



AEROSPACE INFORMATION REPORT

AIR6820™**REV. A**

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Superseding AIR6820

Electrical Wiring Fuel Compatibility

RATIONALE

Limited scope revision is required to correct the operating temperature limit of the cited MIL-PRF-8516. The source specification for the sealant is MIL-PRF-8516 (g). In paragraph 5.2, it specifies the operating range as “(-60 to +200 °F).”

AIR6820A has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This SAE Aerospace Information Report (AIR) is limited to the subject of compatibility of wiring as part of aircraft Electrical Wiring and Interconnect Systems (EWIS) installed in and around aircraft fuel tanks.

1.1 Purpose

This AIR examines the requirements of AS50881, FAA requirements, and related guidelines in regard to installation of aircraft EWIS in and around aircraft fuel tanks. EWIS wiring should not be routed through fuel tanks except where there is no alternative. In addition, EWIS component fluid resistance requirements and results from EWIS fuel compatibility testing conducted by the U.S. DoD will be presented and discussed.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR5128	Electrical Bonding of Aircraft Fuel Systems
AS4373	Test Methods for Insulated Electric Wire
AS22759	Wire, Electrical, Fluoropolymer-Insulated, Copper or Copper Alloy
AS22759/11	Wire, Electrical, Fluoropolymer-Insulated, Extruded TFE, Silver-Coated Copper Conductor, 600 Volt ROHS

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Full document details: [SAE AIR6820A](http://www.sae.org/standards/content/AIR6820A/)

For more information on this standard, visit
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Documents

Standard, visit Sharing Hub

AS22759/18	Wire, Electric, Fluoropolymer-Insulated, Extruded ETFE, Light Weight, Tin-Coated Copper Conductor, 600-Volt, 150 °, ROHS
AS22759/28	Wire, Electric, Fluoropolymer-Insulated, Extruded TFE, Polyimide Coated, Silver-Coated Copper Conductor, 600-Volt, ROHS
AS22759/34	Wire, Electrical, Fluoropolymer-Insulated, Cross-Linked Modified ETFE, Normal Weight, Tin-Coated, Copper, 150 °C, 600 Volt, ROHS
AS22759/87	Wire, Electrical, Polytetrafluoroethylene/Polyimide Insulated, Normal Weight, Nickel Coated, Copper Conductor, 260 °C, 600 Volt ROHS
AS23053	Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for
AS23053/5	Insulation Sleeving, Electrical, Heat Shrinkable, Polyolefin, Flexible, Crosslinked
AS50861/2	Wire, Electrical, Polyvinyl Chloride Insulated, PVC-Glass-Polyamide, Tin-Coated Copper Conductor, 600-Volt, 105 °C
AS50881	Wiring Aerospace Vehicle
AS81044/9	Wire, Electric, Crosslinked Polyalkene Insulated, Tin-Coated Copper, Medium Weight, 600-Volt, 150 °C
AS83519/2	Shield Termination, Solder Style, Insulated, Heat-Shrinkable, Environment Resistant with Pre-Installed Leads for Cables Having Tin or Silver Plated Shields (Class I)

2.2 NEMA Publications

Available from the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209, Tel: 703-841-3200, www.nema.org.

WC27500 Aerospace and Industrial Electric Cable

2.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 25.981-1 Fuel Tank Ignition Source Prevention Guidelines

2.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D286 Method of Test for Autogenous Ignition Temperatures of Petroleum Products

2.5 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

A-A-59877 Insulating Compound, Electrical, Embedding

MIL-DTL-17 Cables, Radio Frequency, Flexible and Semirigid

MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-DTL-81381/7	Wire, Electric, Fluorocarbon/Polyimide Insulated, Light Weight, Silver Coated Copper Conductor, 600 Volts, 200 Degrees C, Nominal 5.8 MIL Wall (Inactive, New design use AS22759/191))
MIL-DTL-83133	Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37)
MIL-I-16923	Insulating Compound, Electrical, Embedding Epoxy (this specification was Cancelled; future acquisitions may refer to A-A-59877)
MIL-PRF-8516	Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-STD-202	Electronic and Electrical Component Parts, Test Method Standard

2.6 U.S. Air Force Technical Report

Available from Materials Integrity Branch (AFRL/RXSA) Building 652, Room 122, 2179 12th Street, Wright-Patterson Air Force Base, OH 45433-7718.

