shall be accomplished with compressed air-driven tools.

4-3.20.3* During top coating of fuel tank sealant base materials, extreme caution shall be taken to eliminate all possible ignition sources.

4-3.21* Additional Requirements for Repair of Bladder Tanks.

4-3.21.1* Fuel cell repair areas shall be well ventilated and segregated from other maintenance or assembly areas.

4-3.21.2 During application of coats of solvent and sealer over and under the patch, extreme caution shall be taken to eliminate all possible ignition sources.

4-3.21.3 Upon reinstallation of the cell, air ventilation procedures shall be started again and maintained until the fuel cell is closed.

4-3.22* Additional Requirements for Repair of Metal Tanks.

4-3.22.1 Required procedures for the safe removal of flammable vapors from metal tanks shall be as specified in NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*.

4-3.22.2 In addition to the precautions contained in NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair,* 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. The stencil or tag shall include a phrase such as "Safe for Welding or Cutting," the signature of the person so certifying, and the date.

4-4 Pressure Testing of Aircraft Fuel Systems.

4-4.1 The requirements of this section shall apply to aircraft fuel system pressure testing using a test fluid or fuel to assure integrity of the fuel system.

4-4.2 Where fuels used have a flash point under 100°F (37.8°C), fuel system pressure testing shall be conducted out of doors.

4-4.3 Aircraft fuel system pressure testing shall be conducted out of doors only if the aircraft tanks contained gasoline or JET B fuels during the preceding 20 flying hours.

4-4.4 Dump-valve tests involving fuel discharge shall also be done out of doors.

4-4.5 Fuel transfer operations done in conjunction with aircraft fuel system pressure testing shall comply with the requirements specified in Section 4-1.

4-4.6* All hangars used for these operations shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars.*

4-4.7 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.

4-4.8 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. Provisions shall be made to tow aircraft using preplanned techniques so that emergency fire control procedures can be undertaken.

4-4.9 Hangar doors shall be open when weather conditions permit and, if closed, unlatched and in a condition such that in an emergency the doors can be opened.

4-4.10 The amount of test fluid or fuel transferred shall be the minimum considered essential to each pressure testing operation.

4-4.11 The area used for fuel system pressure testing operations shall be placarded with suitably worded warning signs.

4-4.12 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.

4-4.13 Any fueling hose used shall be continuous, without intermediate couplings, and shall conform and be maintained in accordance with Section 2-2 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-4.14 Nozzles shall comply with the requirements of 2-3.15.2 and 2-3.15.3 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

4-4.15 Only one aircraft shall undergo fuel system pressure testing at any one time in a single aircraft storage and servicing area.

4-4.16 Any other simultaneous maintenance operation on that aircraft or within 25 ft (7.6 m) of the aircraft fuel system vents, fuel tank openings, or fuel servicing vehicle (if used) that can constitute a source of ignition of vapors that might be released during an operation shall not be permitted.

4-4.17 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.

4-4.18 At least two extinguishers, each with a minimum rating of at least 80-B:C and a minimum capacity of 125 lb (57 kg) of agent, shall be located within a 50-ft (15.2-m) distance, one on each side of the aircraft undergoing maintenance.

4-4.19 All open flame and spark-producing equipment or devices within the vapor hazard area shall be shut down and not operated during the ventilation procedure.

4-4.20 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, *National Electrical Code.*

4-4.21 Procedures to guard against the accumulation of static electrical charges on the aircraft wing section or tank shall utilize equipment as specified in Section 2-15 of NFPA 409, *Standard on Aircraft Hangars.* Apparel worn by personnel shall be made of material that will not accumulate static charges.

4-4.22 Internal combustion engine–powered equipment shall not be operated within 25 ft (8 m) of the aircraft fuel system vents or fuel tank openings prior to the start of fuel system pressure testing.

4-4.23 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 25 ft (8 m) of the aircraft fuel system vents or fuel tank openings.

