

NFPA®

410

**Standard on
Aircraft Maintenance**

2020



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NFPA® 410

Standard on

Aircraft Maintenance

2020 Edition

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

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

Origin and Development of NFPA 410

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

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

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

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

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

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

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

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

Contents

Chapter 1 Administration	410- 4	5.8 Liquid Breathing-Oxygen Storage (in Other Than DOT-Type 4L Cylinders).	410- 11
1.1 Scope.	410- 4	5.9 Gaseous Oxygen Equipment.	410- 11
1.2 Purpose.	410- 4	5.10 Miscellaneous Requirements.	410- 12
1.3 Equivalency.	410- 4		
1.4 Units.	410- 4	Chapter 6 Aircraft Fuel System Maintenance	410- 12
Chapter 2 Referenced Publications	410- 4	6.1 Fuel Transfer Equipment and Operations.	410- 12
2.1 General.	410- 4	6.2 Air Ventilation.	410- 13
2.2 NFPA Publications.	410- 4	6.3 Repair of Fuel Tanks.	410- 14
2.3 Other Publications.	410- 4	6.4 Pressure Testing of Aircraft Fuel Systems.	410- 15
2.4 References for Extracts in Mandatory Sections.	410- 4		
Chapter 3 Definitions	410- 5	Chapter 7 Aircraft External Cleaning, Painting, and Paint Removal	410- 16
3.1 General.	410- 5	7.1 General.	410- 16
3.2 NFPA Official Definitions.	410- 5	7.2 Operational Sites and Precautions.	410- 16
3.3 General Definitions.	410- 5	7.3 Control of Flammable and Combustible Liquids.	410- 17
Chapter 4 Electrical Maintenance Operations	410- 6	7.4 Housekeeping and General Safeguards.	410- 17
4.1 General.	410- 6	7.5 Inspection and Preventive Maintenance.	410- 17
4.2 Battery Charging and Equipment.	410- 6		
4.3 Ground Power Units.	410- 7	Chapter 8 Aircraft Welding Operations	410- 18
4.4 Repair of Aircraft Electrical Systems.	410- 7	8.1 General.	410- 18
4.5 Repairs to Communications and Navigation Equipment.	410- 8	8.2 Flammable Vapors.	410- 18
4.6 Cleaning of Electrical Components Installed on the Aircraft.	410- 8	8.3 Equipment.	410- 18
4.7 Testing of Electrical Equipment During and Following Repair Operations.	410- 8	8.4 Fire Protection.	410- 18
4.8 Energizing and De-Energizing Electric Circuits During Complete Engine Change.	410- 8		
4.9 Electrical Equipment Mounted on Fixed Workstands.	410- 8	Chapter 9 Interior Cleaning and Refurbishing Operations	410- 19
4.10 Electrical Equipment Mounted on Movable Stands.	410- 8	9.1 General.	410- 19
		9.2 Precautions for Flammable or Combustible Liquid Cleaning Agents.	410- 19
Chapter 5 Aircraft Breathing-Oxygen Systems	410- 8		
5.1 Oxygen System Charging Operations and Safeguards.	410- 8	Chapter 10 Fire Protection	410- 20
5.2 Specific Cautions Applicable to Gaseous Breathing Oxygen.	410- 9	10.1 General.	410- 20
5.3 Specific Cautions Applicable to Liquid Breathing Oxygen.	410- 10	10.2 Fire Extinguishers.	410- 20
5.4 Specific Cautions Applicable to Oxygen Generator Systems.	410- 10	10.3 Training.	410- 20
5.5 Aircraft Breathing-Oxygen System Test and Repair Operations and Safeguards.	410- 10	10.4 Materials to Access Aircraft.	410- 20
5.6 Fire Emergencies.	410- 10		
5.7 Breathing-Oxygen Cylinder Storage (DOT Gaseous Oxygen Cylinders and DOT-Type 4L Cylinders of Liquid Oxygen).	410- 11	Annex A Explanatory Material	410- 20
		Annex B Aircraft Breathing-Oxygen Systems	410- 26
		Annex C Ventilation of Aircraft Fuel Tanks	410- 26
		Annex D Nonflammable Agents and Solvents	410- 28
		Annex E Informational References	410- 29
		Index	410- 30

NFPA 410**Standard on****Aircraft Maintenance**

2020 Edition

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

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

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

Chapter 1 Administration

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

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

1.2 Purpose. The purpose of this standard is to provide a degree of protection for life and property from fire through

requirements for aircraft maintenance based on engineering principles, test data, and field experience.

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

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

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

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

Chapter 2 Referenced Publications

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

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

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2018 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2020 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 326, *Standard for the Safeguarding of Tanks and Containers for Entry, Cleaning, or Repair*, 2020 edition.

NFPA 407, *Standard for Aircraft Fuel Servicing*, 2017 edition.

NFPA 409, *Standard on Aircraft Hangars*, 2016 edition.

2.3 Other Publications.

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

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

2.3.2 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2014 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2014 edition.

NFPA 408, *Standard for Aircraft Hand Portable Fire Extinguishers*, 2017 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

3.2.4 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

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

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

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

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

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

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

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

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

3.3.9 Bladder Tank. See 3.3.14.1, Bladder Fuel Tank.

3.3.10 Cleaning.

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

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

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

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

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

3.3.14 Fuel Tank.

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

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

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

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

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

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

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

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

3.3.20 Integral Tanks. See 3.3.14.2, Integral Fuel Tank.

3.3.21 Liquid.

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

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

3.3.22 Oxygen, Gaseous. See 3.3.16.

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

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

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

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

3.3.27 Tanks. See 3.3.14, Fuel Tank.

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

Chapter 4 Electrical Maintenance Operations

4.1 General.

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

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

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

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

4.2 Battery Charging and Equipment.

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

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

4.2.3 Battery Removal.

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

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

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

4.2.4 Precautions.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2.16 Sources of Ignition.

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

4.2.16.2 Warning signs shall be prominently displayed.

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

4.3 Ground Power Units.

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

4.3.2 Proximity to Ignition Sources.

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

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

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

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

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

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

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

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

4.3.6* Battery Switch.

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

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

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

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

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

4.3.8 Cables shall be stowed to prevent damage.

4.3.9 Strains on cables and connectors shall be avoided.

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

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

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

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

4.4 Repair of Aircraft Electrical Systems.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.4.13 Aircraft wiring shall be secured to prevent chafing.

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

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

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

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

4.6 Cleaning of Electrical Components Installed on the Aircraft.

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

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

4.7 Testing of Electrical Equipment During and Following Repair Operations.

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

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

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

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

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

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

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

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

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

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

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

4.9 Electrical Equipment Mounted on Fixed Workstands.

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

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

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

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

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

Chapter 5 Aircraft Breathing-Oxygen Systems

5.1 Oxygen System Charging Operations and Safeguards.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.1.17.1 Connectors that do not fit shall not be forced.

5.1.17.2 Fittings with worn or damaged threads shall be replaced.

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

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

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

5.2* Specific Cautions Applicable to Gaseous Breathing Oxygen.

5.2.1 Opening Valves.

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

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

5.2.2 Method of Opening Valve.

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

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