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MILITARY STANDARD

SELECTION AND INSTALLATION OF AIRCRAFT ELECTRIC EQUIPMENT

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FORWARD

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1. SCOPE

1.1 **Scope.** This standard covers the general requirements for the selection and installation of electric equipment in military aircraft. Electric equipment includes electric power generation, conversion, storage, and distribution equipment, electric power control and protective devices, and motors.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 *Specifications, standards and handbooks.* The following specifications, standards, and handbooks form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-S-61	Shunts, Instrument, External, 50 Millivolt (Lightweight Type)
MS3456	Connectors, Plug, Electrical, Rear Release, Crimp Contact, AN Type
MS3505	Cover for Use with MS90362 External Power Receptacles
MS3506	Connector, Receptacle, External Electric Power, Aircraft, 28 Volt Dc Operating Power
MIL-S-3950	Switches, Toggle, Environmentally Sealed, General Specification for
MIL-S-4040	Solenoid, Electrical, General Specification for
MIL-C-5015	Connectors, Electrical, Circular Threaded, AN Type, General Specification for
MIL-C-5026	Cutout Relay, Engine Generator
MIL-B-5087	Bonding, Electrical, and Lightning Protection, for Aerospace Systems
MIL-W-5088	Wiring, Aerospace Vehicle
MIL-F-5372	Fuse, Current Limiter Type, Aircraft
MIL-F-5373	Fuseholder, Block Type, Aircraft
MIL-C-5809	Circuit Breakers, Trip-Free, Aircraft, General Specification for
MIL-E-6051	Electromagnetic Compatibility Requirements, System
MIL-R-6106	Relays, Electromagnetic (Including Established Reliability (ER) Types), General Specification for
MIL-S-6150	Starter: Engine, Electrical, Direct Cranking Aircraft, 28 Volts Dc
MIL-G-6162	Generators and Starter-Generators, Electric Direct Current, Nominal 30 Volts, Aircraft, General Specification for
MIL-A-6752	Ammeters, Voltmeters, and Loadmeters; Direct Current
MIL-V-6753	Voltmeters; 0-150 Volt, 330 to 1200 Cycles, Alternating Current
MIL-S-6807	Switch, Rotary, Selector Power, General Specification for
MIL-I-7032	Inverters, Aircraft, General Specification for

MIL-C-7115	Converters, Aircraft, General Specification for
MIL-F-7179	Finishes, Coatings, and Sealants for the Protection of Aerospace Weapons Systems
MIL-G-7703	Guard, Switch, General Specification for
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for
MIL-S-7780	Starters: Electric, Constant Current, Dc
MIL-M-7969	Motors, Alternating Current, 400-Cycle, 115/200 Volt System, Aircraft, Class A and B, General Specification for
MIL-F-8378	Frequency Meters, Aircraft, 380 to 420 Hertz and 350 to 450 Hertz
MIL-B-8565	Battery Storage, Aircraft General Specification for
MIL-M-8609	Motors, Direct Current, 28-Volt System, Aircraft, Class A and B, General Specification for
MIL-M-8650	Mockups, Aircraft, General Specification for
MIL-D-8708	Demonstration Requirements for Airplanes
MIL-S-8805	Switches and Switch Assemblies, Sensitive and Push (Snap Action), General Specification for
MIL-S-8834	Switches, Toggle, Positive Break, General Specification for
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for
MIL-P-15024	Plates, Tags and Bands for Identification of Equipment
MIL-F-15160	Fuses: Instruments, Power, and Telephone
MIL-F-15733	Filters and Capacitors, Radio Frequency Interference General Specification for
MS17845	Shield for Use with MS90362 External Power Receptacles
MIL-F-19207	Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating
MIL-F-21346	Fuseholders, Block and Plug Type and Associated Electrical Clips
MIL-G-21480	Generator System, 400 Hertz Alternating Current, Aircraft General Specification for
MIL-S-22885	Switches, Push Button, Illuminated, General Specification for
MIL-D-23222	Demonstration Requirements for Helicopters
MIL-R-23761/1	Regulator Control Panel, Aircraft Direct Current Generator, 28 Volt
MIL-E-24021	Electric Power Monitors, External, Aircraft
MS25018	Connector, Receptacle, External Electric Power, Aircraft, 28 Volt D.C., Jet Starting
MIL-N-25027	Nut, Self-Locking, 250 Deg. F, 450 Deg. F, and 800 Deg. F
MS25043	Cover, Electrical Connector, Receptacle, AN Type
MIL-F-25381	Flight Testing, Electric System, Piloted Aircraft and Guided Missile, General Requirements for
MIL-E-25499	Electrical Systems, Aircraft, Design and Installation of, General Specification for
MIL-M-25500	Mockup Testing, Electric System, Piloted Aircraft and Guided Missile, General Requirements for
MIL-C-27536	Coupling, Clamp, Grooved, V-Band
MS33540	Safety Wiring and Cotter Pinning, General Practices for

MIL-S-81551	Switches; Toggle, Hermetically Sealed, General Specification for
MIL-P-81653	Power Controller, General Specification for
MIL-B-81757	Batteries and Cells, Storage, Nickel-Cadmium, Aircraft General Specification for
MIL-C-81790	Connectors, Receptacle, External Electric Power, Aircraft
MIL-C-83383	Circuit Breakers, Remote Control, Thermal, Trip-Free, General Specification for
MIL-C-83413	Connectors and Assemblies, Electrical, Aircraft Grounding General Specification for
MIL-I-85071	Inverters, Aircraft, DC to AC, General Specification for
MIL-C-85485	Cable, Electric, Filter Line, Radio Frequency Absorptive
MIL-E-85583	Electric Power Generating Channel, Variable Input Speed, Alternating Current, 400 Hz, Aircraft; General Specification for
MIL-B-85584	Battery Relay Control Unit, Aircraft
MIL-V-85603	Voltmeter, DC, Aircraft, Digital Display General Specification for
MIL-F-85731	Fastener, Positive Locking, Electronic Equipment, General Specification for
MIL-E-87219	Electrical Power Systems, Aircraft
MS90362	Connector, Receptacle, External Electric Power, Aircraft, 115/200 Volt, 400 Hertz