4-4.24 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, to prevent overfilling and overpressurizing, and to detect possible leakage. Where such fuel transfer operations cannot be done utilizing the internal aircraft fuel system plumbing, there shall be sufficient personnel to perform the functions outlined in the previous sentence, with particular attention given to the integrity of the external plumbing arrangement.

4-4.25 Aircraft radio, radar, strobe lights, and electronic transmitting equipment shall not be operated during fuel system pressure testing.

4-4.26 Caution shall be exercised to prevent intermixing of test fluids or different grades of fuel.

4-4.27 Any spillage of fuel shall be handled in accordance with the requirements given in Section 3-2 of NFPA 407, *Standard for Aircraft Fuel Servicing.*

Chapter 5 Aircraft External Cleaning, Painting, and Paint Removal

5-1 General.

5-1.1 Cleaning, painting, or paint removal operations using flammable or combustible materials shall be conducted in accordance with the requirements of this chapter.

5-1.2 Cleaning, painting, and paint removal of components and subassemblies that are small enough to be removed from the aircraft for work and that require a total application rate of more than 1 qt (1 L) of material in 1 hour or the cumulative use of more than 1 gal (4 L) of material in 8 hours shall be conducted in accordance with NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* and will not be discussed in this chapter.

5-1.3* In selecting materials for cleaning, painting, and paint removal purposes, material with the highest flash point available shall be used.

5-2 Operational Sites and Precautions.

5-2.1* 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.

5-2.2 Aircraft, Major Aircraft Assemblies, and Aircraft Subassemblies.

5-2.2.1 When cleaning, painting, or paint removal operations of aircraft, major aircraft assemblies or aircraft subassemblies that are not removable as specified in 5-1.2 are conducted in a hangar, that hangar shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars.*

5-2.2.2 Where the hangars house only unfueled aircraft as defined in Section 1-3 of NFPA 409, *Standard on Aircraft Hangars,* the hangar shall be protected with at least an automatic sprinkler system that meets the requirements specified in Section 4-2 of NFPA 409.

5-2.3* Ramp areas used for these maintenance procedures shall be servicing ramps not subject to public access. Sufficient clearance shall be maintained to avoid creating a hazard to adjacent aircraft or structures and to assure access by fire-fighting equipment, and the aircraft being worked on shall not be in the path of other normal aircraft movements on the ramp.

5-2.4 Where cleaning, painting, or paint removal operations are being conducted, no concurrent, potentially hazardous operations shall be conducted within 50 ft (15.2 m) of the working area. Even for touch-up operations, the area shall be inspected prior to the start of operations for any ignition sources within the working area and these sources shall be eliminated. Such conditions shall be maintained hazard-free during the entire work period.

5-2.5 Sufficient air movement to prevent flammable vapor concentrations at floor level, in floor pits and drains, and in aircraft compartments from reaching 20 percent of the lower explosive limit during these operations shall be provided by general ventilation, by opening of hangar doors, or by forced ventilation.

5-2.6 Fixed electrical equipment shall conform to Article 513 of NFPA 70, *National Electrical Code.* Temporary lighting used for general illumination during these operations shall be located so as not to be in direct range of any flammable sprays or liquids or in any "overspray" areas. Such equipment, if not listed for use in Class I, Group D hazardous locations, shall be of the enclosed and gasketed type to minimize the danger of breakage and to reduce entrance of hazardous vapors within the fixtures.

5-2.7 The use of heat lamps to accelerate the drying of painted surfaces shall be prohibited unless used as part of an approved drying booth or enclosure in accordance with the requirements of NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* and NFPA 86, *Standard for Ovens and Furnaces.*

Exception: The use of heat lamps to accelerate the drying of painted surfaces shall be permitted in approved open areas in accordance with NFPA 33, Standard for Spray Application Using Flammable or Combustible Materials, and NFPA 86, Standard for Ovens and Furnaces, where the painting involves no more that 1 qt (1 L) of material by spray or 1 gal (4 L) by brush or roller.

