INTERNATIONAL

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Standard Practice for Inspection of ~~Airplane~~Aircraft Electrical Wiring Systems[1]

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1. Scope

1.1 This practice covers basic inspection procedures for electrical wiring interconnect systems for ~~normal and utility category~~ aircraft electrical wiring systems.

1.2 This practice is not intended to replace any instructions for continued airworthiness published by the aircraft or accessory manufacturer or type design holder.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *Military Standard:*[2]

MIL-C-85049 Connector Accessories, Electrical, General Specification for

2.2 *FAA Guidance Material:*[3]

FAA Advisory Circular 33.4-3 Instructions for Continued Airworthiness; Aircraft Engine High Intensity Radiated Fields (HIRF) and Lightning Protection Features

2.3 *SAE Documents:*[4]

SAE ARP1870 Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety

SAE Aerospace ARP5583 Guide to Certification of Aircraft in a High Intensity Radiated Field (Hirf) Environment

3. Terminology

3.1 *Acronyms:*

3.1.1 *EWIS*—electrical wiring interconnection system

3.1.2 *HIRF*—high-intensity radiated fields

3.1.3 *ICA*—instructions for continued airworthiness

3.1.4 *LRU*—line-replaceable unit

3.1.5 *MS*—military standard

3.1.6 *MTBF*—mean time between failures

3.1.7 *PTFE*—polytetrafluoroethylene

3.1.8 *RF*—radio frequency

3.1.9 *STC*—supplemental type certificate (Federal Aviation Administration)

[1] This practice is under the jurisdiction of ASTM Committee F39 on ~~Normal and Utility Category Airplane Electrical Wiring~~ Aircraft Systems and is the direct responsibility of Subcommittee F39.02 on Inspection, Maintenance, and Repair.

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[2] Available from the U.S. Government Printing Office, Superintendent of Documents, Stop: SSOP, Washington, DC 20402-0001.

[3] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

4. Significance and Use

4.1 The term "electrical system" as used in this practice means those parts of the aircraft that generate, distribute, and use electrical energy, including their support and attachments.

4.2 The satisfactory performance of an aircraft is dependent upon the continued reliability of the electrical system.

4.3 Damaged wiring or equipment in an aircraft, regardless of how minor it may appear to be, cannot be tolerated. It is, therefore, important that maintenance be accomplished using the best techniques and practices to minimize the possibility of failure.

4.4 When inspecting and evaluating EWIS, improper wiring, routing, or repairs shall be corrected regardless of the origin of the error.

4.5 This practice is not intended to supersede or replace any government specification or specific manufacturer's instruction regarding electrical system inspection and repair

5. Causes of Wire Degradation

5.1 The following are considered the principal causes of wiring degradation and should be used to help focus maintenance programs:

5.1.1 *Vibration*—High-vibration areas tend to accelerate degradation over time resulting in "chattering" contacts and intermittent symptoms. High vibration of tie-wraps or string ties can cause damage to insulation. In addition, high vibration will exacerbate any existing wire insulation cracking.

5.1.2 *Moisture*—High-moisture areas generally accelerate corrosion of terminals, pins, sockets, and conductors. Note that wiring installed in clean, dry areas with moderate temperatures appears to hold up well.

5.1.3 *Maintenance*—Scheduled and unscheduled maintenance activities, if done improperly, may contribute to long-term problems and degradation of wiring. Metal shavings and debris have been discovered on wire bundles after maintenance, repair, or alteration work has been performed. Extra attention shall be given to EWIS inspections around areas of previous aircraft maintenance, repair, or alterations.

5.1.4 *Repair*—Since wire splices are more susceptible to degradation, arcing, and overheating, extra care shall be given when inspecting repaired wiring.

5.1.5 *Alterations*—Alterations introduce another area for enhanced scrutiny for similar reasons as repairs. In addition, an alteration may not be documented in the aircraft Instructions for Continued Airworthiness and therefore need independent inspection and a concern for proper wiring, attachments, mounting, and wiring routing.