STANDARDS

MILITARY

MIL-STD-203	Aircrew Station Controls and Displays: Location, Arrangement and Actuation of, for Fixed Wing Aircraft
MIL-STD-250	Aircrew Station Controls and Displays for Rotary Wing aircraft
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Aircraft Electric Power Characteristics
MIL-STD-889	Dissimilar Metals
MIL-STD-961	Military Specifications and Associated Documents, Preparation of
MIL-STD-965	Parts Control Program
MIL-STD-970	Standards and Specifications, Order of Preference for the Selection of
MIL-STD-1553	Digital Time Division Command/Response Multiplex Data Bus

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120-5099.)

2.1.2 *Other Government documents, drawings, and publications.* The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

PUBLICATIONS

NAVAL AIR SYSTEMS COMMAND

SD-8706 General Specification for Design Examinations, Engineering, Aircraft Weapons Systems

(Copies of NAVAIR publications referenced herein are available from the Commander, Naval Air Systems Command, Attn: Specifications and Standards Branch (AIR-5112), Washington, D.C. 20361-5110.)

2.2 **Order of precedence.** In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 **Constant input speed ac generator.** A generator that must receive mechanical power from a constant speed input shaft in order to supply constant frequency ac electric power. The output frequency is directly proportional to the input shaft speed.

3.2 **Constant speed drive.** A constant speed drive hydromechanically converts a variable input speed to a constant output speed.

3.3 **Converter.** A converter converts one type of electric power to another. The input power type may be ac or dc, but the output power is always dc.

3.4 **Cycloconverter.** A cycloconverter electronically converts variable frequency ac power to constant frequency ac power. Also refers to a variable input speed ac generator that incorporates a cycloconverter.

3.5 **Dc generator.** A generator that supplies dc electric power. Includes starter-generators that function as both an engine starter motor as well as a generator.

3.6 **Dc-link.** The dc bus that is internal to the type of variable input speed ac generator that consists of a brushless dc generator connected to a static inverter. Also identifies the type of variable input speed ac generator that incorporates a dc-link.

3.7 **Differential fault protection.** Differential fault protection uses two or more current sensors to measure the net current into and out of a zone of protection and detect both line-to-line and line-to-ground faults within the zone.

3.8 **Electric equipment.** Electric equipment includes electric power generation, conversion, storage, and distribution equipment, electric power control and protective devices, and motors. Electric power utilization equipment, except for motors

larger than 0.5 horsepower, is excluded.

3.9 **Integrated drive generator.** An integrated drive generator integrates a constant speed drive and a constant input speed ac generator into a single package.

3.10 **Inverter.** An inverter converts dc power to ac power. Older rotary inverters use a dc motor driving an ac generator.

3.11 **Main bus.** The main bus of a power source is the common point from which the individual load circuits branch to the individual loads.

3.12 **Power controller.** A power controller is a device that combines the circuit protection capabilities of a circuit breaker and the power switching capabilities of a relay into a single package. The device may be solid state or electromagnetic in design.

3.13 **Power source.** A power source provides electric power for distribution to utilization equipment. Examples of power sources are generators, inverters, converters, and batteries.

3.14 **Utilization equipment.** Electric power utilization equipment is that equipment which receives power from the electric power system. (See MIL-STD-704.)

3.15 **Utilization equipment terminals.** Utilization equipment input power terminals are the interface between the utilization equipment and the electric power system. Power interconnections within the utilization equipment or equipment system are excluded. (See MIL-STD-704.)

3.16 **Variable input speed ac generator.** A generator that receives mechanical power from a variable speed input shaft and supplies constant frequency ac electric power. Examples are integrated drive generators (see 3.9), dc-link (see 3.6) generators, and cycloconverters (see 3.4).

4. GENERAL REQUIREMENTS

4.1 Materials, parts and processes.

4.1.1 *Selection.* Materials, parts and processes shall be of high quality, suitable for the purpose and as specified herein. Specifications and standards used in their design, acquisition, construction and support shall be selected in accordance with MIL-STD-970.

4.1.2 *Metals.* Metals shall be corrosion-resistant or suitably treated to resist corrosion. Electrical contact between dissimilar metals shall be avoided whenever possible. Identification of dissimilar metals and the prevention of galvanic corrosion shall be in accordance with MIL-STD-889.

4.1.3 *Non-metals.* Non-metals shall be moisture and flame resistant, shall be

non-toxic, shall not support fungus growth, shall not support combustion, shall not have harmful effects when exposed to flame, shall not be adversely affected by aircraft fluids, and shall not have adverse effects on other aircraft materials. Except for consumable items such as gaskets and filters that are replaced at scheduled intervals or whenever the equipment is removed from the aircraft, non-metal parts shall remain serviceable throughout the intended service life of the equipment.

4.1.4 *Finishes, coatings and sealants.* Protective finishes, coatings and sealants shall be applied to materials in accordance with MIL-F-7179.

4.1.5 *Workmanship.* All details of workmanship shall be in accordance with high-grade aircraft electric equipment and accessory installation practices.

4.2 **Equipment.** Aircraft electric equipment (see 3.8) shall be selected as specified herein. Government-furnished equipment shall be selected when it is available and suitable for the purpose. Equipment shall complete sufficient laboratory testing to verify its flightworthiness prior to installation in aircraft. Equipment shall be qualified in accordance with the applicable equipment specification prior to deployment of production aircraft. Equipment shall be installed in accordance with the applicable equipment specification and as specified herein. Equipment shall not be used for purposes or in ways not intended by the equipment specification.