5-2.8 When cleaning or paint removal agents are applied through spray nozzles under pressure, the nozzle shall be of the self-closing type so that, when the hand of the operator is removed, the nozzle will automatically close.

5-2.9 Aircraft electrical systems shall be de-energized during cleaning, painting, and paint removal operations.

When aircraft power is required for concurrent operations in accordance with 5-2.4 of this chapter, the electrical equipment exposed to flammable or combustible liquids or vapors shall be de-energized.

5-3 Control of Flammable and Combustible Materials for Painting of Aircraft.

5-3.1 Supply stores of paints and flammable thinners and solvents shall be located in a separate building or segregated from the aircraft maintenance and servicing areas of hangars by a fire partition with openings that shall be protected by an approved and listed fire door. Storage shall conform to the requirements of NFPA 30, *Flammable and Combustible Liquids Code.*

5-3.2 Only an operational supply of paints and flammable solvents, limited to not more than one day's needs, shall be maintained in a hangar. These materials shall be in approved, marked containers located remotely from other operations. Dispensing drums, when essential to the operation, shall be equipped with positive acting pumps and pressure relief fittings and shall be provided with drip pans and static bonding clamps and cables. No pneumatic devices that pressurize the drum shall be used for dispensing the liquids.

5-3.3 Flammable and combustible liquids on the job shall be kept in approved containers that are marked with the product name. Premixed paints shall be kept in their original metal containers and covered when not in use. Maximum solvent or paint container size on the job shall be 5 gal (20 L).

5-3.4 Epoxy or polyester resins shall not be stored close to ketone-type thinners.

5-3.5 Petroleum distillate suitable for use as a dry-cleaning solvent and other solvent cleaners such as mineral spirits, aliphatic naphtha, aromatic naphtha, trichlorethylene, xylene, methyl ethyl ketone, and other ketone-type thinners shall not be used in areas of aircraft oxygen systems.

5-4 Fire Extinguishing Equipment Requirements. Regardless of how small, all aircraft on which cleaning, paint removal, or painting operations are performed shall have, located within 50 ft (15.2 m) of the operation and available for immediate use, a minimum of one hand-portable fire extinguisher having at least a 20-B:C rating with a minimum capacity of 15 lb (6.8 kg) of agent and one nonsparking wheeled fire extinguisher having at least an 80-B:C rating with a minimum capacity of 125 lb (58 kg) of agent.

5-5 Housekeeping and General Safeguards.

5-5.1 Upon completion of each cleaning, paint removal, or painting operation, and at least once each day during the progress of the operation, all waste solvents, wiping waste, used masking tape, and waste paper shall be collected and safely disposed of. Under no circumstances shall flammable liquids or painting materials be dumped into sanitary or storm drains. Industrial waste disposal shall be made. Particular

attention shall be paid to removing waste regularly from floor pits and trenches and from aircraft holds and recesses. Until properly disposed of, waste shall be kept in covered metal containers. Rags contaminated with finishing materials shall be kept in a separate container, not in containers used to keep other waste materials.

5-5.2 The aircraft, unless immobilized, shall be parked in the painting area so that it can be readily removed in an emergency, with no obstacles between the aircraft and the doors.

5-5.3* To reduce the hazards associated with static electricity, aircraft shall be electrically grounded when parked in aircraft hangars. The aircraft manufacturer's description and maintenance instructions shall be consulted regarding the location of grounding points on the aircraft and the number of grounding cables required.

5-5.4* Spills shall be cleaned up as they occur.

5-5.5* Other than designated safe smoking areas, smoking shall be prohibited in hangars or aircraft servicing ramps used for cleaning, paint removal, or painting operations.

5-5.6 Footwear with metal cleats or tacks shall not be permitted to be worn, since they can cause sparks when scuffed along the floor.

5-5.7 No open flame shall be permitted in the vicinity of the working area.

5-6 Inspection and Preventive Maintenance.

