U.S. Department
of Transportation

Federal Aviation Administration

Advisory Circular

Subject: Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes

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AC No. 25.1701-1

1. PURPOSE. This Advisory Circular (AC) provides guidance for certification of electrical wiring interconnection systems (EWIS) on transport category airplanes in accordance with 14 CFR part 25, subpart H, sections 25.1701 through 25.1733 and sections H25.4 and H25.5 of Appendix H to part 25.

2. APPLICABILITY.

a. The guidance provided in this document is applicable to transport category airplane manufacturers, modifiers, foreign civil aviation authorities, Federal Aviation Administration (FAA) transport airplane type certification engineers, designees, and FAA Flight Standards personnel.

b. This guidance can be used to meet the regulatory requirements for development of EWIS maintenance and inspection procedures as required by 14 CFR sections 25.1729 and 26.11. These maintenance and inspection procedures are required to be part of the instructions for continued airworthiness (ICA) specified by 14 CFR part 25, section H25.5(a)(1).

c. This material is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. We will consider other methods of demonstrating compliance that an applicant may elect to present. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not result in compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation or design changes as a basis for finding compliance.

d. This material does not change or create any additional regulatory requirements nor does it authorize changes in or permit deviations from existing regulatory requirements.

e. Terms such as "shall" or "must" are used in this AC only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used.

3. HOW THIS INFORMATION WAS DERIVED.

a. The National Transportation Safety Board (NTSB) recommended that we address all wiring issues identified in our Aging Systems Plan, either through rulemaking or through other means. To accomplish this we established, in 1998, the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC). The ATSRAC provides a forum for airlines, manufacturers, and other regulatory authorities to make recommendations to us based on the Aging Systems Plan. Recommendations have addressed EWIS certification issues, development of standard wiring practices manuals, enhanced EWIS maintenance requirements, and EWIS training.

b. The guidance in this AC is based on recommendations submitted to us by the ATSRAC and by the Aviation Rulemaking Advisory Committee (ARAC). It is derived from best practices identified through extensive research by ATSRAC Industry Working Groups 6, 7, and 9, the ARAC Electrical Systems Harmonization Working Group, United States and European standard aircraft industry practice, and the results of various EWIS-related research and development programs. These recommendations and best practices are based on treating EWIS as an aircraft system, and the belief that EWIS should be designed and installed with the same level of diligence as any other essential or critical system in the aircraft. We endorse these best practices.

4. COMPLIANCE METHODS.

a. The guidance in this AC describes means of compliance with subpart H of part 25 and supplements similar guidance provided in other advisory material and policy memoranda concerning EWIS requirements for airplane systems. A list of related regulations, ACs, and policy memoranda is in Appendix A of this AC.

b. To fully realize the objectives of the guidance contained in this AC, type certificate (TC) holders, supplemental type certificate (STC) holders, maintenance providers, repair stations, and persons performing modifications or repairs may need to adjust their approach to designing and modifying EWIS. They may need to be aware of the history of the EWIS in a particular aircraft and the role it plays in the safe operation of that aircraft. People who design and modify aircraft EWIS should be aware that it should be designed and installed with the same level of diligence given to any other essential or critical system in the aircraft.

c. The guidance in this AC is organized by subpart H section.

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5. SPECIFIC COMPLIANCE GUIDANCE BY SUBPART H SECTION

a. § 25.1701 DEFINITION.

(1) § 25.1701(a).

(a) Section 25.1701 defines EWIS for the purposes of complying with the subpart H requirements and other EWIS-related requirements of part 25. Section 25.1701 identifies which wires and components these requirements apply to. Although this definition is located in subpart H to part 25, it applies to all EWIS requirements regardless of location within part 25.

(b) Section 25.1701(a) defines EWIS as any wire, wiring device, or combination of these, including termination devices, installed in any area of the airplane for the purpose of transmitting electrical energy, including data and signals, between two or more intended termination points. The term “wire” means bare or insulated wire used for the purpose of electrical energy transmission, grounding, or bonding. This includes electrical cables, coaxial cables, ribbon cables, power feeders, and databuses.

(c) Paragraph (a) of this rule provides a listing of the component types that are considered part of the EWIS. These component types are listed as items § 25.1701(a)(1) through § 25.1701(a)(14). While these are the most widely used EWIS components, this is not an all inclusive list. There may be components used by an applicant to support transmission of electrical energy that are not listed in § 25.1701(a) but still meet the EWIS definition. These components will be considered as EWIS components and are subject to EWIS-related regulatory requirements.

(2) § 25.1701(a)(14).

(a) Section § 25.1701(a)(14) says that EWIS components located inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks (e.g., circuit board back-planes and wire integration units) are covered by the EWIS definition.

(b) These components are included in the EWIS definition because the equipment they are inside of, or part of, is typically designed and made for a particular airplane model or series of models. So the requirements that apply to airplane EWIS components must be applied to the components inside that equipment. These contrast with avionics components that must be sent back to their manufacturer or a specialized repair shop for service. Components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks are maintained, repaired, and modified by the same personnel who maintain, repair, and modify the EWIS in the rest of the airplane. For example, in an electrical distribution panel, system separation must be designed and maintained within the panel just like it must be designed and maintained for the EWIS leading up to that panel. Identification of components inside the panel is just as important as it is outside the panel since the wiring inside the panel is treated much the same. Also, while this type of equipment is designed for its intended function and is manufactured and installed to the same standards as other EWIS, it is typically not qualified to an environmental standard such as Radio Technical Commission for Aeronautics (RTCA) document number DO-160.

(3) § 25.1701(b).

(a) There are some exceptions to the EWIS definitions and those are given in §§ 25.1701(b). This paragraph excepts EWIS components inside the following equipment, and the external connectors that are part of that equipment:

1 Electrical equipment or avionics that are qualified to environmental conditions and testing procedures when those conditions and procedures are –

(aa) appropriate for the intended function and operating environment, and

(bb) acceptable to the FAA.

2 Portable electrical devices that are not part of the type design of the airplane including personal entertainment devices and laptop computers.

3 Fiber optics.

(b) The first exception means EWIS components located inside avionic or electrical equipment such as, for example, flight management system computers, flight data recorders, VHF radios, primary flight displays, navigation displays, generator control units, integrated drive generators, and galley ovens, if this equipment has been tested to industry-accepted environmental testing standards. Examples of acceptable standards are RTCA DO-160 and the European Organization for Civil Aviation Equipment (EUROCAE) ED 14, and equipment qualified to an FAA Technical Standard Order (TSO).

(c) An applicant may use any environmental testing standard if the applicant can demonstrate that the testing methods and pass/fail criteria are at least equivalent to the widely accepted standards of DO-160, EUROCAE ED 14, or a specific TSO. Applicants should submit details of the environmental testing standards and results of the testing that demonstrate the equipment is suited for use in the environment in which it will operate.

b. § 25.1703 FUNCTION AND INSTALLATION: EWIS. Section 25.1703 requires that applicants select EWIS components that are of a kind and design appropriate to their intended function just as § 25.1301 requires this for other pieces of equipment installed on the airplane. Factors such as component design limitations, functionality, and susceptibility to arc tracking and moisture or other known characteristics of the particular component must be considered. The following paragraphs, 5.b.(1) through 5.b.(7), provide guidance in showing compliance with the specific provisions of § 25.1703 (a) through (d). Paragraph 5.b.(8) deals with EWIS component selection and paragraph 5.b.(9) has specific guidance on wire selection. Paragraph 5.b.(10) discusses EWIS component selection for future modifications.

(1) § 25.1703(a)(1). This section requires that each EWIS component be of a kind and design appropriate to its intended function. In this context, the requirement means that components must be qualified for airborne use, or otherwise specifically assessed as acceptable for their intended use. To be "appropriate" means that the equipment is used in a manner for which it was designed. For example, a wire rated at 150 degrees Celsius would not be appropriate for installation if that installation would cause the wire to operate at a temperature higher than 150 degrees Celsius. Wire and other components made for household or consumer products use may not be appropriate for airborne use because they are manufactured for the consumer market and not for use in an airborne environment. Other factors that must be considered for EWIS component selection are mechanical strength, voltage drop, required bend radius, and expected service life. Refer to paragraph 5.b.(8)(a) for further explanation of "expected service life."

(2) § 25.1703(a)(2). This section requires that EWIS components be installed according to their limitations. As used here, limitations means the design and installation requirements of the particular EWIS component. Examples of EWIS component limitations are maximum operating temperature, degree of moisture resistance, voltage drop, maximum current-carrying capability, and tensile strength. EWIS component selection and installation design must take into account various environmental factors including, but not limited to, vibration, temperature, moisture, exposure to the elements or chemicals (de-icing fluid, for instance), insulation type, and type of clamp. In addition, characteristics of both conductor and insulation for wires and cables that are required to regularly flex, such as those in doors and hatches, should also be considered when selecting them for such applications.

(3) § 25.1703(a)(3). This section requires that EWIS function properly when installed. The key word in understanding the intent of this section is "properly," as that relates to airworthiness of the airplane. For an EWIS component to function properly means that it must be capable of safely performing the function for which it was designed. For example, the fact that an in-flight entertainment (IFE) system fails to deliver satisfactory picture or sound quality is not what the term "properly" refers to, is not a safety issue, and thus is not a certification issue. Failure of an EWIS component has the potential for being a safety hazard whether it is part of a safety-related system or an IFE system. Therefore, EWIS components must always function properly (safely) when installed, no matter what system they are part of, and any malfunction of the EWIS must not degrade the airworthiness of the airplane (refer to § 25.1705 for terminology relating to failure classifications).