4.2.1 *Government-furnished.* Unless otherwise authorized by the procuring activity, government-furnished equipment shall not be modified and shall be installed and operated in accordance with the applicable equipment specification. Modified equipment shall be identified as such on the nameplate of the unit.

4.2.2 *Contractor-furnished.* If contractor-furnished equipment is selected, the contractor shall prepare a detail specification for the equipment in accordance with MIL-STD-961. The applicable general specification for the equipment shall be as specified herein or by the procuring activity. The complete equipment specification shall consist of the applicable general specification and the detail specification prepared by the contractor. Any exceptions to or modifications of the requirements of the general specification shall be stated explicitly in the detail specification and shall be subject to procuring activity approval. The equipment specification shall completely and precisely define the performance required of the equipment and its interface with the aircraft and the electrical system.

4.3 **Performance.** Electric equipment shall be selected and installed so that the aircraft electrical system provides electric power in accordance with MIL-STD-704 at the input terminals of all aircraft electric power utilization equipment (see 3.14).

4.4 **Identification of equipment.** Electric equipment shall be identified on the adjacent structure and on inspection covers leading to the equipment as to the name and function of the equipment. Names shall be consistent with nomenclature used in wiring diagram manuals and maintenance handbooks.

4.5 **Grounding.** Aircraft electric equipment shall be integrated into the aircraft grounding system. Equipment cases shall be bonded to aircraft structure in accordance with MIL-B-5087 to prevent isolated buildup of static charge, to assure controlled discharge of accumulated static charge, to provide lightning protection, to reduce electromagnetic interference, to assure tripping of fault protection devices when internal shorts to case occur, to avoid ground loop currents, and to keep the aircraft structure and equipment cases at a uniform electric potential.

4.5.1 *Grounding receptacles.* Grounding receptacles shall be in accordance with MIL-C-83413. Sufficient grounding receptacles shall be provided in addition to those specified in 4.5.2 to simultaneously bond the aircraft to a flight line static ground, a mobile electric power plant, and a fueler. At least one grounding receptacle shall be so located that a ground crewman can attach a static ground grounding assembly without himself touching the aircraft.

4.5.2 *Fuel nozzle grounding.* Fuel nozzle grounding during fueling shall be provided for in accordance with MIL-C-83413. Grounding receptacles shall be provided within 12 inches of each pressure fuel servicing adapter and within 42 inches of each gravity-fill fuel filler port. A minimum separation of 12 inches shall be provided between grounding receptacles and gravity-fill fuel filler ports to reduce spark hazards.

4.5.3 *Static ground.* A static grounding device shall be installed to automatically provide a discharge path for static charge upon landing. The static grounding device shall be bonded to the aircraft structure and shall make electric contact with the ground. The device shall be adjustable or replaceable to compensate for normal wear, and shall not protrude from the aircraft during flight, except on landing and takeoff, if retractable landing gear is employed.

4.5.4 *Current returns.* Each ac neutral and dc negative current return terminal shall be connected to its own current return wire. The current return wiring shall be separate from any wires used to bond equipment cases to the airframe. Wires carrying return currents from power sources of different nominal voltage or frequency shall not be electrically joined together or attached to a common terminal point. A current return wire shall not carry return currents from power sources of different nominal voltage or frequency. When aircraft structure is used as a current return path, the ground points for current return wires shall be segregated according to nominal voltage and frequency.

4.5.5 *Internally grounded equipment.* Internally grounded equipment shall not be used without procuring activity approval. The path to ground through the mounting attachment of internally grounded equipment shall remain intact and withstand any fault current resulting from an internal short to case so that the fault can be cleared by circuit protective devices in the power distribution system. The impedance of the intended ground path shall be small enough to limit stray currents to levels that do not cause electromagnetic interference or galvanic corrosion.

4.5.6 *Switchgear cases.* The cases of switchgear (relays, circuit breakers, power

controllers) having uninsulated metal cases shall be bonded to airframe ground in accordance with MIL-B-5087. The path to ground shall remain intact and withstand any fault current resulting from an internal short to case so that the fault is cleared by protective devices in the power distribution system. As an alternative, the switchgear cases shall be insulated from airframe ground to allow continued operation following an internal short to case provided that the short to case is automatically detected and reported for later maintenance action, and provided that the switchgear is enclosed in such a manner that eliminates shock hazard to personnel.

4.5.7 *Bonding.* Equipment bonding shall be in accordance with MIL-B-5087. The equipment case shall be bonded to the airframe either through its mounting or by a single bonding jumper. The equipment case to airframe bond shall not serve as a current return path for power or other electrical circuits during normal operation, however, it shall be capable of carrying the fault current from an internal short without damage to the airframe.

4.6 **Electromagnetic compatibility.** The electric system shall be in accordance with MIL-E-6051. Electric equipment shall be in accordance with MIL-STD-461 and shall be tested in accordance with MIL-STD-462.

4.6.1 *Filters.* Electric equipment shall be selected and installed to obviate the use of external filters to keep electrical noise out of electrical system power and control wiring. Filters in accordance with MIL-F-15733 shall be installed between electrical system wiring and the terminals of equipment that generates excessive electrical noise. The connecting wire between the noise-generating equipment and the filter shall be as short as practical and shall not exceed 4 inches. Filter line wiring shall be in accordance with MIL-C-85485 and shall be used in place of discrete filters when practical.

4.7 **Mounting.** Electric equipment shall be mounted in accordance with the applicable detail specification and as specified herein.

4.7.1 *Mounting hardware.* Only quick attach-detach clamps, machine screws or bolts shall be used to mount electric equipment. Coupling clamps shall be type RL (quick release with secondary safety latch) in accordance with MIL-C-27536. Threaded fasteners shall have threads in accordance with MIL-S-7742 or MIL-S-8879. Threaded fasteners shall have slotted, hexagon, crossed recessed, crossed recessed hexagon or slotted hexagon heads. Metric sizes shall not be used. Self-locking nuts in accordance with MIL-N-25027 shall be used. Plate nuts in accordance with MIL-N-25027 shall be used if the underside of the mounting is inaccessible. Nonrotating equipment mounted in racks or trays and located in protected areas may be secured with hand operated fasteners and rear holddown devices in accordance with MIL-F-85731.