5.1.6 *Indirect Damage*—Events such as pneumatic duct ruptures or duct clamp leakage can cause damage that, while not initially evident, can later cause wiring problems. When events such as these occur, surrounding EWIS shall be carefully inspected to ensure that there is no damage or potential for damage evident. Indirect damage caused by these types of events may be broken clamps or ties, broken wire insulation, or even broken conductor strands. In some cases, the pressure of the duct rupture may cause wire separation from the connector or terminal strip.

6. Procedure

6.1 *Inspection and Operation Checks*—Inspect equipment, electrical assemblies, and wiring installations for damage, general condition, and proper functioning to ensure the continued satisfactory operation of the electrical system. Adjust, repair, overhaul, and test electrical equipment and systems in accordance with the recommendations and procedures in the aircraft or component manufacturer's maintenance instructions or both. Replace components of the electrical system that are damaged or defective with identical parts, aircraft manufacturer's approved equipment, or its equivalent to the original in operating characteristics, mechanical strength, and environmental specifications. A list of suggested problems to look for and checks to be performed are:

6.1.1 Damaged, discolored, or overheated equipment, connections, wiring, and installations;

6.1.2 Excessive heat or discoloration at high-current-carrying connections;

6.1.3 Misalignment of electrically driven equipment;

6.1.4 Poor electrical bonding (broken, disconnected, or corroded bonding strap) and grounding, including evidence of corrosion;

6.1.5 Dirty equipment and connections;

6.1.6 Improper, broken, inadequately supported wiring and conduit, loose connections of terminals, and loose ferrules;

6.1.7 Poor mechanical or cold solder joints;

6.1.8 Condition of circuit breaker and fuses;

6.1.9 Insufficient clearance between exposed current-carrying parts and ground or poor insulation of exposed terminals;

6.1.10 Broken or missing safety wire, broken bundle lacing, cotter pins, and so forth;

6.1.11 Operational check of electrically operated equipment such as motors, inverters, generators, batteries, lights, protective devices, and so forth;

6.1.12 Condition of electric lamps; and

6.1.13 Missing safety shields on exposed high-voltage terminals (that is, 115/200 V ac).

6.2 *Functional Check of Standby or Emergency Equipment*—An aircraft should have functional tests performed at regular intervals as prescribed by the manufacturer.

6.3 *Bus Bars*—Annually check bus bars for general condition, cleanliness, and security of all attachments and terminals. Grease, corrosion, or dirt on any electrical junction may cause the connections to overheat and eventually fail. Bus bars that exhibit corrosion, even in limited amounts, shall be disassembled, cleaned and brightened, and reinstalled.

6.4 *Generating System*—Inspect generator(s)/alternator(s) for general condition, cleanliness, and security of attachment and terminals. Any sign of overheating terminals or wiring is reason for rejection. Inspect drive belts for condition and wear. Replace any belt showing signs of abnormal wear or overheating. Inspect brushes for proper condition and wear patterns. Inspect brush holders for condition and signs of arcing or overheating. Inspect voltage regulation components and wiring for condition and security. Inspect generator(s)/alternator(s) warning system for condition and operation.

6.5 *Battery Inspection*—Battery inspection procedures vary with the types of chemical technology and physical construction. Always follow the battery manufacturer's approved procedures. Battery performance at any time in a given application will depend upon the battery's age, state of health, state of charge, and mechanical integrity.

6.5.1 *Aircraft Battery Inspection:*

6.5.1.1 Inspect battery sump jar (if installed) and lines for condition and security.

6.5.1.2 Inspect battery terminals and quick-disconnect plugs and pins for evidence of corrosion, pitting, arcing, and burns. Clean as required. Inspect battery cables for condition and signs of chafing.

6.5.1.3 Inspect battery drain and vent lines for restriction, deterioration, and security. Battery drain areas shall be checked for signs of structure corrosion.

6.5.1.4 Routine preflight and postflight inspection procedures shall include observation for evidence of physical damage, loose connections, and electrolyte loss.