(4) § 25.1703(a)(4). This section requires that EWIS components be designed and installed so mechanical strain is minimized. This means the EWIS installation must be designed so that strain on wires would not be so great as to cause the wire or other components to fail. This section requires that adequate consideration be given to mechanical strain when selecting wire and cables, clamps, strain reliefs, stand-offs, and other devices used to route and support the wire bundle when designing the installation of these components.

(5) § 25.1703(b). This section requires that selection of wires takes into account known characteristics of different wire types in relation to each specific application, to minimize risk of damage. It is important to select the aircraft wire type whose construction matches the application environment. The wire type selected should be constructed for the most severe environment likely to be encountered in service. This means, for example, that insulation types susceptible to arc tracking should not be used in areas exposed to high vibration and constant flexing in a moisture-prone environment.

(6) § 25.1703(c). This section contains the requirement formerly located in§ 25.869(a)(3) that design and installation of the main power cables allow for a reasonable degree of deformation and stretching without failure. Although now located in § 25.1703(c), the meaning of the requirement has not changed. The reason for this requirement is the same as for § 25.993(f), which requires that each fuel line within the fuselage be designed and installed to allow a reasonable degree of deformation and stretching without leakage. The idea is that the fuselage can be damaged with partial separation or other structural damage without the fuel lines or electrical power cables breaking apart. Allowing for a certain amount of stretching will help to minimize the probability of a fuel-fed fire inside the fuselage. As it is used in this requirement, a "reasonable degree of deformation and stretching" should be about 10% of the length of the electrical cable.

(7) § 25.1703(d). This section requires that EWIS components located in areas of known moisture build-up be adequately protected to minimize moisture's hazardous effects. This is to ensure that all practical means be considered and the most appropriate method used to address potential damage from fluid contact with EWIS components. Wires routed near a lavatory, galley, hydraulic lines, severe wind and moisture problem areas such as wheel wells and wing trailing edges, and any other area of the airplane where moisture collection could be a concern must be adequately protected from possible adverse effects of exposure to moisture.

(8) EWIS component selection.

(a) Expected service life. Expected service life should be considered in selecting EWIS components to use. Expected service life means the expected service lifetime of the EWIS. This is not normally less than the expected service life of the aircraft structure. If the expected service life requires that all or some of the EWIS components be replaced at certain intervals, then these intervals must be specified in the ICA as required by § 25.1529.

(b) Qualified components. EWIS components should be qualified for airborne use or specifically assessed as acceptable for the intended use and be appropriate for the environment in which they are installed. Aircraft manufacturers list approved components in their manuals, such as the standard wiring practices manual (ATA Chapter 20). Only the components listed in the applicable manual or approved substitutes should be used for the maintenance, repair, or modification of the aircraft. EWIS modifications to the original type design should be designed and installed to the same standards used by the original aircraft manufacturer or other equivalent standards acceptable to the FAA. This is because the manufacturer's technical choice of an EWIS component is not always driven by regulatory requirements alone. In some cases, specific technical constraints would result in the choice of a component that exceeds the minimum level required by the regulations.

(c) Mechanical strength. EWIS components should have sufficient mechanical strength for their service conditions.

1 The EWIS should be installed with sufficient slack so that bundles and individual wires are not under undue tension.

2 Wires connected to movable or shock-mounted equipment should have sufficient length to allow full travel without tension on the bundle to the point where failure of the EWIS could occur.

3 Wiring at terminal lugs or connectors should have sufficient slack to allow for two re-terminations without replacement of wires, unless other design considerations apply. This slack should be in addition to the drip loop and the allowance for movable equipment.

4 In order to prevent mechanical damage, wires should be supported by suitable clamps or other devices at suitable intervals. The supporting devices should be of a suitable size and type, with the wires and cables held securely in place without damage to the insulation as per Society of Automotive Engineers (SAE) AS50881 or equivalent standard. In-service experience has revealed abrasion and chafing of wires contained in troughs, ducts, or conduits, so the design should mitigate possibilities for this occurring. This may require additional support or other design strategies.

(d) Minimum bend radius. To avoid damage to wire insulation, the minimum radius of bends in single wires or bundles should be in accordance with the wire manufacturer's specifications. Guidance on the minimum bend radius can be found in the airplane manufacturer's standard wiring practices manual. Other industry standards such as the European Association of Aerospace Industries' document AECMA EN3197 or SAE AS50881 also contain guidance on minimum bend radius. For example, SAE AS50881b states:

> For wiring groups, bundles, or harnesses, and single wires and electrical cables individually routed and supported, the minimum bend radius shall be ten times the outside diameter of the largest included wire or electrical cable. At the point where wiring breaks out from a group, harness or bundle, the minimum bend

radius shall be ten times the diameter of the largest included wire or electrical cable, provided the wiring is suitably supported at the breakout point. If wires used as shield terminators or jumpers are required to reverse direction in a harness, the minimum bend radius of the wire shall be three times the diameter at the point of reversal providing the wire is adequately supported.

(e) Coaxial cable damage. Damage to coaxial cable can occur when the cable is clamped too tightly or bent sharply (normally at or near connectors). Damage can also be incurred during unrelated maintenance actions around the coaxial cable. Coaxial cable can be severely damaged on the inside without any evidence of damage on the outside. Installation design should minimize the possibility of such damage. Coaxial cables have a minimum bend radius. SAE AS50881b states: "The minimum radius of bend shall not adversely affect the characteristics of the cable. For flexible type coaxial cables, the radius of bend shall not be less than six times the outside diameter. For semi-rigid types, the radius shall not be less than ten times the outside diameter."

(f) Wire bundle adhesive clamp selection. Certain designs use adhesive means to fasten bundle supports to the aircraft structure. Service history shows that these can become loose during aircraft operation, either as a result of improper design, or because of inadequate surface preparation. You should pay particular attention to the selection of such means and to the methods used for affixing this type of wire bundle support.

(g) Wire bundle routing. Following are some considerations that should go into the design of an EWIS installation.

1 Wire bundles should be routed in accessible areas that are protected from damage from personnel, cargo, and maintenance activity. As far as practicable they should not be routed in areas where they are likely to be used as handholds or as support for personal equipment or where they could become damaged during removal of aircraft equipment (reference §§ 25.1719 and 25.1721).

2 Wiring should be clamped so that contact with equipment and structure is avoided. Where this cannot be accomplished, extra protection, in the form of grommets, chafe strips, etc., should be provided. Wherever wires cannot be clamped, protective grommets should be used, in a way that ensures clearance from structure at penetrations. Wire should not have a preload against the corners or edges of chafing strips or grommets.

3 As far as practicable, wiring should be routed away from high-temperature equipment and lines to prevent deterioration of insulation (reference § 25.1707(j)).

4 Wiring routed across hinged panels should be routed and clamped so that the bundle will twist, rather than bend, when the panel is moved. When this is not possible, the bending radius must be in accordance with the acceptable minimum bundle radius.

(h) Conduits. Conduits should be designed and manufactured so that potential for chafing between the wiring and the conduit internal walls is minimized.

1 Non-metallic conduit. Insulating tubing (or sleeving) is sometimes used to provide additional electrical, environmental, and limited additional mechanical protection or to increase the external wire dimension. Insulating tubing should not be considered as the sole mechanical protection against external abrasion of wire because it does not prevent external abrasion. At best, it provides only a delaying action against the abrasion. The electrical and mechanical properties of the tubing should be appropriate for the type of protection the designer intends it to be used for. Additional guidance on the use of tubing or sleeving is given in paragraph 5. d(2)(c) of this AC.

2 Metallic conduit. The ends of metallic conduits should be flared and the interior surface treated to reduce the possibility of abrasion.

(i) Connector selection. The connector used for each application should be selected only after a careful determination of the electrical and environmental requirements.

1 Additional scrutiny should be given to any use of components with dissimilar metals, because this may cause electrolytic corrosion.

2 Environment-resistant connectors should be used in applications that will be subject to fluids, vibration, temperature extremes, mechanical shock, corrosive elements, etc.

3 You should use sealing plugs and contacts in unused connector cavities. In addition, firewall class connectors incorporating sealing plugs should be able to prevent the penetration of fire through the aircraft firewall connector opening and continue to function without failure for the period of time that the connector is designed to function when exposed to fire.

4 When electromagnetic interference and radio frequency interference (EMI and RFI) protection is required, you should give special attention to the termination of individual and overall shields. Back shell adapters designed for shield termination, connectors with conductive finishes, and EMI grounding fingers are available for this purpose.

(j) Splice selection. Environmentally sealed splices should be used in accordance with the requirements of the airframe manufacturer's standard wiring practices or SAE AS81824/1, or equivalent specification, particularly in un-pressurized and severe wind and moisture prone (SWAMP) areas. However, the possibility of fluid contamination in any installation needs to be considered.

1 Splices in pressurized areas. In pressurized areas, pre-insulated splices conforming to SAE AS7928 or equivalent specification may be used if these types of splices are listed as acceptable for use by the manufacturer in its standard wiring practices manual. If these are not included in the standard wiring practices manual, then you should get approval from your Aircraft Certification Office to use them. In any case, you need to show that the possibility of fluid contamination has been adequately considered.

2 Mechanically protected splices. Mechanical splices give maintenance personnel an alternative to using a heat gun for splices in fuel vapor areas on post-delivery aircraft. The generally available environmental splices use heat shrink material that require heat application. Most of these heat sources cannot be used in flammable vapor areas of an aircraft without proper precautions. Mechanical splices are acceptable for use in high temperature and fuel vapor areas, provided the splice is covered with a suitable plastic sleeve, such as a dual wall shrink sleeve or high temperature tape, such as Teflon, wrapped around the splice and tied at both ends. If high temperature tape is used, it should be permanently secured at both ends. Mechanical splices should be installed according to the airframe manufacturer's standard practices, or equivalent specification. The manufacturer's standard wiring practices manual should provide part number detail and best practices procedures for mechanical splices. It should also detail the applicability of each of the recommended splices for all required critical airplane installations.