5-6.1 Electrical equipment shall be inspected to ensure that it is being properly maintained in first-class condition and that it will not cause short circuits.

5-6.2 Grounding or bonding equipment shall be regularly inspected, properly maintained, and properly used.

5-6.3 Pumps, faucets, and pressure relief vents of containers used for flammable liquids or solvents shall be kept leak-free and functioning.

5-6.4 Any damage to containers, structure, seals, or flame arrestors shall be promptly and properly repaired.

5-6.5 Cleaning solution spray equipment, paint removal equipment, paint spray equipment, and other applicators shall be maintained in a safe condition.

5-6.6 Stands, docks, floors, filters, scaffolds, staging, and drop curtains shall be maintained on a regular basis to keep them sound and free from combustible accumulations.

5-6.7 Floors, roof trusses, light fixtures, and overhead equipment shall be regularly inspected for paint overspray and dust accumulation and cleaned when necessary.

Chapter 6 Aircraft Welding Operations

6-1 General Requirements.

6-1.1* Aircraft welding operations shall conform to the requirements of this chapter.

6-1.2 Only gas-shielded arc welding shall be performed on aircraft.

6-1.3 Only qualified welders, trained in the technique and familiar with the hazards involved, shall be permitted to do this work.

6-1.4* A written, special welding permit shall be obtained for each welding operation conducted on an aircraft from an individual designated by management as responsible for authorizing welding operations. A welding fire safety checklist shall also be tailor-made and used to cover the individual hazards of each type of operation. 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.

6-1.5 No welding shall be conducted, or welding equipment brought to the work area, until a permit has been issued.

6-1.6 No other work shall be permitted within a 25-ft (7.6-m) radius of the location of any gas-shielded arc-welding operation.

6-1.7 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.

6-2 Flammable Vapors.

6-2.1 Welding shall not be done on an aircraft while work is in progress on any system or component of the aircraft that contains, or did contain, fuel or other flammable or combustible liquids.

6-2.2 Welding shall not be done on an aircraft while work is in progress on the fuel systems on any other aircraft within 50 ft (15.2 m) from the point of welding.

6-2.3 Fuel tank access plates and any fuel tank openings shall be closed on all aircraft within 50 ft (15 m) from the point of any welding. All fuel lines, valves, manifolds, and other fuel components on the aircraft on which welding is being done shall be in place, secured, or capped prior to the start of welding operations and during such welding operations.

6-2.4* All fuel tank vents on the aircraft being worked on and the vents of other aircraft within a 50-ft (15-m) radius of the welding operation shall be plugged or covered prior to the start of welding operations and during such welding operations.

6-2.5 Prior to the start of welding and at least every 15 minutes during the welding operation, a qualified person shall check with a combustible gas analyzer to assure that flammable vapors do not reach 20 percent of the lower explosive limit whenever welding is being done in the vicinity of sources of flammable vapors. Floor drains in the area of a welding operation, when conducted in a hangar, shall be checked in the same manner.

6-3 Equipment.

6-3.1 Welding generating equipment shall be placarded as follows: "Warning — Keep 5 ft (1.5 m) Horizontally Clear of Aircraft Engines, Fuel Tank Areas, and Vents."

6-3.2 Welding equipment shall have no electrical components other than flexible lead cables within 18 in. (457 mm) of the floor. 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, not the clip type. Components that could produce arcs, sparks, or hot metal under any condition of operation shall be of the totally enclosed type or shall have suitable guards or spacing in compliance with the requirements of Article 500, Hazardous (Classified) Loca-

tions, of NFPA 70, *National Electrical Code*. The inert gas cylinder shall be securely fastened to prevent tipping and the regulator and gauge shall be in proper working condition.

6-4 Fire Protection.

6-4.1 Welding Operations in a Hangar.

6-4.1.1 When welding operations are performed in an aircraft hangar, that hangar shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars*.