4.7.2 *Mounting holes.* All wiring connector and electric equipment mounting holes shall be utilized and occupied by a screw or bolt or other approved fastener.

4.7.3 *Safetying.* Any hardware, fittings, or attached parts that are not

self-locking shall be secured in place by means of safety wiring or cotter pins in accordance with MS33540 or other means approved by the procuring activity. Adhesives, including adhesive tape, shall not be used as a primary means of securing parts without procuring activity approval, except that adhesive-backed nameplates in accordance with MIL-P-15024 may be used in protected environments for applications such as marking hermetically sealed equipment where other marking methods are impractical.

4.7.4 *Shock-mounting.* Electric equipment shall not be shock-mounted unless approved by the procuring activity. The envelope of maximum movement of the shock-mounted unit shall clear the surrounding structure by at least 0.25 inches and shall clear the envelopes of maximum movement of adjacent shock-mounted units by at least 0.50 inches. Shock-mounted units shall be mounted in the manner for which the shock mounts are designed. Cables and hoses attached to the shock-mounted unit shall be of sufficient length and flexibility to allow proper operation of the shock mounts.

4.8 **Location.** Electric equipment shall be located in accordance with the applicable detail specification and as specified herein.

4.8.1 *Clearance.* Adequate clearance shall be provided to install, service and remove equipment using ordinary hand tools, to allow adequate ventilation and to ensure that shock and vibration do not result in physical contact with other equipment, cabling, hoses or aircraft structure.

4.8.2 *Accessibility.* Electric equipment shall be located so that it is readily accessible to maintenance personnel for installation, inspection, servicing, and removal. Ready access shall involve removal of no more than one access door and one panel cover, shall not involve the use of any tools other than ordinary hand tools, and shall not require removal or disconnection of other equipment. Electric equipment mounted on engines and gearboxes shall be accessible with the engine or gearbox installed in the aircraft and all of its accessories in place. Electric equipment shall be installed so that it can be installed and removed in a direct manner without tilting, wiggling, repeated back and forth, up and down, or left and right movement, or excessive brute force to negotiate an access path that is too narrow or too serpentine. Electric equipment shall be installed so that it can be installed and removed without banging, scraping, or otherwise damaging aircraft structure, wiring, or other equipment. Electric equipment shall be installed so that sight gages, oil fill and drain ports, and points requiring occasional visual inspection can be directly viewed without using a mirror and without removing or disconnecting any equipment.

4.8.3 *Physical protection.* Electric equipment shall be located so that it is protected from physical damage that may result from abrasion, crew movements, loading and shifting of cargo, ejection of shell cases and clips, excessive ram air pressures, loading of armament and maintenance of equipment. Exposed electric power terminals shall be protected from shorts caused by loose foreign objects by insulating terminal covers or insulating wire boots. Terminal covers are preferred for power source terminals and wire boots are preferred for load equipment terminals. Equipment shall not be located below

drip points and fittings of hoses and tubes carrying fluids.

4.8.4 *Environment.* Electric equipment shall be located so that it is not exposed to environmental conditions (acceleration, dust, salt fog, aircraft fluids, temperature, altitude, temperature shock, mechanical shock, vibration, conducted and radiated electromagnetic fields, radiation, humidity, moisture, corrosive and explosive substances, fungus) for which it has not been designed or which exceed the requirements specified in the equipment's detail specification.

4.8.5 *Vulnerability.* Electric equipment and wiring shall be located to minimize the vulnerability of the electric power system as a whole to electrical faults, fire, and battle damage. Maximum advantage shall be taken of the physical shielding offered by major pieces of structure or equipment. Redundant components shall be separated to the maximum extent practical.

4.8.6 *Power panels.* Relays, busbars, and circuit protective devices shall be located inside power panels capable of containing any fire caused by an electrical fault. Separate power panels shall be provided for the power distribution equipment associated with each power source. Power distribution equipment controlling the distribution of power of different nominal voltage or frequency shall not be located in the same power panel. Where the operating power of power distribution equipment is of a different nominal voltage or frequency from that of the power being distributed, the circuit protective devices for the power distribution equipment operating power shall be located inside another power panel. The bus shall be identified on the front of the power panel and each circuit shall be identified adjacent to the corresponding circuit protective device.

4.9 **Wiring.** Selection and installation of electric power distribution wiring shall be in accordance with MIL-W-5088.

4.9.1 *Power feeder size.* Power source feeders shall be derated in accordance with MIL-W-5088 and sized for the rated capacity of the power source.

4.9.2 *Overcurrent protection.* All power distribution wiring shall be protected against overcurrent damage from overloads and faults. Circuit protective devices shall be located no farther than one foot of wire length from the point of power takeoff for every power distribution circuit, including bus ties and other feeders. Bidirectional feeders shall have circuit protective devices at both ends. Differential fault protection (see 3.7) shall be provided for generator feeders.

4.9.3 *Wire routing.* Power distribution wiring carrying power from different power sources or of different nominal voltage or frequency shall be separated a minimum of three inches and shall not be bundled or routed together. Three-phase ac power distribution wiring carrying power from the same power source shall be bundled together. Dc and single-phase ac power distribution wiring shall be bundled with its current return (negative or neutral) wire or shall be routed as closely as practical to its primary current return path through the aircraft structure.

4.10 **Point of regulation.** The point of regulation for a regulated power source shall be located as near as practicable to its main bus (see 3.11). The main bus shall be centrally located with respect to its connected loads to minimize voltage drops in individual load circuits. The neutral or negative or ground reference sensing input to the voltage regulation circuit shall be connected to the single-point ground associated with the main bus or to a ground point centrally located with respect to the connected loads.