3 Aluminum wire splice. Splices for aluminum wires should be in accordance with the requirements of the airframe manufacturer's standard practices or SAE AS70991, MS25439, or equivalent specification. You should avoid conditions that result in excessive voltage drop and high resistance at junctions that may ultimately lead to failure of the junction. The preferable location for aluminum splices is in pressurized areas.

> **NOTE:** To avoid contamination from foreign particles, the crimp tool should be dedicated to aluminum wire crimping.

(9) Wire selection.

(a) Installation environment.

1 Careful attention should be applied when deciding on the type of wire needed for a specific application. You should consider whether the wire's construction properly matches the application environment. For each installation, you should select wire construction type suitable for the most severe environment likely to be encountered in service. As examples, use a wire type suitable for flexing for installations involving movement; and a wire type with a high temperature rating for higher temperature installations.

2 When considering the acceptability of wire, you should refer to the industry standards defining acceptable test methods for aircraft wire, including arc tracking test methods (e.g. European Norm (EN) 3475, SAE AS4373, or alternative manufacturer standards).

3 Wires in such systems as fire detection, fire extinguishing, fuel shutoff, and fly-by-wire flight control that must operate during and after a fire must be selected from wire types qualified to provide circuit integrity after exposure to fire for a specified period.

(b) Wire insulation selection. Wire insulation type should be chosen according to the environmental characteristics of wire routing areas. One wire insulation characteristic of particular concern is arc tracking. Arc tracking is a phenomenon in which a conductive carbon path forms across an insulating surface. A breach in the insulation allows arcing and carbonizes the insulation. The resulting carbon residue is electrically conductive. The carbon then provides a short circuit path through which current can flow. This can occur on either dry or wet wires. Certain types of wire insulation, such as wire insulated with aromatic polyimide, are more susceptible to arc tracking than others. Although there are new types of aromatic polyimide insulated wire, such as hybrid constructions (e.g., the aromatic polyimide tape is the middle layer, and the top and bottom layer is another type of insulation such as Teflon tape) wire insulated with only aromatic polyimide tape is more susceptible to arc tracking than other types of commonly used wire insulation. Therefore, its use should be limited to applications where it will not be subjected to high moisture, high vibration levels, or abrasion, and where flexing of the wire will not occur.

(c) Mechanical strength of wire. Wires should be sufficiently robust to withstand all movement, flexing, vibration, abrasion, and other mechanical hazards to which they may be subjected on the airplane. Generally, conductor wire should be stranded to minimize fatigue breakage. Refer to AS50881 and European Association of Aerospace Industries (AECMA) EN3197 for additional guidance. Additionally, wires should be robust enough to withstand the mechanical hazards they may be subjected to during installation into the aircraft.

(d) Mixing of different wire insulation types. Different wire types installed in the same bundle should withstand the wire-to-wire abrasion they will be subject to. Consideration should be given to the types of insulation mixed within wire bundles, especially if mixing a hard insulation type with a relatively softer type, and particularly when relative motion could occur between the wires. Such relative motion between varying wire insulation types could lead to accelerated abrasion and subsequent wire failure.

(e) Tin plated conductors. Tin plated conductors may be difficult to solder if not treated properly, so preparation of the conductor is necessary to ensure a good connection is made.

(f) Wire gage selection. To select the correct size of electrical wire, the following should be considered:

1 The wire size should be matched with the circuit protective device with regard to the required current.

2 The wire size should be sufficient to carry the required current without overheating.

3 The wire size should be sufficient to carry the required current over the required distance without excessive voltage drop (based on system requirements).

4 Particular attention should be given to the mechanical strength and installation handling of wire sizes smaller than AWG 22 (e.g., consideration of vibration, flexing, and termination). Use of high-strength alloy conductors should be considered in small gauge wires to increase mechanical strength.

NOTE: Additional guidance for selecting wire and other EWIS components can be found in SAE AS50881 and AECMA EN2853 as well as in AC 43-13.1B.

(g) Wire temperature rating. Selection of a temperature rating for wire should include consideration of the worst-case requirements of the application. You should use caution when locating wires in areas where heat is generated—oxygen generators or lighting ballast units, for example.

1 Wires have a specified maximum continuous operating temperature. For many types, this may be reached by any combination of maximum ambient temperature and the temperature rise due to current flow.

2 In general, it is undesirable to contribute more than 40^{o}C rise to the operating temperature by electrical heating.

<u>3</u> Other factors to be considered are altitude de-rating, bundle size de-rating, and use of conduits and other enclosures.

<u>4</u> Particular note should be taken of the specified voltage of any wire where higher than normal potentials may be used. Examples are discharge lamp circuits and windscreen heating systems.

(h) EWIS components in moisture areas.

<u>1</u> **Severe wind and moisture prone areas.** Areas designated as severe wind and moisture prone (SWAMP) areas are different from aircraft to aircraft, but they are generally considered to be such areas as wheel wells, wing folds, pylons, areas near wing flaps, and other exterior areas that may have a harsh environment. Wires for these applications should incorporate design features that address these severe environments.

<u>2</u> **Silver plated conductors**. Many high-strength copper alloy conductors and coaxial cables use silver plating. Contamination of silver-plated conductors with glycol (de-icing fluid) can result in electrical fire. Accordingly, you should not use silver-plated conductors in areas where de-icing fluid can be present unless suitable protection features are employed. Silver plated conductors and shields can exhibit a corrosive condition (also known as 'Red Plague') if the plating is damaged or of poor quality and is exposed to moisture. Designers should be aware of these conditions.

<u>3</u> **Fluid contamination of EWIS components.** Fluid contamination of EWIS components should be avoided as far as practicable. But EWIS components should be designed and installed with the appropriate assumptions about fluid contamination, either from the normal environment or from accidental leaks or spills. Industry standards, such as RTCA DO-160/EUROCAE ED-14, contain information regarding typical aircraft fluids. It is particularly important to appreciate that certain contaminants, notably from toilet waste systems, galleys, and fluids containing sugar, such as sweetened drinks, can induce electrical tracking in already degraded electrical wires and unsealed electrical components. The only cleaning fluids that should be used are those recommended by the airplane manufacturer in its standard practices manual.

(10) EWIS component selection for future modifications. If a TC includes subpart H in its certification basis, future modifiers of those TCs would be able to substantiate compliance with the subpart H requirements by using the same or equivalent standards and design practices as those used by the TC holder. If modifiers choose to deviate from those standards and design practices, they will have to substantiate compliance independently. They will also have to consider the standards and design practices used by the TC holder in order to justify their own choice of components. However, this does not mean that the airplane manufacturer is required to divulge intellectual property to future modifiers. It is incumbent upon the modifiers to determine what constitutes equivalent standards and design practices.

c. § 25.1705 SYSTEMS AND FUNCTIONS: EWIS. This section requires consideration of EWIS components in showing compliance with the certification requirements for specific airplane systems. Although not all part 25 certification requirements directly address EWIS, many address EWIS in an indirect way. The EWIS associated with such systems play an integral role in ensuring the safe operation of the system and of the airplane. If a system is required by type certification or by operating rules, EWIS associated with that system must be evaluated as part of showing compliance of the system. Section 25.1705(a) and (b) may seem redundant. Section 25.1705(a) has the general requirement. Section 25.1705(b) identifies specific regulations to which this requirement applies. These specific sections contain requirements that do not lend themselves to creating a separate EWIS-based subpart H requirement. But this is not an exclusive list. If a regulation is absent from 25.1705(b) it must still be considered under the general terms of 25.1705(a). The general requirement of (a) is necessary because there may be other regulations where EWIS must be considered. It also ensures that EWIS is given full consideration for any system-related regulation adopted in the future.

d. § 25.1707 SYSTEM SEPARATION: EWIS.

GENERAL GUIDANCE FOR § 25.1707

(1) Summary. The continuing safe operation of an airplane depends on the safe transfer of electrical energy by the EWIS. If an EWIS failure occurs, the separation that the EWIS has from other EWIS, systems, or structure plays an important role in ensuring that hazardous effects of the failure are mitigated to an acceptable level. Section 25.1707 requires applicants to design EWIS with appropriate separation to minimize the possibility of hazardous effects upon the airplane or its systems. As used in § 25.1707, the term “separation” is a measure of physical distance. The purpose of separation is to prevent hazards of arcing between wires in a single bundle, between two or more bundles, or between an electrical bundle and a non-electrical system or structure.

(2) Separation by physical distances versus separation by barrier. Section 25.1707 states that adequate physical separation must be achieved by separation distance or by a barrier that provides protection equivalent to that separation distance. The following should be considered when designing and installing EWIS:

(a) In most cases, physical distance is the preferred method of achieving the required separation. This is because barriers themselves can be the cause of EWIS component damage (e.g., chafing inside of conduits) and can lead to maintenance errors, such as barriers removed during maintenance and inadvertently left off. They can also interfere with visual inspections of the EWIS.

(b) If a barrier is used to achieve the required separation, § 25.1707 requires that it provide at least the same level of protection that would be achieved with physical distance. That means that when deciding on the choice of the barrier, factors such as dielectric strength, maximum and minimum operating temperatures, chemical resistivity, and mechanical strength should be taken into account.

(c) In addition to the considerations given in paragraph (b) above, when wire bundle sleeving (or tubing) is used to provide separation, designers should consider that the sleeving itself is susceptible to the same types of damage as wire insulation. The appropriate type of sleeving must be selected for each specific application and design consideration must be given to ensuring that the sleeving is not subjected to damage that would reduce the separation it provides.