6-4.1.2 Where the hangars house only aircraft with drained and purged fuel tanks as defined in 1-3.7 of NFPA 409, *Standard on Aircraft Hangars,* the hangar shall be protected with at least an automatic sprinkler system that meets the requirements specified in Section 4-2 of NFPA 409.

6-4.2 Any welding performed shall take into consideration the type of automatic fire detection equipment installed in the hangar in order to avoid false alarms or accidental actuation of the fire protection equipment provided.

6-4.3 The specific location where the welding is being done shall be roped off or otherwise segregated by physical barrier to prevent unintended entry into the welding area. A placard reading "Welding Operations in Progress" shall be prominently displayed.

6-4.4 Good housekeeping shall prevail in the welding area.

6-4.5 At least one hand-portable fire extinguisher having a minimum rating of 20-B with a minimum capacity of 15 lb (6.8 kg) of agent shall be positioned in the immediate area of the welding operation and be ready for instant use, and one wheeled extinguisher having a minimum rating of 80-B with a minimum capacity of 125 lb (58 kg) of agent shall be readily available.

6-4.6 A qualified fire watcher shall be assigned to operate this equipment and shall monitor the entire welding operation. In the event a hazardous condition develops, the fire watcher shall have the authority to stop the welding operation.

Chapter 7 Interior Cleaning and Refurbishing Operations

7-1 General Requirements.

7-1.1* Flammable liquid cleaning agents shall not be used. Combustible liquid cleaning agents shall be permitted to be used.

7-1.2* Aircraft cleaning or refurbishing operations using combustible liquids shall be conducted in accordance with this chapter.

7-2 Precautions for Combustible Liquid Cleaning Agents.

7-2.1 Combustible liquids shall be stored and controlled in accordance with the provisions of NFPA 30, *Flammable and Combustible Liquids Code*. Container storage areas shall be segregated from the aircraft maintenance and servicing area of hangars by a fire partition with openings protected by an approved fire door or located in a separate building.

7-2.2 Combustible liquids shall be handled only in approved containers appropriately marked.

7-2.3 Aircraft interiors shall be provided with ventilation sufficient at all times to prevent the accumulation of flammable or combustible vapors. To accomplish this, doors to interiors shall be open to secure maximum advantage of natural ventilation. Where such natural ventilation is insufficient, approved mechanical ventilation equipment shall be provided and used to prevent the accumulation of flammable or combustible vapors from reaching 20 percent of the lower flammability limit of the particular vapor being used.

7-2.4 All open flame– and spark-producing equipment or devices that might be brought within the vapor hazard area shall be shut down and not operated during the period when flammable or combustible vapors might exist.

7-2.5 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, Division 1 hazardous locations as defined by NFPA 70, *National Electrical Code*.

7-2.6 Temporary lighting used outside the hazard area for general illumination within an interior during cleaning and refurbishing operations that is not listed for use in Class I, Group D hazardous locations shall be enclosed and gasketed to reduce entrance of hazardous vapors within the fixtures, attached and located so as to minimize danger of breakage, and installed so as not to be in direct contact with any combustible liquids or "overspray."

7-2.7 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 might exist.

7-3 Fire Protection Requirements.

7-3.1* During such cleaning or refurbishing operations in an aircraft outside of the hangar, portable fire extinguishers having a minimum rating of 4-A:20-B with a minimum capacity of 15 lb (6.8 kg) of agent shall be provided at cabin entrances.

7-3.2 When such cleaning or refurbishing operations are performed in an aircraft hangar, that hangar shall meet the requirements of NFPA 409, *Standard on Aircraft Hangars*.

7-3.2.1 Where the hangars house only aircraft with drained and purged fuel tanks as defined in 1-3.7 of NFPA 409, *Standard on Aircraft Hangars,* the hangar shall be protected with at least an automatic sprinkler system that meets the requirements specified in Section 4-2 of NFPA 409.

7-3.2.2 In all cases, aircraft undergoing such operations in any hangar shall also have the portable fire extinguishers required in 7-3.1.