4.11 **Inspections.** The contractor shall be responsible for performing inspections to verify that aircraft electric equipment have been selected and installed in accordance with this standard. Inspections of aircraft mockups, first aircraft, production aircraft, and aircraft modifications shall be performed by the contractor under supervision of the Government inspector. The aircraft shall be made available for inspection at all stages of assembly to allow inspection of installation features that are hidden or difficult to access when assembly is complete. The Government inspector shall determine at what stages of assembly to conduct inspections.

5. DETAILED REQUIREMENTS

5.1 **Ac generators.** Variable input speed ac generators (see 3.16) shall be in accordance with MIL-E-85583. Constant input speed ac generators (see 3.1) shall be in accordance with MIL-G-21480. All generator control and voltage regulation circuitry shall be contained within the generator package. Multipackage generator systems with a separately packaged constant speed drive (see 3.2), generator control panel, voltage regulator, inverter, output transformer, or cycloconverter (see 3.4) shall not be used without procuring activity approval. If a multipackage system is used, the separate components shall be located as closely together as practical. Interconnecting wiring shall be as short as practical, shall not be bundled with other wiring, and shall be installed so that it can be readily removed and replaced without disturbing other aircraft wiring.

5.2 **Dc generators.** Dc generators (see 3.5) shall be in accordance with MIL-G-6162 and incorporate generator control and voltage regulation circuitry in accordance with MIL-R-23761/1. High voltage (270 volt) dc generators shall not be used without procuring activity approval. Requirements for 270 volt dc generators shall be as provided by the procuring activity.

5.3 **Motors.** Ac motors shall be three-phase motors in accordance with MIL-M-7969. Dc motors shall be in accordance with MIL-M-8609. Motor starting current shall not exceed the five-second overload rating of the generator that powers it. Motor starting current shall be determined with the motor at 77°F (25°C) and the voltage applied at the input terminals of the motor maintained at nominal voltage and frequency. The measurement shall be corrected for any voltage sag at the motor input terminals by multiplying the measured current by the ratio of the nominal voltage to the actual voltage. The starting current of motors that can start simultaneously shall be summed together when applying this requirement. This paragraph is applicable to motors that are rated at greater than 500 volt-amperes or 500 watts input power or 0.5 horsepower output power.

5.4 **Converters and inverters.** Converters (see 3.3) shall be in accordance with MIL-C-7115. Inverters (see 3.10) shall be in accordance with MIL-I-7032 or MIL-I-85071. Power conversion equipment that converts to or from 270 volt dc power shall not be used without procuring activity approval. Requirements for 270 volt dc power conversion equipment shall be as provided by the procuring activity.

5.5 **Batteries.** Batteries shall be in accordance with MIL-B-8565 or MIL-B-81757. A battery relay control unit in accordance with MIL-B-85584 shall be installed for each battery to prevent complete discharge of the battery during ground operations when battery charging is unavailable. The battery relay control unit installation shall be such that the battery is not disconnected if either battery charging is available or the aircraft is in flight.

5.6 **External power circuits.** At least one external power circuit shall be provided for supplying electric power to the aircraft during ground operations. Each circuit shall include one receptacle, one contactor, one monitor, and one or two control switches. Electrical interconnections between the external power receptacle, monitor, contactor, and control switches shall be in accordance with the installation circuit diagrams of MIL-E-24021. The installation shall not allow the external power monitor to be reset automatically or more than once in response to one operation of a control switch (see 5.17.2). No provision shall be made for 270 volt dc external power without procuring activity approval. Any 270 volt dc power requirement during ground operations shall be supplied by ac-to-dc converters installed on the aircraft.

5.7 **External power contactors.** External power contactors shall be in accordance with MIL-R-6106. The external power receptacle shall be connected to normally open contacts of the contactor. Power connections between the contactor and the aircraft bus shall be arranged so that voltage from onboard power sources cannot be present at the external power receptacle if the external power contactor fails in the closed position.

5.8 **External power monitors.** External power monitors shall be in accordance with MIL-E-24021. Requirements for 270 volt dc external power receptacles and 270 volt dc external power monitors shall be as provided by the procuring activity. An external power monitor shall be installed for each external power receptacle, except that a power monitor is not required for a receptacle that supplies power only to an electric engine starter. The voltage sensing inputs of the power monitor shall be connected to the terminals of the external power receptacle. The connecting wire shall be either #20 AWG copper wire not exceeding 16 feet in length, or #22 AWG copper wire not exceeding 10 feet in length, to ensure a low impedance connection.

5.8.1 *External power monitors for 115/200 volts ac.* An external power monitor shall be installed for every 115/200 volt ac power receptacle. An M24021-3 power monitor shall be used with a dc-operated external power contactor and an M24021-5 power monitor shall be used with an ac-operated contactor.

5.8.2 *External power monitors for 28 volts dc.* An M24021-6 power monitor shall be installed for every 28 volt dc power receptacle that supplies power to utilization equipment. When a 28 volt dc receptacle supplies power to an electric engine starter as well as utilization equipment, pins C and E of the M24021-6 power monitor shall be used in accordance with MIL-E-24021 to inhibit tripping of the power monitor during the engine start. The start inhibit voltage shall be applied to pin C or pin E but not both at the same time. On a two engine aircraft, pin C may be used for one engine and pin E may be used for the other engine. The start inhibit voltage shall be applied between 0.2 and 2.0 seconds before the start and shall be removed no later than 2.0 seconds after the start. Start inhibit voltage shall not be applied to either pin when an engine start is not in progress.