(3) Determination of separation. Determining the necessary amount of physical separation distance is essential. But because each system design and airplane model can be unique, and because manufacturers have differing design standards and installation techniques, § 25.1707 does not mandate specific separation distances. Instead it requires that the chosen separation be adequate so that an EWIS component failure will not create hazardous effects on the airplane or its systems. The following factors should be considered when determining the separation distance:

(a) The electrical characteristics, amount of power, and severity of failure condition of the system functions performed by the signals in the EWIS and adjacent EWIS.

(b) Installation design features, including the number, type, and location of support devices along the wire path.

(c) The maximum amount of slack wire resulting from wire bundle build tolerances and other wire bundle manufacturing variabilities.

(d) Probable variations in the installation of the wiring and adjacent wiring, including position of wire support devices and amount of wire slack possible.

(e) The intended operating environment, including amount of deflection or relative movement possible and the effect of failure of a wire support or other separation means.

(f) Maintenance practices as defined by the airplane manufacturer's standard wiring practices manual and the ICA required by § 25.1529 and § 25.1729.

(g) The maximum temperature generated by adjacent wire/wire bundles during normal and fault conditions.

(h) Possible EMI, HIRF, or induced lightning effects.

(4) Cases of inadequate separation. Some areas of an airplane may have localized areas where maintaining the minimum physical separation distance is not feasible. This is especially true in smaller transport category airplanes. In those cases, other means of ensuring equivalent minimum physical separation may be acceptable, if testing or analysis demonstrates that safe operation of the airplane is not jeopardized. The testing or analysis program should be conservative and consider the worst possible condition not shown to be extremely improbable. The applicant should substantiate to the ACO that the means to achieve the necessary separation provides the necessary level of protection for wire related failures. Electro-magnetic interference (EMI) protection must also be verified.

(5) Meaning of the term "hazardous condition" as used in § 25.1707.

(a) The term "hazardous condition" in § 25.1707 is used in a different context than it is used in§ 25.1709. In the EWIS System Safety rule, § 25.1709, the applicant must show that each EWIS system is designed and installed so that each hazardous failure condition **is extremely remote**. The definition of a hazardous failure condition is the same as it is for section § 25.1707 (see Table 1). In § 25.1709, however, a numerical probability is required to demonstrate that the possibility for such an occurrence is extremely remote.

(b) In the System Separation rule, § 25.1707, separation distances or a barrier that provides protection equivalent to the separation distance must be used to ensure that none of the types of failures described in the rule will create a situation that would fit the definition of a hazardous condition. The operative term in this rule is that such failures **will not create a hazardous condition**. To show that a given failure will not create a hazardous condition, the applicant must perform a qualitative design assessment of the installed EWIS. This assessment involves the use of reasonable engineering and manufacturing judgment and assessment of relevant service history to decide whether an EWIS, system, or structural component could fail in such a way as to create a condition that would affect the airplane's ability to continue safe operation. However, the requirements of § 25.1707 do not preclude the use of valid component failure rates if the applicant chooses to use a probability argument in addition to the design assessment to demonstrate compliance. It also does not preclude the FAA from requiring such an analysis if the applicant cannot adequately demonstrate that hazardous conditions will be prevented solely by using the qualitative design assessment. Also note that a numerical probability assessment may still be required by § 25.1709 if the airplane-level functional hazard assessment identifies EWIS failures that could affect safe operation of the airplane.

(c) To illustrate the type of assessment required by § 25.1707, consider the following simple example involving the use of wire bundle clamps. Clamps are used to secure a wire bundle to structure in order to hold the bundle in place and route it from one location to another along a predetermined path. An airplane manufacturer, using the criteria contained in paragraph 5.d.(3) above, determines that a 2-inch separation between a certain wire bundle and some hydraulic lines is necessary. The manufacturer further decides that one clamp every 10 inches is needed to maintain that separation. However, there is one localized area where a single clamp failure would potentially create a hazard. This is because the area in question is a high vibration, high temperature area, subject to exposure to moisture. So the clamp in this particular area is exposed to severe environmental conditions that could lead to accelerated degradation. The manufacturer decides that using just a single clamp every 10 inches in this area would not suffice to preclude a hazardous event. The manufacturer prescribes use of double clamps every 10 inches in that area.

SECTION-BY-SECTION GUIDANCE FOR § 25.1707

(6) Specific guidance by section of § 25.1707

(a) § 25.1707(a). Paragraph 25.1707(a) requires that adequate physical separation be achieved by separation distance or by a barrier that provides protection equivalent to that separation distance. Refer to paragraphs 5.(d)(2), (3), and (4) for further guidance regarding separation distances and the use of barriers.

(b) § 25.1707(b).

1 This section requires that each EWIS be designed and installed so that any electrical interference likely to be present in the airplane will not result in hazardous effects on the airplane or its systems.

2 One type of electrical interference is electromagnetic interference (EMI). Electromagnetic interference can be introduced into airplane systems and wiring by coupling between electrical cables or between cables and coaxial lines or other airplane systems. The design should not allow system function to be affected by EMI generated by adjacent wire. EMI between its source wiring and wire susceptible to it increases in proportion to the length of parallel runs. It decreases with greater separation. Wiring of sensitive circuits that may be affected by EMI should be routed away from other wiring that may cause such interference, or it should be provided with sufficient shielding to avoid system malfunctions under operating conditions. The design should limit EMI to negligible levels in wiring related to systems necessary for continued safe flight, landing, and egress. The following sources of interference should be considered:

(aa) Conducted and radiated interference caused by electrical noise generation from apparatus connected to the bus bars.

(bb) Coupling between electrical cables or between cables and aerial feeders.

(cc) Malfunctioning of electrically-powered apparatus.

(dd) Parasitic currents and voltages in the electrical distribution and grounding systems, including the effects of lightning currents or static discharge.

(ee) Different frequencies between electrical generating systems and other systems.

(c) § 25.1707(c). This section contains the wire-related requirements formerly located in § 25.1353(b). Coverage is expanded beyond wires and cable carrying heavy current to include their associated EWIS components as well. This means that all EWIS components, as defined by § 25.1701, that are associated with wires and cables carrying heavy current must be installed in the airplane in such a way that damage to essential circuits will be minimized under fault conditions.

(d) § 25.1707(d). Section 25.1707(d) contains wire-related requirements from §§ 25.1351(b)(1) and (b)(2) and introduces additional requirements. As used in this section, "independent airplane power source" means a general source of power for the whole of the airplane or for major subsystems (such as flight controls – as, for instance, permanent magnet generators on the engines for the fly-by-wire system). Examples include engine- or APU-driven generators, batteries, and ram air turbines.

1 Paragraph (d) requires that EWIS components associated with the generating system receive the same degree of attention as other components of the system, such as the electrical generators.

2 Paragraph (d)(1) prohibits airplane independent electrical power sources from sharing a common ground terminating location. Paragraph (d)(2) prohibits airplane static grounds from sharing a common ground terminating location with any airplane independent electrical power sources. The reason for these paragraphs is twofold:

- to help ensure the independence of separate electrical power sources so that a single ground failure will not disable multiple power sources; and
- to prevent introduction of unwanted interference into airplane electrical power systems from other airplane systems.

(e) §§ 25.1707(e), (f), (g), (h). These paragraphs contain specific separation requirements for the fuel, hydraulic, oxygen, and waste/water systems. They require adequate EWIS separation from those systems except to the extent necessary to provide any required electrical connection to them. EWIS must be designed and installed with adequate separation so a failure of an EWIS component will not create a hazardous condition and any leakage from those systems (i.e., fuel, hydraulic, oxygen, waste/water) onto EWIS components will not create a hazardous situation.

1 Under fault conditions and without adequate EWIS separation, a potential catastrophic hazard could occur if an arcing fault ignited a flammable fluid like fuel or hydraulic fluid. Also, an arcing fault has the potential to puncture a line associated with those systems if adequate separation is not maintained. If there is leakage from one of those systems and an arcing event occurs, fire or explosion could result. Similarly, leakage from the water/waste system can damage EWIS components and adversely affect their integrity. An EWIS arcing event that punctures a water or waste line could also introduce fluids into other airplane systems and create a hazardous condition.

2 In addition to the required separation distance, the use of other protection means such as drip shields should be considered to prevent fluids from leaking onto EWIS.

(f) § 25.1707(i). To prevent chafing, jamming, or other types of interference, or other failures that may lead to loss of control of the airplane, EWIS in general and wiring in particular must be physically separated from flight control or other types of control cables. Mechanical cables have the potential to cause chafing of electrical wire if the two come into contact. This can occur either through vibration of the EWIS and/or mechanical cable or because of cable movement in response to a system command. A mechanical cable could also damage other EWIS components, such as a wire bundle support, in a way that would cause failure of that component. Also, if not properly designed and installed, a wire bundle or other EWIS component could interfere with movement of a mechanical control cable by jamming or otherwise restricting the cable's movement. Without adequate separation, an arcing fault could damage or sever a control cable. A control cable failure could damage EWIS. Therefore, paragraph (i) requires an adequate separation distance or barrier between EWIS and flight or other mechanical control systems cables and their associated system components. It also requires that failure of an EWIS component must not create a hazardous condition and that the failure of any flight or other mechanical control systems cables or systems components must not damage EWIS and create a hazardous condition. Clamps for wires routed near moveable flight controls should be attached and spaced so that failure of a single attachment point cannot interfere with flight controls or their cables, components, or other moveable flight control surfaces or moveable equipment.

(g) § 25.1707(j). This section requires that EWIS design and installation provide adequate physical separation between the EWIS components and heated equipment, hot air ducts, and lines. Adequate separation distance is necessary to prevent EWIS damage from extreme temperatures and to prevent an EWIS failure from damaging equipment, ducts, or lines. High temperatures can deteriorate wire insulation and other parts of EWIS components, and if the wire or component type is not carefully selected, this deterioration could lead to wire or component failure. Similarly, should an arcing event occur, the arc could penetrate a hot air duct or line and allow the release of high pressure, high temperature air. Such a release could damage surrounding components associated with various airplane systems and potentially lead to a hazardous situation.