7-3.2.3 In all cases, aircraft undergoing such operations in a Group I or II hangar shall also have at least one hose line available with an adjustable spray nozzle and a discharge of not less than 50 gpm (189.25 L/min). This hose line shall be capable of reaching into the cabin area.

Chapter 8 Aircraft Ramp Fire Protection

8-1 General Requirements.

8-1.1 This chapter shall apply to the minimum requirements for fire safety on aircraft ramps.

8-1.2 The requirements of NFPA 407, *Standard on Aircraft Fuel Servicing,* shall be met during aircraft fuel servicing operations.

8-1.3 Smoking shall be prohibited on the ramp.

8-1.4 Open flames shall not be allowed within a 50-ft (15-m) radius of aircraft.

8-1.5 A permit to work shall be obtained before commencement of any open flame or hot work on the ramp. The permit shall be issued on a daily basis by the authority having jurisdiction.

8-1.6 Aircraft shall be kept under observation when connected to ground power.

8-1.7 Rubbish shall not be allowed to accumulate on the ramp and shall be disposed of in approved containers.

8-1.8 All waste flammable liquids shall be placed in approved containers prior to disposal.

8-1.9 Flammable liquids shall not be placed in trash cans or poured down storm drains.

8-2 Fire Extinguishers.

8-2.1* At least one wheeled extinguisher having a rating of not less than 80-B and a minimum capacity of not less than 125 lb (55 kg) shall be provided at each gate or stand or at intervals of 200 ft (61 m) along the length of aircraft ramps.

8-2.2 All portable extinguishers shall meet the requirements of NFPA 10, *Standard for Portable Fire Extinguishers.*

8-3 Fire Incidents.

8-3.1* In the event of a fire on or adjacent to an aircraft, the captain, crew, or personnel on board shall be alerted immediately so that an evacuation can be initiated.

8-3.2* The fire shall be reported immediately to the fire department and the exact location and aircraft registration given by one or more of the following methods:

(1) Telephone
(2) Mobile or portable radio
(3) Aircraft radio
(4) Fire alarm

8-3.3* All personnel employed on aircraft ramps shall be given training on action to take in case of fire. This shall include hands-on training in the use of portable and wheeled extinguishers.

Chapter 9 Referenced Publications

9-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix B.

9-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers,* 1998 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 1995 edition.

NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites,* 1996 edition.

NFPA 70, *National Electrical Code®,* 1999 edition.

NFPA 86, *Standard for Ovens and Furnaces,* 1999 edition.

NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair,* 1999 edition.

NFPA 407, *Standard for Aircraft Fuel Servicing,* 1996 edition.

NFPA 409, *Standard on Aircraft Hangars,* 1995 edition.

9-1.2 Other Publication.

9-1.2.1 CGA Publication. Compressed Gas Association, Inc., 1725 Jefferson Davis Highway, Arlington, VA 22202.

CGA Pressure Relief Device Standards, Part 1 — *Cylinders for Compressed Gases,* S-1.1, 1979.

Appendix A Explanatory Material

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

A-1-3 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-1-3 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-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-3 Fuel Tanks, Bladder. 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-1-3 Fuel Tanks, Integral. Integral fuel tanks can be part of either the wing or the fuselage. Integral fuel tanks discussed here 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 the completion of fabrication of the unit where the tank is located.

A-1-3 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-1-3 Oxygen, Gaseous. Above its critical temperature of −180.4°F (−82.4°C), oxygen can exist only as a gas regardless of the pressure exerted on it.

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 ASTM E 380, *Standard for Metric Practice.*

The conversion procedure for the SI units is to multiply the quantity by the conversion factor and then round the result to the appropriate number of significant digits.

A-2-2.3.1 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. Finger rings, wrist watches, wrist chains, 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.