5.9 **External power receptacles.** External power receptacles shall be in accordance with MIL-C-81790. Receptacles shall be located where they are accessible to maintenance personnel standing on the ground and where hazards to personnel from engine operation and fuel vent overflow are minimized. Receptacles that may be powered by the same power cart shall be separated by no more than five feet and, where feasible, shall be located behind the same access door. Receptacles shall be located where equipment and other access doors when open do not impede access to the receptacles and attached power cords. Access doors shall be hinged along the prevailing windward edge, normally the forward edge for fixed wing aircraft and the upper edge for helicopters. The access door shall be secured in the closed position by spring loading or by quick release fasteners. Receptacles shall not be located in wheel wells or bomb bays. Receptacles installed on vertical surfaces shall be oriented with the long edge aligned up and down and the small pins down. Receptacles installed on horizontal surfaces shall be oriented with the long edge aligned fore and aft and the small pins aft. Only the hardware supplied with the receptacle shall be used to secure wiring to the receptacle terminals.

5.9.1 *Marking and identification.* Receptacles shall be identified as "External Power Receptacle", and with the type of power, either "400 hertz, 115/200 volts ac" or "28 volts dc". When more than one ac receptacle or more than one dc receptacle is used, they shall be differentiated according to function: For example, "Bus 1", "Bus 2", "Engine Starting". The complete identification shall be marked on the access door, and also adjacent to the receptacle when more than one receptacle is located behind the same access door.

5.9.2 *External power receptacles for 115/200 volts ac.* External power receptacles for 115/200 volt ac power shall be in accordance with MS90362. An MS90362-4 receptacle assembly with shield and terminal cover shall be used. The MS3501-1 terminal cover may be omitted subject to procuring activity approval if a satisfactory alternate means is provided of protecting against shock hazard to personnel. The MS17845-1 shield may be omitted subject to procuring activity approval if a satisfactory alternate means is provided of preventing contact misalignment and relieving shear stress on the receptacle's pin contacts. Unshielded receptacles shall be separated by at least 2.5 inches measured center-to-center of the pins.

5.9.3 *External power receptacles for 28 volts dc.* External power receptacles for 28 volt dc power shall be in accordance with MS3506.

5.9.4 *External power receptacles for engine starting.* A separate external power receptacle for engine starting shall be provided if necessary to ensure that 28 volt dc power supplied to other utilization equipment is in accordance with MIL-STD-704 during the engine starting operation. External power receptacles for type E-3 and type E-4 electric engine starters conforming to MIL-S-7780 shall be in accordance with MS25018. External power receptacles for all other types of electric engine starters that are designed to utilize 28 volt dc power in accordance with MIL-STD-704, including type E-5 starters conforming to MIL-S-7780 and starters conforming to MIL-S-6150, shall be in accordance with MS3506. Receptacles conforming to MS25018 mate with plugs of power carts that supply dc power that does not conform to MIL-STD-704. Receptacles conforming to MS3506 mate only with plug connectors of power carts that supply 28 volt dc power conforming to MIL-STD-704. Utilization equipment designed to utilize 28 volt dc power conforming to MIL-STD-704 shall not be connected to circuits that may be supplied power via a receptacle conforming to MS25018.

5.10 **Utility receptacles.** Utility receptacles shall be in accordance with MIL-C-5015. Each receptacle shall be labelled as a "Utility Receptacle", with type of power and amperage rating. Wiring to each utility receptacle shall be protected in the same manner as other aircraft wiring (see 5.13). A protective cover in accordance with MS25043 shall be provided for each utility receptacle and shall be permanently attached by its retaining chain to nearby structure. Utility receptacle connector shells shall be class R bonded in accordance with MIL-B-5087 to the aircraft structure and shall provide a low impedance path between airframe ground and the shell of the mated plug connector.

5.10.1 *Utility receptacles for 115/200 volts ac.* Utility receptacles for 115/200 volts ac shall mate with an MS3456W 20-4P plug connector. Contact assignment shall be as follows: A - phase A; B - phase B; C - phase C; D - neutral.

5.10.2 *Utility receptacles for 28 volts dc.* Utility receptacles for 28 volts dc shall mate with an MS3456W 16-11P plug connector. Contact assignment shall be as follows: A - negative (0 volts); B - positive (+28 volts).

5.10.3 *Utility receptacles for 270 volts dc.* Utility receptacles for 270 volts dc rated at 10 amperes or less shall mate with an MS3456W 18-22P plug connector. Utility receptacles for 270 volts dc rated at more than 10 amperes shall mate with an MS3456W 20-3P plug connector. Contact assignment shall be as follows: A - negative (0 volts); B - positive (+270 volts); C - case ground.

5.11 **Multiplexing.** Electric equipment utilizing multiplexed data communications shall have dual redundant interfaces in accordance with MIL-STD-1553 or shall be as specified in the aircraft specification.

5.12 **Relays.** Relays used for switching electrical power shall be in accordance

with MIL-R-6106. Reverse current cutout relays that are otherwise in accordance with MIL-C-5026 may be used provided they are modified to isolate the case from the internal electrical circuits and provide an additional terminal to serve as the control current return path. Dc-operated relays shall incorporate voltage transient suppression to limit the absolute magnitude of the reverse voltage (back emf) generated by the coil to 150% of the nominal voltage. Ac-operated relays shall use full-wave rectification to provide the coil operating power. Relays shall be located within power panels (see 4.8.6).

5.13 **Circuit protective devices.** Circuit protective devices shall be installed to prevent damage to aircraft wiring, wire insulation, and electric power distribution equipment from overloads and faults. They shall be installed at the power source end (both ends of bidirectional bus tie feeders) of circuits with no more than one foot of wire between the point of power takeoff and the circuit protective device. Circuits shall be individually protected. Circuit protective devices shall have current interrupting capacities that exceed the maximum available fault current into the circuit being protected. Circuit protective devices shall not open grounded conductors such as ac neutrals and dc negative returns. Circuit protective devices for three-phase ac circuits shall be three-phase devices. Circuit protective devices include power controllers, circuit breakers, and fuses. Circuit protection can also be implemented by integrating overcurrent sensing into relay control circuits. Circuit protective devices shall be located within power panels (see 4.8.6) and grouped and arranged according to circuit function. Space shall be provided in power panels for the installation of at least one additional circuit protective device for each group of ten or fraction thereof installed. The space for spare circuit protective devices shall be determined by the equipment and circuit data available at the aircraft electrical system critical design review.