(h) § 25.1707(k). Reliability for some airplane systems is so critical that independent, redundant systems are required. The autoland system is an example. If one channel of a redundant autoland system is lost, the airplane can continue to operate safely. But if both channels of a two-channel system were lost because of a common failure, the results could be catastrophic. To maintain the independence of redundant systems and equipment so that safety functions are maintained, adequate separation and electrical isolation between these systems must be ensured. Paragraph (k) requires that EWIS associated with any system requiring redundancy to meet certification requirements have an adequate separation distance or barrier.

1 EWIS of redundant aircraft systems, as required by certification rules, operating rules, or as a result of the assessment required by § 25.1709, should be routed in separate bundles and through separate connectors to prevent a single fault from disabling multiple redundant systems. Separation of functionally similar EWIS components is necessary to prevent degradation of their ability to perform their required functions.

2 Power feeders from separate power sources should be routed in bundles separate from each other and from other aircraft wiring in order to prevent a single fault from disabling more than one power source.

3 Wiring that is part of electro-explosive subsystems, such as cartridge-actuated fire extinguishers and emergency jettison devices, should be routed in shielded and jacketed twisted-pair cables, shielded without discontinuities, and kept separate from other wiring at connectors.

(i) § 25.1707(l). This section requires that EWIS be designed and installed so they are adequately separated from aircraft structure and protected from sharp edges and corners. This is to minimize the potential for abrasion and chafing, vibration damage, and other types of mechanical damage. This protection is necessary because over time the insulation on a wire that is touching a rigid object, such as an equipment support bracket, will fail and expose bare wire. This can lead to arcing that could destroy that wire and other wires in its bundle. Structural damage could also occur, depending on the amount of electrical energy the failed wire carries.

e. § 25.1709 SYSTEM SAFETY: EWIS. Section 25.1709 requires applicants to perform a system safety assessment of the EWIS. The analysis required for compliance with § 25.1709 is based on a qualitative *and* quantitative approach to assessing EWIS safety, as opposed to a purely numerical, probability-based quantitative analysis. The safety assessment must consider the effects that both physical and functional failures of EWIS would have on airplane safety. That safety assessment must show that each EWIS failure considered hazardous is extremely remote. It must show that each EWIS failure considered to be catastrophic is extremely improbable and will not result from a single failure.

(1) Objective. The objective of § 25.1709 is to use the concepts of § 25.1309 to provide a thorough and structured analysis of aircraft wiring and its associated components. As in § 25.1309, the fail-safe design concept applies. Any single failure condition, such as an arc fault, should be assumed to occur regardless of probability.

(2) Inadequacies of § 25.1309 in relation to EWIS safety assessments. Section 25.1309 requires the applicant to perform system safety assessments. But current § 25.1309 practice has not led to the type of analysis that fully ensures all EWIS failure conditions affecting airplane level safety are considered. This is because the current § 25.1309(a) only covers systems and equipment that are "required by this subchapter," and wiring for nonrequired systems is sometimes ignored. Even for systems covered by § 25.1309(b) and (d), the safety analysis requirements have not always been applied to the associated wire. When they are, there is evidence of inadequate and inconsistent application. Traditional thinking about nonrequired systems, such as in-flight entertainment systems, has been that, since they are not required, and the function they provide is not necessary for the safety of the airplane, their failure could not affect the safety of the airplane. This is not a valid assumption. Failure of an electrical wire, regardless of the system it is associated with, can cause serious physical and functional damage to the airplane, resulting in hazardous or even catastrophic failure conditions. An example of this is arcing from a shorted wire cutting through and damaging flight control cables. There are more failure modes than have been addressed with traditional analyses. Some further examples are arcing events that occur without tripping circuit breakers, resulting in complete wire bundle failures and fire, or wire bundle failures that lead to structural damage.

(3) Integrated nature of EWIS. The integrated nature of wiring and the potential severity of failures demand a more structured safety analysis approach than that traditionally used in showing compliance with § 25.1309. Section 25.1309 system safety assessments typically evaluate effects of wire failures on system functions. But they have not considered physical wire failure as a cause of the failure of other wires within the EWIS. Traditional assessments look at external factors like rotor burst, lightning, and hydraulic line rupture, but not at internal factors, like a single wire chafing or arcing event, as the cause of the failure of functions supported by the EWIS. Compliance with § 25.1709 requires addressing those failure modes at the airplane level. This means that EWIS failures need to be analyzed to determine what effect they could have on the safe operation of the airplane.

(4) Compliance summary. As specified above, the analysis required for compliance with § 25.1709 is based on a qualitative approach to assessing EWIS safety as opposed to numerical, probability-based quantitative analysis. The intent is not to examine each individual wire and its relation to other wires. Rather, it is to ensure that there are no hazardous combinations. However, in case the "top down" analysis process described in this AC determines that a failure in a given bundle may lead to a catastrophic failure condition, the mitigation process may lead to performing a complete analysis of each wire in the relevant bundle.

(5) Qualitative probability terms. When using qualitative analyses to determine compliance with § 25.1709, the following descriptions of the probability terms have become commonly accepted as aids to engineering judgment:

(a) Extremely remote failure conditions. These are failure conditions that are not anticipated to occur to an individual airplane during its total life but which may occur a few times when considering the total operational life of all airplanes of the type.

(b) Extremely improbable failure conditions. These are failure conditions so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type.

(6) Relationship to other part 25 system safety assessments. The analysis described may be accomplished in conjunction with the required aircraft system safety assessments of §§ 25.1309, 25.671, etc.

(7) Classification of failure terms. The classification of failure conditions is given in Table 1. These failure conditions are identical to those proposed by the Aviation Rulemaking Advisory Committee for the draft (Arsenal) version of AC 25.1309-1b, dated June 10, 2002.

Table 1: Classification of Failure Conditions

Term	Explanation
No Safety Effect	Failure conditions that would have no effect on safety, for example failure conditions that would not affect the operational capability of the airplane or increase flightcrew workload.
Minor	Failure conditions that would not significantly reduce airplane safety, and involve flightcrew actions that are well within their capabilities. For example, minor failure conditions may include: • a slight reduction in safety margins or functional capabilities; • a slight increase in flightcrew workload, such as routine flight plan changes; or • some physical discomfort to passengers or cabin crew.
Major	Failure conditions that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions to the extent that there would be, for example: • a significant reduction in safety margins or functional capabilities; • a significant increase in flightcrew workload or in conditions impairing flightcrew efficiency; • discomfort to the flightcrew; or • physical distress to passengers or cabin crew, possibly including injuries.

Hazardous	Failure conditions that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions to the extent that there would be, for example: • a large reduction in safety margins or functional capabilities; • physical distress or excessive workload such that the flightcrew cannot be relied upon to perform their tasks accurately or completely; or • serious or fatal injuries to a relatively small number of persons other than the flightcrew.
Catastrophic	Failure conditions that would result in multiple fatalities, usually with the loss of the airplane. (NOTE: A catastrophic failure condition was defined differently in previous versions of § 25.1309 and in accompanying advisory material as “a failure condition that would prevent continued safe flight and landing.”)

(8) Flowcharts depicting the analysis process. Flowcharts 1 and 2, which follow, outline one method of complying with the requirements of § 25.1709. The processes in both Flowcharts 1 and 2 identify two aspects of the analysis: physical failures and functional failures. The analysis processes described in both flowcharts begin by using the aircraft level functional hazard analysis developed for demonstrating compliance with § 25.1309 to identify catastrophic and hazardous failure events. A step-by-step explanation of the analysis depicted in the flowcharts is given in this AC in paragraphs 5.e.(11) (for Flowchart 1) and 5.e.(12) (for Flowchart 2).

(a) Flowchart 1. This flowchart applies to applicants for pre-TC work and for amended TCs, and STCs when the applicant has all data necessary to perform the analysis per Flowchart 1. If Flowchart 1 is used for post-TC modifications, the available data must include identification of the systems in the EWIS under consideration for modification and the system functions associated with that EWIS.

(b) Flowchart 2. This flowchart applies to applicants for post-TC modifications when the applicant cannot identify the systems or systems functions contained in EWIS under consideration for modification.

(9) Definitions applicable to § 25.1709. For this discussion the following definitions apply:

(a) Validation. Determination that requirements for a product are sufficiently correct and complete.

(b) Verification. Evaluation to determine that requirements have been met.