AFRL/RXS 08-065	Heat Shrinkable Wire Insulation Material Compatibility with Aviation Fuels by Immersion Testing (Materials Evaluation)
AFRL/RXS 08-052	Fluid Immersion Testing of Aircraft Wiring System Materials (Materials Evaluation)
AFRL/RXS 08-040	Wire Insulation Materials Compatibility with Aviation Fuels by Immersion Testing (Materials Evaluation)

2.7 U.S. Navy Technical Report

Available from Lectromechanical Design Company, LLC, 4230-K Lafayette Center Drive, Chantilly, VA 20151 USA.

N457-R0001	Final Report of Extended High Temperature Fuel Immersion
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3. DEFINITIONS

AUTO-IGNITION TEMPERATURE: The minimum temperature at which an optimized flammable vapor and air mixture will spontaneously ignite when heated to a uniform temperature in a normal atmosphere without an external source of ignition, such as a flame or spark.

BARRIER: A physical partition attached to aircraft structure that separates one wire or group of wires from another wire or group of wires in order to prevent arcing, fire, and other physical damage between wires or groups of wires.

CRITICAL DESIGN CONFIGURATION CONTROL LIMITATIONS: Limitations that define those design parameters that must be maintained to ensure that ignition sources will not develop within the fuel tank.

ELECTRICAL SPARKS: A spark that is initiated by a potential difference which causes an electrical breakdown of a dielectric, such as a fuel/air mixture, produced between initially separated electrodes, with the circuit initially carrying no current. The term voltage sparks is sometimes used interchangeably with the term electrical sparks.

ELECTRICAL ARCS: An electrical arc is an electrical breakdown of gas which produces an ongoing plasma discharge, resulting from a current flowing through normally nonconductive media such as air, resulting in a luminous discharge forms when an electrical current jumps a gap between two electrical potentials.

EXPLOSION PROOF: Components designed and constructed so they will not ignite flammable vapors or liquids surrounding the component under any normal operating and failure conditions.

FLAMMABLE: A characteristic of a material which is demonstrated by the tendency of the material to ignite and burn when an ignition source is brought sufficiently close.

FLASH POINT: The flash point of a flammable fluid is defined as the lowest temperature at which the application of a flame to a heated sample causes the vapor to ignite momentarily, or “flash.” The test standard for jet fuel is defined in the fuel specification.

FISCHER-TROPSCH (F-T) AVIATION FUEL: Synthetic aviation turbine fuel which is produced using the Fischer-Tropsch process that converts a mixture of carbon monoxide and hydrogen into liquid hydrocarbons.

FRICTION SPARK: A heat source in the form of a spark that is created by mechanical contact, such as debris contacting a rotating fuel pump impeller.

F-24 FUEL: Simply put F-24 (NATO Code) is Jet-A aviation turbine fuel plus the military additives S-1745 (FSII), S-1747 (CI/LI), and SDA. It has a freezing point of -104 °F (-40 °C) compared to -117 °F (-47 °C) for JP-8. The main difference between JP-8 and F-24 is cost. JP-8 and F-24 are completely interchangeable fuels for all contiguous United States operations.

HOT SHORT: Electrical energy introduced into equipment or systems as a result of unintended contact with a power source, such as bent pins in a connector or damaged insulation on adjacent wires.

IGNITION SOURCE: A source of sufficient energy to ignite a fuel/air mixture. Surfaces that can exceed the auto-ignition temperature of the flammable vapor under consideration are considered to be ignition sources. Electrical arcs, electrical sparks, and friction sparks are also considered ignition sources if sufficient energy is released to initiate combustion.

INTRINSICALLY SAFE: Any instrument, equipment, or wiring that is incapable of releasing sufficient electrical or thermal energy under normal operating conditions, anticipated failure conditions, and environmental conditions which could cause an ignition source within the fuel tank.

JP-4 FUEL: Aviation turbine fuel, 50-50 kerosene-gasoline blend specified and used widely by the U.S. military, primarily by the Air Force between 1951 and 1995. It is specified by MIL-DTL-5624. JP-4 was a non-conductive liquid, prone to build up static electricity when being moved through pipes and tanks. As it is volatile and has a low flash point, the static discharge could cause a fire. Beginning in the mid-1980s, an antistatic agent was added to the fuel to lower the charge buildup and decrease the corresponding risk of fires. Flow rates must be controlled, and all the equipment used must be electrically interconnected and well grounded. JP-4 is no longer widely used due to flammability concerns. It has been most commonly replaced by JP-8 after 1995.