5.13.1 *Power controllers.* Power controllers (see 3.12) shall be in accordance with MIL-P-81653. Mounting plates for solid state power controllers shall have sufficient heat sink and dissipation capacity to support all the power controllers mounted thereon when each power controller is carrying its full rated current. Empty positions reserved for future growth shall be clearly marked as to the maximum power controller rating allowed.

5.13.2 *Circuit breakers.* Circuit breakers shall be in accordance with MIL-C-5809 or MIL-C-83383. Circuit breakers shall not be used as switches unless they have been designed for use as switches. A switch or relay shall be connected in series with the circuit breaker when a switching capability is required for a circuit protected by a circuit breaker. Toggle circuit breakers shall be oriented so that the circuit is open when the handle is in the down or rear position, as perceived by the operator.

5.13.3 *Fuses.* Fuses shall not be used as the primary overcurrent protection device for a circuit without the approval of the procuring activity. Fuses used for short-circuit protection of major power feeders and load circuits shall be current limiter type fuses in accordance with MIL-F-5372, and shall be installed in fuseholders in accordance with MIL-F-5373. Fuses used for overload protection of individual load circuits shall be in accordance with MIL-F-15160, and shall be installed in fuseholders in accordance with

either MIL-F-19207 or MIL-F-21346. The fuse rating and part number shall be plainly marked adjacent to the fuseholder and shall be readable with the fuse in place. Fuseholders shall be so located that checking and replacement of fuses can be easily accomplished.

5.14 **Switches.** Switch orientation shall be in accordance with MIL-STD-203 for fixed wing aircraft and MIL-STD-250 for rotary wing aircraft.

5.14.1 *Toggle switches.* Toggle switches shall be in accordance with MIL-S-3950, MIL-S-8834, or MIL-S-81551. Lever-lock toggle switches shall be used when positive locking is required to prevent inadvertent operation of critical or hazardous circuits. Toggle switches shall be accessible for operation in flight, except for switches used only during ground operations. Switches that are essential for flight shall be easily operable by the appropriate crewman with seat belt fastened and shoulder harness locked.

5.14.2 *Switch guards.* Switch guards used with toggle switches to prevent accidental operation shall be in accordance with MIL-G-7703. Switch guards shall be installed so that they prevent accidental operation of the switches to any other than the desired position. Switches that are to be used with switch guards shall be installed so that when the guard is installed and closed, it does not exert force on the toggle lever.

5.14.3 *Limit and pushbutton switches.* Limit and pushbutton switches shall be in accordance with MIL-S-8805 or MIL-S-22885. Limit and pushbutton switches shall not be adapted from any switch designed for toggle operation. Limit switch adjustment shall have a positive lock and adjustment, be readily accessible, and not require special tools for servicing. The assembly shall be sufficiently rigid to prevent rough service handling from misaligning the adjustment. The installation shall also be sufficiently rigid to prevent misoperation owing to flexure of structure or relative motion between the switch actuator and striker. The bending of a tab to adjust a limit switch is not satisfactory. Limit switches used on exposed landing-gear-control and landing-gear-warning systems shall be sealed limit switches.

5.14.4 *Rotary switches.* Rotary switches shall be in accordance with MIL-S-6807. Rotary switches shall be installed so that the extreme counterclockwise position is the "OFF" position, and so that the switch case cannot rotate with respect to the mounting panel.

5.14.5 *Additional switch space.* Space shall be provided on each switch panel containing four or more switches for the subsequent installation of two spare switches. The space for spare switches will be determined by the equipment and circuit data available at the aircraft electrical system critical design review.

5.15 **Meters.** Analog ac and dc meters, such as ammeters, voltmeters, watt-var meters, and frequency meters, with moving arm displays shall be in accordance with MIL-A-6752, MIL-V-6753, or MIL-F-8378. Meters with digital displays, including those in accordance with MIL-V-85603, or whose outputs are displayed on multifunction cockpit

displays are also acceptable.

5.16 **Shunts.** Shunts for ammeters shall be in accordance with MIL-S-61. Shunts in dc systems shall be installed in the negative (zero volts) current return path. Shunt terminals shall not be used as terminal blocks.

5.17 **Controls and displays.** Controls and displays shall be located, oriented and installed in accordance with MIL-STD-203 for fixed wing aircraft and MIL-STD-250 for rotary wing aircraft. Controls and displays shall allow the crew to manually override the automatic operation of the electrical system, however, the electrical system shall be designed for fully automatic operation and reconfiguration in response to faults with all controls placed in the ON position. As a minimum, controls and displays shall include the following.

5.17.1 *Generator control switches.* A separate control switch shall be provided for each generator. Separate control switches shall also be provided for each output of a generator that has multiple outputs that are independently regulated or are produced by separate windings. A separate control switch is not required for an output that is primarily used to operate contactors and relays. A control switch is not required for an output dedicated to flight critical systems requiring uninterrupted power. Generator control switches shall be two-position toggle switches with ON (up) and OFF (down) positions. Generator control switches shall be located in the cockpit. The generator shall be connected automatically to its bus when its control switch is in the ON position and the generator is ready to provide power to the bus. Cycling the control switch from ON to OFF to ON shall reset the generator if it has tripped on a manually resettable protective function.