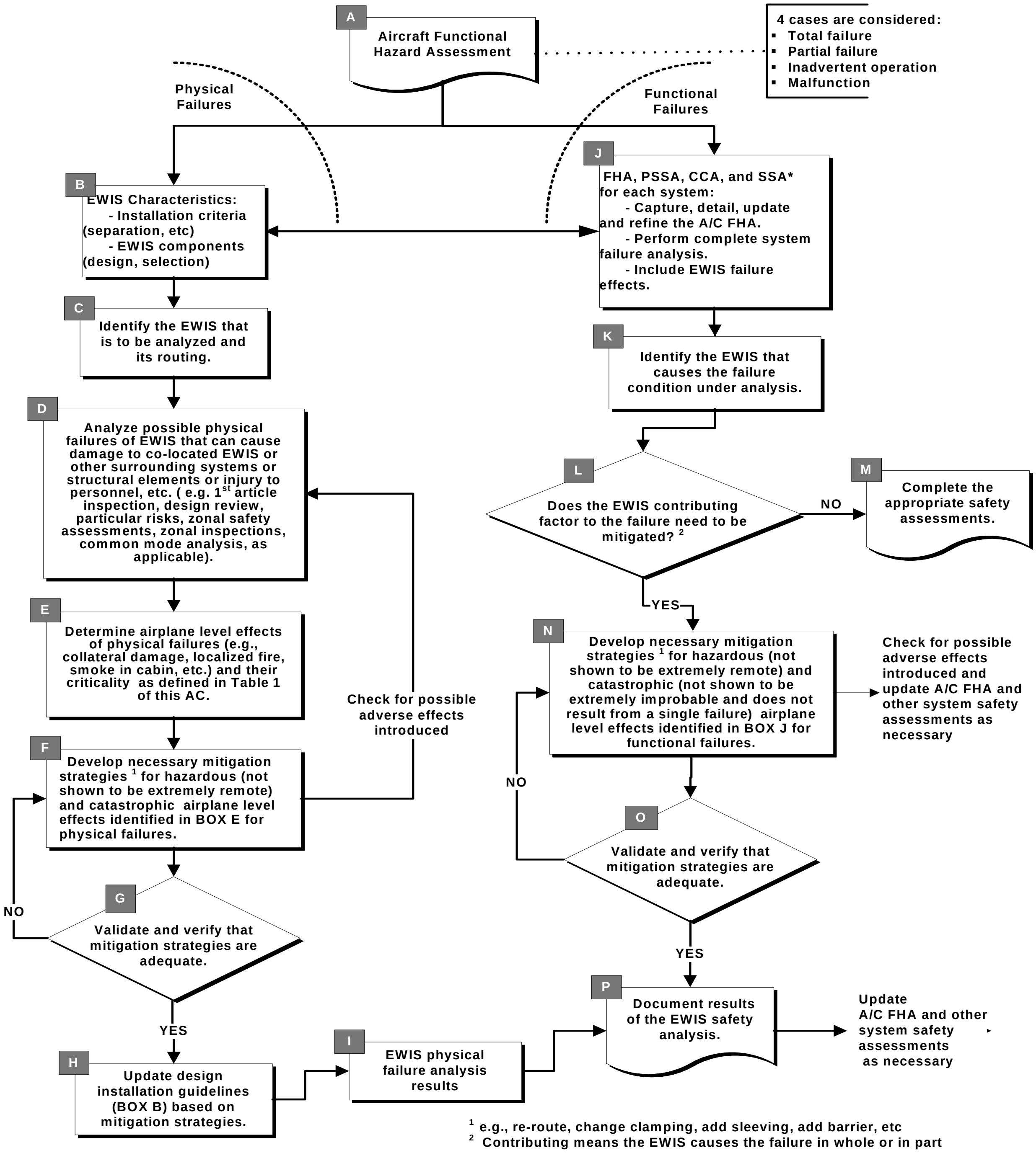
(c) Mitigation. Elimination of a hazard entirely or minimization of its severity and probability to an acceptable level. In the case of this rule, an EWIS failure must be mitigated to a point where the probability of a hazardous failure must be at least extremely remote and the probability of a catastrophic failure at least extremely improbable

(10) Physical failure analysis.

(a) Only single common cause events or failures need to be addressed during the physical failure analysis as described in this AC and shown on the left hand sides of Flowcharts 1 and 2**.** Multiple common cause events or failures need not be addressed.

(b) In relation to physical effects, it should be assumed that wires are carrying electrical energy and that, in the case of an EWIS failure, as defined in paragraph 5.e.(10)(a), this energy may result in hazardous or catastrophic effects directly or when combined with other factors, for example fuel, oxygen, hydraulic fluid, or damage by passengers. These failures may result in fire, smoke, emission of toxic gases, damage to co-located systems and structural elements, or injury to personnel. This analysis considers all EWIS from all systems (autopilot, auto throttle, PA system, IFE systems, etc.) regardless of the system criticality.

Flowchart 1: Pre- and Post-Type Certification Safety Analysis Concept



[1] e.g., re-route, change clamping, add sleeving, add barrier, etc
[2] Contributing means the EWIS causes the failure in whole or in part
* FHA: Functional Hazard Assessment
PSSA: Preliminary System Safety Assessment
CCA: Common Cause Analysis
SSA: System Safety Assessment

Mitigation as used in this flowchart means to eliminate the hazard entirely or minimize its severity and probability to an acceptable level. In the case of § 25.1709, the EWIS failure must be mitigated to a point where the probability of a hazardous failure is at least extremely remote and the probability of a catastrophic failure is at least extremely improbable

(11) Descriptive text for Flowchart 1

(a) BOX A Aircraft functional hazard assessment.

1 The functional failure analysis assumes that electrical wires are carrying power, signal, or information data. Failure of EWIS under these circumstances may lead to aircraft system degradation effects.

2 The functional hazard assessment (FHA) referred to in this box is not a stand-alone separate document specifically created to show compliance with § 25.1709. It is the aircraft level FHA that the applicant will have developed in compliance with § 25.1309 to help demonstrate acceptability of a design concept, identify potential problem areas or desirable design changes, or determine the need for and scope of any additional analyses (refer to AC 25.1309-1B).

ANALYSIS OF POSSIBLE PHYSICAL FAILURES

(b) BOX B EWIS characteristics. Use the results of the FHA (**BOX A**) and the preliminary system safety assessment (PSSA), common cause analysis (CCA), and system safety assessment (SSA) (**BOX J**) to identify EWIS installation criteria and definitions of component characteristics. Results from **BOX B** are fed into the preliminary system safety analysis (PSSA) and system safety analysis (SSA) of **BOX J**.

(c) BOXES C, D, and E Validation and verification of installation criteria.

1 Ensure that the EWIS component qualification satisfies the design requirements and that components are selected, installed, and used according to their qualification characteristics and the aircraft constraints linked to their location (refer to the requirements of §§ 25.1703 and 25.1707).

2 Use available information (digital mockup, physical mockup, airplane data, and historical data) to perform inspections and analyses to validate that design and installation criteria are adequate to the zone/function, including considerations of multi-systems impact. Such inspections and analyses may include a 1st article inspection, design review, particular risk assessment, zonal safety assessment, zonal inspection, and common mode analysis, as applicable. Use such assessments and inspections to ascertain whether design and installation criteria were correctly applied. You should give special consideration to known problem areas identified by service history and historical data (areas of arcing, smoke, loose clamps, chafing, arc tracking, interference with other systems, wires and cables that are required to regularly flex, such as those in doors and hatches, etc.). Regardless of probability, any single arcing failure should be assumed for any power-carrying wire. The intensity and consequence of the arc and its mitigation should be substantiated. Give special consideration to cases where new (previously unused) material or technologies are used. In any case § 25.1703(b) requires that the selection of wires must take into account known characteristics in relation to each installation and application to minimize the risk of wire damage, including any arc tracking phenomena.

3 You should evaluate deviations from installation and component selection criteria identified by these activities. A determination can then be made about their acceptability. Develop alternative mitigation strategies as necessary.

(d) BOXES F & G Development and validation of mitigation strategy. Identify and develop a mitigation strategy for the physical failures and their adverse effects identified in **Boxes D** and **E**. Validation and verification of the mitigation solution should ensure that:

1 Hazardous failure conditions are extremely remote.

2 Catastrophic failure conditions are extremely improbable and do not result from a single common cause event or failure.

3 This mitigation solution does not introduce any new potential failure conditions.

(e) BOX H Incorporation of applicable mitigation strategies. Incorporate newly developed mitigation strategies (**BOX F**) into guidelines (**BOX B**) for further design and inspection and analysis processes.

(f) BOX I Physical failure analysis results. From the EWIS physical failure analysis, document:

- Physical failures addressed.
- Effects of those physical failures.
- Mitigation strategies developed.

This information supports the final analysis documentation (**BOX P**).

ANALYSIS OF POSSIBLE FUNCTIONAL FAILURES

(g) BOX J System safety assessments. Use the results of the airplane level FHA (**BOX A**) to guide the system level FHA (**BOX J**). Incorporate EWIS failures identified by § 25.1709 into the system level and aircraft level FHA, as necessary, the PSSA, the CCA, and the SSA. These analyses are performed to satisfy requirements of § 25.1309. Use results of these analyses to update the EWIS definition (**BOX B**).

(h) BOXES K, L, and M Hazardous and catastrophic failure conditions.

Use the analyses in **BOX J** to determine if the EWIS associated with the system under analysis can contribute (in whole or in part) to the failure condition under study. Determine whether the EWIS failure needs to be mitigated. If so, develop, validate, and verify a mitigation strategy. If no mitigation is needed, complete the appropriate safety assessment per § 25.1309, § 25.671, etc..