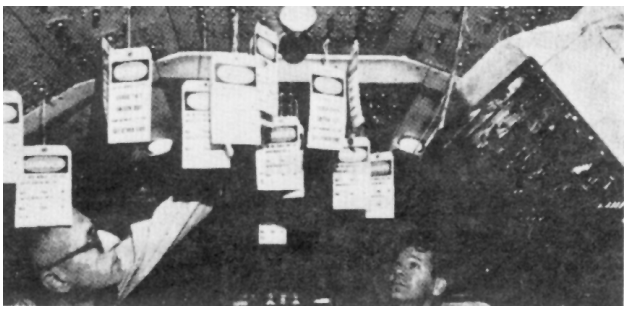
A-2-2.5 Most aircraft have battery compartments designed for in-flight ventilation only, and if batteries are charged in such compartments while the aircraft is on the ground, an explosive gas–air mixture could be trapped in the battery compartment.

A-2-2.11 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-2-3.6 This is extremely important, because in some aircraft the battery switch has a midposition and if the switch is in this 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-2-4.7 See Figure A-2-4.7.

Figure A-2-4.7 Typical illustration of the use of a tag-out system. ***(Courtesy of American Airlines, Inc.)***



A-2-4.8(a) No fewer than two persons should work on energized electrical systems in areas containing flammable fluid lines.

A-3-1.1 For information on bulk storage of oxygen, see NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites,* and NFPA 53, *Recommended Practice on Materials, Equipment, and Systems Used in Oxygen-Enriched Atmospheres.*

Description of Gaseous and Liquid Oxygen. Current aircraft breathing-oxygen systems can utilize either gaseous or liquid oxygen or a chemical-oxygen generator. 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 −180.4°F (−82.4°C), oxygen can exist only as a gas regardless of the pressure exerted on it.

Liquid oxygen is a light blue, transparent liquid that flows like water. It boils at −297°F (−147.2°C) at standard atmospheric pressure. The gaseous oxygen formed at room temperature [70°F (21°C)] and standard atmospheric pressure [29.92 in. (760 mm) 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 40,000 psi (276 MPa)]. For this reason, liquid oxygen containers must be fitted with safety relief devices or vented to the atmosphere.

Hazards. 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 ignitible 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 will cause 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.

A-3-2 *Low-Pressure Breathing-Oxygen Systems.* These fixed systems utilize compressed gaseous oxygen stored in containers having a maximum service pressure of about 400 to 450 psi (2.76 to 3.10 MPa). 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 permit charging the system, and one or more of the types of regulators previously described.

High-Pressure Breathing-Oxygen Systems. These fixed systems utilize compressed gaseous oxygen stored in containers having a maximum service pressure of about 1800 to 2200 psi (12.4 to 15.2 MPa). 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. Portable equipment ("walk-around bottles") utilize compressed gaseous oxygen in either the low- or high-pressure containers. A typical system is comprised 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-3-3 *Liquid Breathing-Oxygen Converter Systems.* These fixed systems 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-3-3.11 The following recommendations outline procedures considered typical; however, variances in design between aircraft systems and charging equipment might require deviations. The equipment manufacturer's instruction should always be observed.

(a) 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.

(b) To develop the desired pressure to effect transfer, close the vent valve and open the pressure build-up valve slowly. Allow the pressure to reach the desired level, then close the pressure build-up valve.

(c) Attach the transfer hose to the tank and open the fill-drain valve. Purge the transfer hose in accordance with the specific instructions of the manufacturer, then close the fill-drain valve.

(d) After purging, attach the hose to the fill fitting in the aircraft oxygen system and open the fill-drain valve slowly.

(e) 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.

(f) 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. It might be necessary to operate the pressure relief valve several times until there is no further pressure rise. Disconnect the transfer hose from the aircraft fill fitting.

(g) 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 such containers sufficiently to volatilize and clean out the impurities, can concentrate these 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-3-4 *Oxygen Generator Systems.* These 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-3-5.1 If available, breathing air, rather than oxygen, can be used for this purpose.