5.17.2 *External power control switches.* Control switches shall be provided for each external power receptacle. The primary control switch shall be located in the cockpit for use by the aircrew both to reset the power monitor and to disconnect external power from the aircraft buses. The secondary control switch shall be located adjacent to the external power receptacle for use by the ground crew to reset the power monitor. Placing the primary control switch in the OFF position shall disconnect external power from the aircraft buses by opening the external power contactor. Holding either control switch in the RESET position shall reset the external power monitor by connecting its reset input pin to ground. Placing the primary control switch in the NORM position shall allow the external power monitor to control the external power contactor. The secondary control switch may be omitted if the ground crew can use the primary control switch to reset the power monitor while coordinating with the operator of the external power source. The primary control switch shall be a two-pole three-position toggle switch with RESET (momentary up), NORM (center) and OFF (down) positions. The RESET position shall be momentary with spring return to the NORM position when released. The first pole shall be connected in series with the external power contactor coil and shall be open in the OFF position and closed in the RESET and NORM positions. The second pole shall be connected as a shunt from the reset input pin of the external power monitor to ground, and shall be open in the NORM and OFF positions and closed in the RESET position.

The secondary control switch shall be a spring loaded one-pole two-position toggle or pushbutton switch with a momentary RESET position. The RESET position shall be up for a toggle switch and depressed for a pushbutton switch. The pole shall be connected in parallel with the second pole of the primary control switch as a shunt from the reset input pin of the external power monitor to ground, and shall be closed in the RESET position. A control switch shall not latch in the RESET position and shall remain in the RESET position only as long as it is held in that position by an operator.

5.17.3 *Battery control switch.* A battery control switch shall be provided if one or more batteries are used during ground operations when neither onboard generated power nor external power is available to prevent discharge of the batteries. The switch shall be a two-position toggle switch with ON (up) and OFF (down) positions. The switch shall be located in the cockpit. The batteries shall be disconnected from the bus when the switch is in the OFF position. The batteries shall be connected to the bus when the switch is in the ON position, unless the battery relay control unit has acted to disconnect the batteries. Cycling the switch from ON to OFF to ON shall reset the battery relay control unit.

5.17.4 *Generator warning lights.* A separate generator warning light shall be provided for each generator. A separate warning light shall also be provided for each generator output that has a separate control switch. The generator warning light shall be illuminated whenever the generator is not powering its primary bus, and shall be off when the generator is powering its bus. The generator warning light shall be located adjacent to the corresponding generator control switch. The control switches and warning lights shall be arranged so that it is clear which control switch corresponds to which warning light. As an alternative, the generator warning light function can be implemented with appropriate advisory messages on a multifunction cockpit display. If a generator warning light is not provided adjacent to the generator control switch, then a means shall be provided of resetting the tripped generator without operating the generator control switch. The reset mechanism shall be designed to eliminate the possibility of inadvertently turning off the wrong generator. Messages on cockpit displays shall be tailored to indicate the reason the generator is off line, such as the generator has failed, the generator line contactor has failed to close, the generator has been manually switched off, or the generator input shaft has not reached its operating speed range.

5.17.5 *External power ready light.* An external power ready light shall be provided to indicate that aircraft buses will be transferred to external power if onboard generators are turned off. The external power ready light shall be illuminated if acceptable external power is available and the external power monitor has been manually reset and the external power contactor has closed. As an alternative, the external power ready light function can be implemented on a multifunction cockpit display.

5.17.6 *Flight critical equipment.* Circuit protective devices for flight critical equipment shall be resettable by the pilot. Manually resettable circuit protective devices for flight critical equipment shall be located in power panels in the cockpit. Remotely resettable circuit protective devices for flight critical equipment shall be resettable via

controls located in the cockpit.

5.18 **Solenoids.** Solenoids shall be rated for continuous duty and in accordance with MIL-S-4040.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 **Intended use.** Electric equipment covered by this standard are intended for use on military aircraft as components of the electric power generation and distribution system. These do not include engines, auxiliary power units, or gearboxes that drive generators, but do include the generator systems mounted thereon. A constant speed drive is considered to be a part of an ac generating system. The electric power distribution system extends up to the input terminals of the electric power utilization equipment, but does not include the electric power utilization equipment. However, motors larger than 0.5 horsepower have been included as electric equipment because of their significant impact on the performance of the electric power system.

6.2 **Tailoring guidance.** This standard should be applied as a whole by including the statement *"Selection and installation of electric equipment shall be in accordance with MIL-STD-7080."* in the aircraft specification cited by invitations for bids, requests for proposals, and contractual statements of work. Tailoring of its requirements should be accomplished by listing specific deviations, waivers, and changes that have been approved by the procuring activity. Specific requirements for design analyses, examinations, development tests, demonstration tests, and acceptance tests to be performed to verify compliance with this standard should be included in the applicable aircraft specification. For Navy aircraft, these requirements are found in SD-8706, MIL-D-8708 (or MIL-D-23222 for rotary wing aircraft), and MIL-M-8650. For Air Force aircraft, these requirements are found in MIL-E-87219, MIL-M-25500, and MIL-F-25381. The procuring activity should also designate a Government inspector to supervise the contractor's inspections of the electric equipment installation.

6.3 **Government inspectors.** Navy and other procuring activities needing the services of a Government electrical inspector should write to the Naval Air Warfare Center Aircraft Division (SY60), Patuxent River, Maryland 20670 or telephone the same at (301) 826-4161 or autovon 326-4161.

6.4 **Subject term (key word) listing.**

Ac
Battery
Converter
Dc
Electric power

Electrical inspector
External power monitor
Generator
Inverter
Motor
Power distribution
Wiring

6.5 **Changes from previous issue.** Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Preparing activity:
Navy - AS

(Project GDRQ-0139)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1,2,3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4,5,6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE *(YYMMDD)*
	MIL-STD-7080	940531

3. DOCUMENT TITLE
Selection and Installation of Aircraft Electric Equipment

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)*	
	(1) Commercial (301) 826-4161/4433	(2) AUTOVON 326-4161/4433
c. ADDRESS *(Include Zip Code)* Naval Air Warfare Center Aircraft Division Code SY60, Building 1461, Re: MIL-STD-7080 Patuxent River, Maryland 20670	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340	