6.5.1.5 Perform capacity performance test of battery per manufacturer's instructions to ensure continued airworthiness.

6.5.1.6 Inspect battery warning system components (if installed) for condition and operation.

6.5.1.7 For nickel-cadmium battery installations, inspect battery temperature sensing, over-temperature warning, and battery failure-sensing systems for proper operation. Inspect the means for disconnecting the battery(ies) for the charging source in the event of an over-temperature condition.

6.6 *Emergency Power Supply/Battery Inspection:*

6.6.1 Emergency power supplies or batteries shall be inspected and functionally tested per the manufacturer instructions.

6.6.2 Perform capacity performance tests of batteries per manufacturer's instructions to ensure continued airworthiness.

6.6.3 Inspect installations for condition, security, and routing of wiring.

6.7 *Electrical Switch Inspection:*

6.7.1 Special attention should be given to electrical circuit switches, especially the spring-loaded type, during the course of normal airworthiness inspection. An internal failure of the spring-loaded type may allow the switch to remain closed even though the toggle or button returns to the OFF position. During inspection, attention should also be given to the possibility that an unapproved switch substitution may have been made.

6.7.1.1 With the power off, suspect aircraft electrical switches should be checked in the ON position for opens (high resistance) and in the OFF position for shorts (low resistance) with an ohmmeter. A power-on check can be made by checking the voltage drop across the switch. A voltage drop across the switch indicates abnormal internal resistance of the switch contacts.

6.7.1.2 Any abnormal side-to-side movement of the switch should be an alert to imminent failure even if the switch tested was shown to be acceptable with an ohmmeter.

6.7.1.3 When a switch is activated, it should have a noticeable detent feel when switched. If a switch does not have a detent feel when switching, it is suspect and further inspection shall be done before considering it airworthy. Any switch with a soft or spongy feel when switched shall be replaced.

6.7.1.4 Each installed switch shall be labeled to indicate its operation and the circuit controlled.

6.8 *Wires, Cables, and Clamps*—Wires and cables shall be inspected for adequacy of support, protection, and general condition throughout. The desirable and undesirable features in aircraft wiring installations are listed in the following and indicate conditions that may or may not exist. Accordingly, aircraft wiring shall be visually inspected for the following requirements. (**Warning—**For personal safety and to avoid the possibility of fire, turn off all electrical power before starting an inspection or performing maintenance of the aircraft electrical system.)

6.8.1 Wires and cables are supported by suitable clamps, grommets, or other devices at intervals of not more than 24 in. (61 cm), except when contained in troughs, ducts, or conduits. The supporting devices shall be of a suitable size and type with the wires and cables held securely in place without damage to the insulation. Inspect wire and cable clamps for proper tightness. Where cables pass through structure or bulkheads, inspect for proper clamping and grommets. Inspect for sufficient slack between the last clamp and the electronic equipment to prevent strain at the cable terminals and to minimize adverse effects on shock-mounted equipment.

6.8.2 Mechanical standoffs shall be used to maintain clearance between wires and structure. Using tape or tubing is not acceptable as an alternative to standoffs for maintaining clearance.

6.8.3 Phenolic blocks, plastic liners, or rubber grommets are installed in holes, bulkheads, floors, or structural members where it is impossible to install off-angle clamps to maintain wiring separation. Inspect the EWIS to ensure separation between the wire and the hole, bulkhead, floor, or structural member.

6.8.4 Wires and cables in junction boxes, panels, and bundles are properly supported and laced to provide proper grouping and routing.

6.8.5 Clamp-retaining screws are properly secured so that the movement of wires and cables is restricted to the span between the points of support and not on soldered or mechanical connections at terminal posts or connectors.

6.8.6 Wire and cables are properly supported and bound so that there is no interference with other wires, cables, and equipment.