JP-5 FUEL: Aviation turbine fuel, specified and used widely by the U.S. military. It is regarded as a high flashpoint, kerosene type fuel, specified by MIL-DTL-5624. It is mixed with corrosion inhibitor/antioxidant, static dissipator, and anti-icing additives to improve its characteristics.

JP-8 FUEL: Aviation turbine fuel, specified and used widely by the U.S. military. It is specified by MIL-DTL-83133, and British Defense Standard 91-87, and is similar to commercial aviation's Jet-A-1, but with the addition of corrosion inhibitor and anti-icing additives. JP-8+100 is a version of JP-8 with an additive that increases its thermal stability by 100 °F (56 °C). JP-8+100LT is a variant of JP-8+100, with additives to facilitate low-temperature performance.

TRANSIENT SUPPRESSION DEVICE (TSD): A device that limits transient voltages or currents on wiring to systems such as the fuel tank quantity, fuel temperature sensors, and fuel level switches, etc., to a predetermined level.

4. GUIDELINES FOR EWIS INSTALLATION IN AND AROUND AIRCRAFT FUEL TANKS

- 4.1 AS50881 covers all aspects of EWIS from selection through installation of wiring devices used in aerospace vehicles. Aerospace vehicles include manned and unmanned aircraft, helicopters, lighter-than-air vehicles, missiles, and external pods. The following information in regard to EWIS routed through and inside fuel tanks is extracted from AS50881F, and it is recommended that the user refer to the complete document for guidance. Information in parentheses refer to AS50881F paragraph.

4.1.1 Wiring through Fuel Tanks (refer to 3.11.12)

Wiring should not be routed through fuel tanks except where there is no alternative. Wiring that must be routed through fuel tanks, but that is not part of the fuel management, or control wiring shall be routed through a dry access channel or passage so as to preclude contact of the wiring insulation and the fuel. The channel or passage shall be of a size to facilitate the removal and repair of the wiring without removal of the fuel tank and shall have a fluorocarbon liner which will preclude electrical contact. The routing of fiber optic cables through fuel tanks is not recommended.

4.1.2 Wiring Inside Fuel Tanks (refer to 3.11.13)

Wiring that is essential to the operation of fuel management or control system may be routed inside fuel tanks only if there is no alternative. Wiring that is used in circuits that are capable of generating energy levels greater than 0.02 microjoules must be encased in a grounded metal conduit having a fluorocarbon liner. Wiring that comes in contact with fuel must have an insulation system which is compatible with the fuel and fuel vapor. Clamps and hardware used to attach wiring inside fuel tanks must also be compatible with the fuel and fuel vapor. Tie tape, string, mechanical straps, or other items that could become loose and clog fuel filters shall not be used inside fuel tanks.

4.1.3 Splices (refer to 3.19.4j)

Splices shall not be used on wires inside of fuel tanks.

4.2 FAA Advisory Circular (AC) 25.981-1 provides guidance for prevention of ignition sources within the fuel tanks of transport category aircraft. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable FAA regulations. The following information is extracted from the FAA AC 25.981-1B, and it is recommended that the user refer to the latest published version and complete document for guidance. Information in parentheses refer to AC 25.981-1B paragraph.

4.2.1 Primary Sources of Ignition (refer to paragraph 8a)

FAA AC 25.981-1 identifies four primary phenomena that can result in ignition of fuel vapors from within aircraft fuel tanks:

- Electrical arcs and sparks,
- Filament heating,
- Friction sparks, and
- Hot surface ignition or auto-ignition.

4.2.2 Due to the difficulty in predicting fuel tank flammability and eliminating flammable vapors from the fuel tank, it is assumed that a flammable fuel-air mixture may exist in aircraft fuel tanks and have required that no ignition sources be present (refer to paragraph 8a).

4.2.3 Any components located in or adjacent to a fuel tank must be designed and installed in such a manner that, during both normal and anticipated failure conditions, ignition of flammable fluid vapors will not occur. Testing of components to meet the appropriate level of explosion-proof requirements may be carried out for various single failures, and combinations of failures, to show that arcing, sparking, auto-ignition, hot surface ignition, or flame propagation from the component will not occur (refer to paragraph 8a(1)).