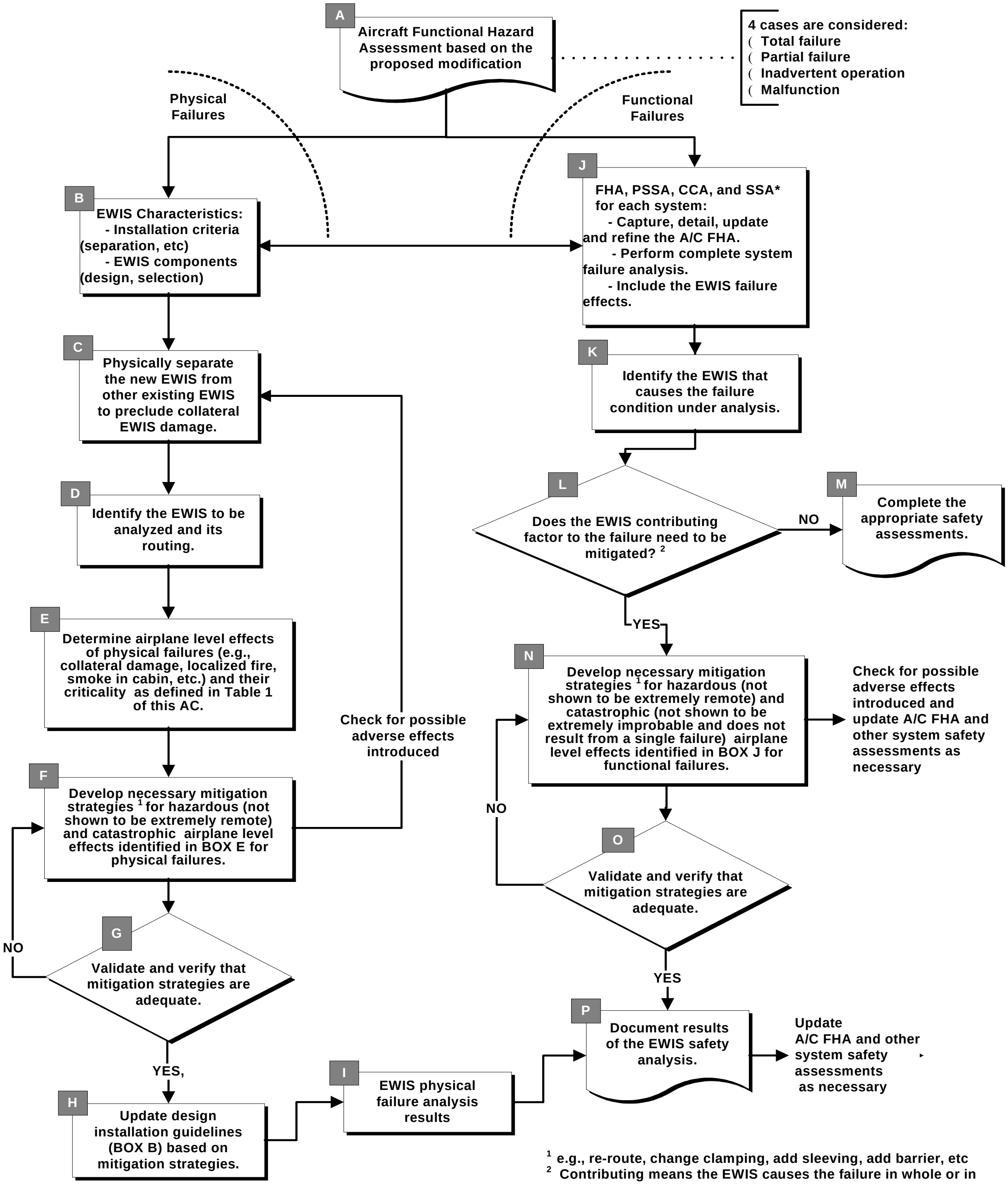
> **NOTE:** If the EWIS was the failure cause, the subsequent mitigation strategy developed may introduce new adverse effects not previously identified by the analysis. Check for any new adverse effects and update the aircraft level FHA and other system safety assessments as necessary.

(i) BOXES N and O Development and validation of mitigation strategy. Identify and develop a mitigation strategy for the functional failures and adverse effects identified in **BOX J**. Validation and verification of the mitigation solution should -

- Determine if initial objective is fully reached.
- Confirm that this mitigation solution is compatible with existing installations and installation criteria.

(j) BOX P Documentation of EWIS safety analysis results. After mitigation strategies have been validated and verified, document the results of the§ 25.1709 analysis. Update as necessary the aircraft level FHA that has been developed in support of certification of the proposed modification, in compliance with § 25.1309 (**BOX A**).

Flowchart 2: Post-TC Safety Analysis Concept



[1] e.g., re-route, change clamping, add sleeving, add barrier, etc
[2] Contributing means the EWIS causes the failure in whole or in part
* FHA: Functional Hazard Assessment
PSSA: Preliminary System Safety Assessment
CCA: Common Cause Analysis
SSA: System Safety Assessment

Mitigation as used in this flowchart means to eliminate the hazard entirely or minimize its severity and probability to an acceptable level. In the case of § 25.1709, the EWIS failure must be mitigated to a point where the probability of a hazardous failure is at least extremely remote and the probability of a catastrophic failure is at least extremely improbable

(12) Descriptive Text for Flowchart 2.

(a) Applicants for post-TC modifications should use the analysis depicted in Flowchart 2 when the applicant cannot identify the systems or systems functions contained in existing aircraft EWIS that may be utilized as part of the modification. An applicant should not add EWIS to an existing EWIS if the systems or systems functions contained in the existing EWIS are unknown. To do so could introduce unacceptable hazards. For example, IFE power wires could inadvertently be routed with aircraft autoland EWIS.

(b) The main objectives are to ensure that the proposed modification –

- Will be correctly designed and installed.
- Will not introduce unacceptable hazards either through its own failure or by adversely affecting existing aircraft systems.

As far as EWIS is concerned, correct incorporation of the modification should be ensured by both good knowledge of original aircraft manufacturer installation practices and their correct implementation or by adequate separation of the added EWIS from existing EWIS. In either case, physical analyses should be performed (similar to the physical failures part of Flowchart 1).

(c) **BOX A** **Aircraft functional hazard assessment.** Airplane level effects must be considered for modified systems or systems added to the aircraft. If the airplane level FHA is available, the applicant should examine it to determine the airplane level effect of the proposed modification. If the airplane level FHA is not available, then the applicant must generate an airplane level FHA based on the proposed modification. This airplane level FHA would be limited to just those airplane systems affected by the proposed modification. If it is determined that no airplane level functional effects are introduced, a statement to this effect and the supporting data is sufficient to satisfy **BOX A**.

ANALYSIS OF POSSIBLE PHYSICAL FAILURES

(d) **BOX B** **EWIS characteristics.** Use results of the airplane level FHA (**BOX A**) to identify EWIS installation criteria and definitions of component characteristics. Results of **BOX B** are fed into the PSSA and SSA of **BOX J**.

(e) **BOX C** **Physical separation of new EWIS from existing EWIS.**

1 Separate the EWIS to be added from existing airplane EWIS since the systems or system functions contained in the existing EWIS are unknown. Establish physical separation between the new and existing EWIS either by separation distance or by an appropriate barrier or other means shown to be at least equivalent to the physical separation distance when allowed by § 25.1707. Methods given in the advisory material for § 25.1707 provide an acceptable way to determine adequate separation.

2 In cases where separation cannot be maintained because of physical constraints (e.g., terminal strips and connectors), the applicant should accomplish the appropriate analysis to show that no adverse failure conditions result from sharing the common device. This analysis requires knowledge of the systems or system functions sharing the common device (e.g., terminal strips and connectors).

(f) BOXES D and E Validation and verification of installation criteria.

1 Ensure that the EWIS component qualification satisfies the design requirements and that components are selected, installed, and used according to their qualification characteristics and the airplane constraints linked to their location (refer to the requirements of §§ 25.1703 and 25.1707).

2 Use available information (digital mockup, physical mockup, airplane data, and historical data) to perform inspections and analyses to validate that design and installation criteria are adequate to the zone/function, including considerations of multi-systems impact. Such inspections and analyses may include a 1^{st} article inspection, design review, particular risk assessment, zonal safety assessment, zonal inspection, and common mode analysis, as applicable. Use such assessments and inspections to ascertain whether design and installation criteria were correctly applied. You should give special consideration to known problem areas identified by service history and historical data (areas of arcing, smoke, loose clamps, chafing, arc tracking, interference with other systems, etc.). Regardless of probability, any single arcing failure should be assumed for any power-carrying wire. The intensity and consequence of the arc and its mitigation should be substantiated. You should give special consideration to cases where new (previously unused) material or technologies are used. Evaluate deviations from installation and component selection criteria identified by these activities and determine their acceptability.

3 Alternative mitigation strategies should be developed as necessary.

(g) BOXES F & G Development and validation of mitigation strategy. Identify and develop a mitigation strategy for the physical failures identified in **BOXES D** and **E** and resulting adverse effects. Validation and verification of a mitigation solution should ensure that:

1 Hazardous failure conditions are extremely remote.

2 Catastrophic failure conditions are extremely improbable and do not result from a single common cause event or failure.

3 This mitigation solution does not introduce any new potential failure conditions.

h) BOX H Incorporation of Applicable Mitigation Strategies. Incorporate newly developed mitigation strategies (**BOX F**) into guidelines (**BOX B**) for further design and inspection and analysis process.

(i) BOX I Physical failure analysis documentation. From the EWIS physical failure analysis, document:

- Physical failures addressed.
- Effects of those physical failures.
- Mitigation strategies developed.

This information supports the final analysis documentation (**BOX P**).

ANALYSIS OF POSSIBLE FUNCTIONAL FAILURES

(j) BOX J System safety assessments. Use the results of the airplane level FHA (**BOX A**) to guide the system level FHA (**BOX J)**. Incorporate EWIS failures identified by § 25.1709 into the system level and aircraft level FHA, as necessary, the PSSA, the CCA, and the SSA. These analyses are performed to satisfy requirements of § 25.1309. Use results of these analyses to update the EWIS definition (**BOX B**).

(k) BOXES K, L, and M Hazardous and catastrophic failure conditions. Use the analyses in **BOX J** to determine if the EWIS associated with the system under analysis can contribute (in whole or in part) to the failure condition under study. Determine whether the EWIS failure needs to be mitigated. If so, develop, validate, and verify a mitigation strategy. If no mitigation is needed, complete the appropriate safety assessment (e.g., per § 25.1309, § 25.671, etc.).

(l) BOXES N and O Development and validation of mitigation strategy. Identify and develop a mitigation strategy for the functional failures and adverse effects identified in **BOX J**. Validation and verification of the mitigation solution should:

- Determine if initial objective is fully reached.
- Confirm that this mitigation solution is compatible with existing installations and installation criteria.

> **NOTE:** If the EWIS was the failure cause, the subsequent mitigation strategy developed may introduce new adverse effects not previously identified by the analysis. Check for any new adverse effects and update the aircraft level FHA and other system safety assessments as necessary.