6.8.7 Wires and cables are adequately supported to prevent excessive movement in areas of high vibration.

6.8.8 Insulating tubing is secured by tying, tie straps, or with clamps.

6.8.9 Continuous lacing (spaced 6 in. (15 cm) apart) is not used except in panels and junction boxes where this practice is optional. When lacing is installed in this manner, outside of junction boxes, it shall be removed and replaced with individual loops.

6.8.10 Do not use tapes (such as friction or plastic tape) that will dry out in service, produce chemical reactions with wire or cable insulation, or absorb moisture.

6.8.11 Insulating tubing shall be kept at a minimum and shall be used to protect wire and cable from abrasion, chafing, exposure to fluid, and other conditions that could affect the cable insulation. However, the use of insulating tubing for support of wires and cable in lieu of standoffs is prohibited.

6.8.12 Do not use moisture-absorbent material as "fill" for clamps or adapters.

6.8.13 Ensure that wires and cables are not tied or fastened together in conduit or insulating tubing.

6.8.14 Ensure cable supports do not restrict the wires or cables in such a manner as to interfere with operation of equipment shock mounts.

6.8.15 Do not use tape, tie straps, or cord for primary support.

6.8.16 Ensure that drain holes are present in drip loops or in the lowest portion of tubing placed over the wiring.

6.8.17 Ensure that wires and cables are routed in such a manner that chafing will not occur against the airframe or other components.

6.8.18 Ensure that wires and cables are positioned in such a manner that they are not likely to be used as handholds or as support for personal belongings and equipment.

6.8.19 Ensure that wires and cables are routed, insofar as practicable, so that they are not exposed to damage by personnel moving within the aircraft.

6.8.20 Ensure that wires and cables are located so as not to be susceptible to damage by the storage or shifting of cargo.

6.8.21 Ensure that wires and cables are routed so that there is not a possibility of damage from battery electrolytes or other corrosive fluids.

6.8.22 Ensure that wires and cables are adequately protected in wheel wells and other areas in which they may be exposed to damage from impact of rocks, ice, mud, and so forth. (If rerouting of wires or cables is not practical, protective jacketing may be installed.) This type of installation shall be held to a minimum.

6.8.23 Where practical, route electrical wires and cables above fluid lines and provide a 6-in. (15-cm) separation from any flammable liquid, fuel, or oxygen line, fuel tank wall, or other low-voltage wiring that enters a fuel tank and requires electrical isolation to prevent an ignition hazard. Where 6-in. (15-cm) spacing cannot practically be provided, a minimum of 2 in. (5 cm) shall be maintained between wiring and such lines, related equipment, fuel tank walls, and low-voltage wiring that enters a fuel tank. Such wiring shall be closely clamped and rigidly supported and tied at intervals such that contact between such lines, related equipment, fuel tank walls, or other wires would not occur assuming a broken wire and a missing wire tie or clamp. If questions arise regarding proper spacing, the wire routing and clamping should be verified against the aircraft type design.

6.8.24 Ensure that a trap or drip loop is provided to prevent fluids or condensed moisture from running into wires and cables dressed downward to a connector, terminal block, panel, or junction box.

6.8.25 Ensure that wires and cables installed in bilges and other locations where fluids may be trapped are routed as far from the lowest point as possible or otherwise provided with a moisture-proof covering.

6.8.26 Ensure that wires are separate from high-temperature equipment, such as resistors, exhaust stacks, heating ducts, and so forth, to prevent insulation breakdown. Wires that must run through hot areas shall be protected with a high-temperature insulation material such as fiberglass or polytetrafluoroethylene (PTFE). Avoid high-temperature areas when using cables having soft plastic insulation such as polyethylene because these materials are subject to deterioration and deformation at elevated temperatures. Many coaxial cables have this type of insulation.

6.8.27 Ensure the minimum radius of bends in wire groups or bundles is not be less than ten times the outside diameter of the largest wire or cable, except that at the terminal strips where wires break out at terminations or reverse direction in a bundle. Where the wire is suitably supported, the radius may be three times the diameter of the wire or cable. Where it is not practical to install