4.2.4 Electrical Sparks and Electrical Arcs (refer to paragraph 8b)

Laboratory testing has shown that the minimum ignition energy in an electrical spark required to ignite hydrocarbon fuel vapor is 200 microjoules. Therefore, for electrical or electronic systems that introduce electrical energy into fuel tanks, such as fuel quantity indicating systems, any electrical arcs or sparks that are created in any fuel tank should be less than 200 microjoules during either normal operation or operation with failures. Fuel tank systems should be designed to limit the allowable energy level to the lowest practical level. Systems with a maximum energy of 20 microjoules are considered technologically feasible. Normal systems operations at minimum ignition energies of up to 50 microjoules are acceptable. Under failure conditions, the system should not have an ignition energy which would exceed 200 microjoules (refer to paragraph 8b(1)).

Electrical transients caused by environmental conditions, such as lightning strikes, with the potential to create electrical sparks and arcs in the fuel tank, should be limited so that the energy from any electrical spark or arc from the electrical transient is less than 200 microjoules (refer to paragraph 8b(2)).

4.2.5 Filament Heating Current Limit (refer to paragraph 8c)

For electrical or electronic systems that introduce electrical energy into fuel tanks, such as fuel quantity indicating systems, the electrical current introduced into any fuel tank should be limited. Because there is considerable uncertainty associated with the level of current necessary to produce an ignition source from filament heating, a factor of safety should be applied to this value when establishing a design limit. A maximum steady-state current of 25 mA RMS is considered an intrinsically safe design limit for electronic and electrical systems that introduce electrical energy into fuel tanks. For failure conditions, limit the current to 50 mA RMS and for lightning-induced transients to 125 mA peak current.

4.2.6 Friction Sparks (refer to paragraph 8d)

Service experience has shown that pump inlet check valves, inducers, nuts, bolts, rivets, fasteners, lockwire, roll pins, cotter pins, drill chips, and manufacturing debris, etc., have been inducted into fuel pumps and contacted the impeller resulting in the possibility of metallic deposits on rotating and stationary components within the pump. This condition has resulted in the creation of friction sparks and should be an assumed failure condition.

4.2.7 Hot Surface Ignition (refer to paragraph 8e)

4.2.7.1 Maximum Surface Temperature (refer to paragraph 8e(1))

Surfaces that come within 50 °F (10 °C) degrees of the auto-ignition temperature of the fuel-air mixture for the fluid are considered to be ignition sources. Historically, 400 °F (200 °C) is accepted for maximum surface temperatures for kerosene-type fuels.

4.2.7.2 Flammable Fluid Properties (refer to paragraph 8e(2))

Flammable Fluid Properties. Fuels approved for use on transport category airplanes have differing flammability characteristics. The auto-ignition temperature of JP-4, as determined by ASTM Test Method D286, is approximately 468 °F at one atmosphere of pressure. By this method of testing, under the same atmospheric conditions the auto-ignition temperature of JET A (kerosene) is approximately 435 to 450 °F (224 to 232 °C), and of gasoline, approximately 800 °F (427 °C). The auto-ignition temperature of these fuels varies inversely with the ambient pressure. In view of this, factors affecting the pressure in the fuel tank should be taken into consideration when determining compliance with § 25.981.4.2.8 Fuel System Electrostatics (refer to paragraph 8f).

Fuel System Electrostatics. Electrostatic charges are generated in liquid hydrocarbons when they are in motion with respect to another surface such as fueling hoses, filters, nozzles, fuel tank structure and aircraft plumbing. The references in paragraphs 4c(4) and 4e(9) of this AC provide information on this subject. During airplane refueling, jet fuel is loaded either from a tanker truck or from an airport hydrant system. Flowing fuel can generate an electrical charge especially through fuel filtration. The accumulation of charge in the fuel is a function of many factors. If the fuel conductivity is low, the relaxation time for dissipation of the electrical charge is long. As a consequence, the fuel may accumulate an electrical charge inside an aircraft fuel tank. This electrical charge may produce a high potential on the fuel surface and an electrical discharge to structure. This is particularly a concern when large unbonded objects are located inside an airplane fuel tank. Smaller components may also become charged and this should be addressed in the safety assessment. If the vapor space fuel/air mixture is in the flammable range, ignition of the mixture is possible, resulting in a fuel tank explosion and fire.