A-3-6.1 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-3-7 *Breathing-Oxygen Cylinder Storage.* Gaseous breathing oxygen is generally received in high-pressure [1800 to 3000 psi (12.4 to 20.7 MPa)] 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, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Weld-*

ing, Cutting, and Allied Processes, and NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites,* should be followed. NFPA 51 is applicable to cylinder storage in smaller quantities. NFPA 50 is applicable to larger systems that utilize both gaseous and liquid oxygen.

A-3-8 *Liquid Oxygen Storage Equipment.* In the United States, liquid oxygen storage containers are fabricated from materials meeting the impact test requirements of Paragraph UG-84 of the ANSI B31.1, *Power Piping Code,* Section VIII — Unfired Pressure Vessels, or meet the specifications of DOT for 4-L cylinders. Vessels (other than DOT 4-L cylinders) operating at pressures above 15 psig (103 kPa gauge) 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-3-9.

A-3-9 *Gaseous Oxygen Equipment. (See also A-3-8.)* In the United States, regulations of the Department of Transportation govern the type and capacity of containers in which commercial oxygen as a nonflammable compressed gas can be transported and stored. 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 40 psi (276 kPa) absolute [25 psig (272 kPa gauge) approximate] at 70°F (21.1°C) 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 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 70°F (21.1°C) 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-4, *Method for Marking Portable Compressed Gas Containers to Identify the Material Contained.*

A-3-9.1 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-3-9.5 Types of Aircraft Breathing-Oxygen Regulators. The three basic types of aircraft breathing-oxygen regulators are supplied from fixed or portable oxygen systems as described in A-3-2, A-3-3, and A-3-4.

(a) 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.

(b) 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 may 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.

(c) A pressure breathing demand-type regulator, when used with the proper mask, imposes a predetermined pressure upon the lungs at certain altitudes [usually above 30,000 ft (9000 m)]. Below that altitude, the regulator functions as an ordinary diluter demand-type.

A-3-9.5.4 Such means can be a dead-end chamber directly connected to the inlet passage of the regulator or some other heat-absorbing device.

A-3-9.6 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-4-1.1 See NFPA 407, *Standard for Aircraft Fuel Servicing,* for aircraft fuel transfer operations not associated with aircraft maintenance or overhaul operations.

A-4-1.5.1 While Chapter 5 of NFPA 407 does not allow 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, Standard for Aircraft Fuel Servicing.)* This document, NFPA 410, covers aircraft fuel system maintenance, and the provisions of 4-1.5.1 allow the fuel transfer piping to extend into a hangar for aircraft fuel system maintenance operations provided that it is protected as stated.

A-4-1.7 Aircraft that are brought into a heated hangar from a cold outdoor atmosphere should be carefully watched for fuel expansion, because normalization to ambient temperature can take several hours.

A-4-1.26 Certain residual fuel siphoning system design requirements prevent the hose from being extended and fixed below the liquid level of the system's receiving tank. This type of system is designed as a complete system, and its components are bonded to reduce the hazard of liquid surface electrostatic generation.

A-4-2 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 lower flammability limits 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 flammability 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 three basic factors:

(a) 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 lower flammable limit.

(b) Establishment of adequate air circulation through the tank to assure 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 assure 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.

(c) 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 assure 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.

Example Procedure, Air Ventilation (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.

(a) 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.

(b) 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).

(c) When a closed ventilating system *(see 4-2.10)* 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 assure effective fuel vapor removal.)

NOTE: 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.

(d) 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.

(e) Maintain the ventilation for the time prescribed to achieve a safe atmosphere within the tank *(see 4-2.5)* and during all tank maintenance work. Check the actual conditions periodically with the combustibles detector.

(f) Halt tank maintenance operations when any unsafe condition develops, and do not resume operations until a safe condition is restored. *(See 4-2.10.)*

(g) 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 three or four minutes to permit removal of all vapors from the ducts. Disconnect the static bond wires from the aircraft and turn off the exhaust fan.

A-4-2.9 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-4-2.17 See A-4-1.7.