(m) BOX P Documentation of EWIS safety analysis results. After mitigation strategies have been validated and verified, document the results of the § 25.1709 analysis. Update as necessary the aircraft level FHA that has been developed in support of certification of the proposed modification, in compliance with § 25.1309, (BOX A).

f. § 25.1711 COMPONENT IDENTIFICATION: EWIS. Section 25.1711 requires applicants to identify EWIS components using consistent methods that facilitate easy identification of the component, its function, and its design limitations. For EWIS associated with flight-essential functions where specific certification requirements are met by redundancy, identification of the EWIS must also include separation requirements. This section requires that the identifying markings remain legible throughout the expected service life of the EWIS component, and that the method used to identify components have no adverse effect on their performance.

(1) § 25.1711(a). This section requires a consistent method of EWIS identification to avoid confusion and mistakes during airplane manufacturing, modification, and maintenance. This means we expect airplane manufacturers to develop an EWIS identification method that facilitates easy identification of the systems that any specific EWIS component supports and use that identification method in a consistent manner throughout the airplane. This consistent identification method must be used for new type certifications and changes to those designs.

(2) § 25.1711(b). Certain airplane systems are installed with redundancy because of certification rules or operating rules or in order to meet the reliability requirements of § 25.1709. For EWIS components associated with these systems, paragraph (b) requires specific identification indicating component part number, function, and separation requirement. This is necessary to prevent modifiers from unintentionally introducing unsafe design or installation features on previously certified airplanes when they install new or modified systems. Such identification will aid the designers and installers of the new system by alerting them to the presence of these systems. It will enable them to make appropriate design and installation decisions. Component identification will also make those performing maintenance and inspections more aware of what systems are associated with specific EWIS in the areas undergoing maintenance or inspection.

(3) § **25.1711(c).** Paragraph (c) requires that identifying markings required by § 25.1711(a) and (b) remain legible throughout the design life of the component. As most wire installations are designed to remain on the airplane throughout the airplane's service life, this means the identification marks must be able to be read for the life of the airplane. The method of marking must take into account the environment in which the EWIS component will be installed. The Society of Automotive Engineers (SAE) documents ARP 5607, "Legibility of Print on Aerospace Wire and Cables," and AS 5942, "Marking of Electrical Insulating Materials," provide guidance on this subject. Dot matrix and ink-jet marking should only be used when there is no strong need for chemical or mechanical resistance of the ink. The color used for identification should contrast with the wire insulation, sleeve, support material, or other EWIS components.

(4) § **25.1711(d).** Paragraph (d) requires that the means used to identify an EWIS component may not have an adverse effect on component performance throughout its design life. The preferred method of EWIS component identification is with dot matrix, ink-jet, or laser marking.

(a) Certain wire marking methods have potential to damage wire insulation. Hot-stamp marking is one such method. According to SAE aerospace information report AIR5575, "Hot Stamp Wire Marking Concerns for Aerospace Vehicle Applications," the hot-stamp marking method is not well suited for today's generation of aircraft wiring. As noted in that document, wire insulation has become markedly thinner over the years since the procedure was first introduced in the 1940s. Because of this, problems have arisen over wire damage from excessive penetration by the hot stamp process. The document further states: "The frequent need for adjustments in temperature, pressure, and dwell time inherent to achieving legible hot stamp wire marking provides many opportunities for error. The controls, methods, and guidance necessary to achieve satisfactory performance with hot stamp marking are often not made available to operators in smaller wire shops."

(b) If damage to the insulation occurs during the marking process, it may fail later in service after exposure to the sometimes-harsh environmental conditions of aircraft use. While § 25.1711(d) does not prohibit use of hot-stamp marking, its use is not encouraged. To comply with this paragraph, if the hot-stamp marking process is used, the guidelines of SAE recommended practice ARP5369, “Guidelines for Wire Identification Marking Using the Hot Stamp Process” or equivalent should be followed. Other information related to the use of the hot-stamp marking process can be found in SAE AIR 5575 and European Association of Aerospace Industries (AECMA) EN3197.

(c) In some cases it may not be practical to mark an EWIS component directly because of component size or identification requirements. In this case other methods of identification, such as a label or sleeve, should be used.

(5) § 25.1711(e). Paragraph (e) requires that EWIS modifications to the type design take into consideration the identification scheme of the original type design. This is to ensure that the consistency required by § 25.1711(a) is maintained when a modification is installed. The intent of this requirement is to provide continuity for EWIS identification on a particular model. It is not the intent of the requirement to impose on the modifier the exact wire identification methods of the airplane manufacturer. However, since the purpose of § 25.1711 is to make it easy to identify those airplane systems essential to safe operation of the airplane, it is in the best interest of safety that designers of any modifications to the original design consider the approved type design identification methods. For example it would not be appropriate for a modifier to use purple wire to identify a specific flight critical system when the approved type design used the color green, especially if the type design already uses purple wire to identify non-essential systems. Such a scheme could cause confusion and lead future modifiers or maintainers to believe that the routing of purple wires with green wires (and thus critical systems with non-essential systems) is acceptable. The regulation does not prescribe a particular method for identification but is meant to ensure that consistent identification is maintained throughout the life of the airplane.

(6) Visible Identification of Critical Design Configuration Limitations. Section 25.981(b) states that "...visible means to identify critical features of the design must be placed in areas of the airplane where maintenance actions, repairs, or alterations may be apt to violate the critical design configuration limitations (e.g., color-coding of wire to identify separation limitation)." The design approval holder should define a method of ensuring that this essential information will:

- be communicated by statements in appropriate manuals, such as wiring diagram manuals, and
- be evident to those who may perform and approve such repairs and alterations.

An example of a critical design configuration control limitation that would result in a requirement for visible identification means would be a requirement to maintain wire separation between FQIS (fuel quantity indication system) wiring and other electrical circuits that could introduce unsafe levels of energy into the FQIS wires. Acceptable means of providing visible identification for this limitation would include color-coding of the wiring or, for retrofit, placement of identification tabs at specific intervals along the wiring.

(7) Types of EWIS component identification. There are at least four types of EWIS component identification that are accomplished at different stages. They are listed and described below.

(a) Component manufacturer part number. EWIS components should be identified by their manufacturer in accordance with the International Organization for Standardization document ISO 2574, "Aircraft – Electrical Cables – Identification Marking," or similar specifications. This identification comprises product part number, manufacturer identification, and, when possible or specifically required, batch identification or year of manufacture. This helps ensure:

- Identification and traceability of the component.
- Verification of compliance with the aircraft certification basis.
- Accuracy in manufacture, maintenance, quality control, storage, and delivery.
- Verification of the use of approved/qualified sourcing.
- Monitoring of the aircraft configuration during the aircraft life.

1 EWIS component manufacturer identification. It is common practice to use the five-digit/letter C.A.G.E. (commercial and government entity) code for manufacturer identification, particularly for wires. Alternatively, for small components whose size may make it difficult to use other forms of clear identification, a logo may be used.

2 Identification intervals. Wires and cables should be identified at intervals of not more than 15 inches (380mm). Exceptions can be made for short runs of wires or cables or when the majority of the wire or cable is installed in a manner that facilitates easy reading of the identification markings.

3 Manufacturer markings. Wire manufacturer markings should generally be green to differentiate them from the black marking typically used by the airplane manufacturer, but other contrasting colors are also acceptable.

4 The component technical specification should include methods used for identification and legibility during the design life of the component.

(b) Airframe manufacturer component function identification number. In addition to the type identification imprinted by the original wire manufacturer, aircraft wire should also contain a unique circuit identification coding that is accomplished at time of harness assembly. This allows existing installed wire to be identified as to its performance capabilities when considering replacement. Inadvertent use of a lower performance and unsuitable replacement wire can thus be avoided. Identification of EWIS components by the airframe manufacturer helps ensure:

- Identification and inspection of cable runs.
- Accuracy of manufacture, maintenance, quality control, storage, and delivery.
- Verification of the system to which the component belongs.
- Identification of components related to systems required for safe flight, landing, or egress or that have the potential to impact the flightcrew’s ability to cope with adverse operating conditions.

Identification of EWIS components should clearly correspond to aircraft wiring manuals.

(c) Airframe manufacturer routing identification and modification. Electrical drawings should describe wire routings through the entire airplane indicating, for example, incompatibility between routes, minimum distance between routes, and absolute bans on combining bundles. Electrical drawings should be available in the maintenance documentation as required by paragraph H25.5 of Appendix H to part 25. This information ensures that modification designers and maintenance personnel are aware of the defined physical separation of the different routes of the aircraft model they are working on. Coding for identification of routes or bundles used on aircraft should be displayed by adequate means such as labels, tags, placards, colored ties, or bar-codes. This type of component identification helps insure:

- Identification and inspection of bundles.
- Accuracy of manufacture, maintenance, quality control, storage, and delivery.
- Determination of the type of route, or route function, (feeder power, radio etc.).
- Clear identification of systems that require physical separation (to detect the possible mix of different routes/bundles, the misrouting of a system in an area, etc.).
- Identification of routes taken by systems required for safe flight, landing, egress, or those that have the potential to

impact the ability of the flightcrew to cope with adverse operating conditions.

1 Modification and repairs identification, in a form that helps ensure the original airplane manufacturer's identification scheme, should be maintained throughout the service life of the airplane.

2 Wire and cable routing information should be identified at intervals of preferably not more than 18 inches (460mm) and should not obscure the identification markings of the EWIS component manufacturer or airframe manufacturer component function identification numbers described in paragraphs 5.f.(7)(a) and 5.f.(7)(b). Also, exceptions can be made for short runs of wires or cables or when the majority of the wire or cable is installed in a manner that facilitates easy reading of the identification markings. Coaxial cables may be identified at both ends of the coax if marking the cable at regular intervals would cause crushing of the cable and potentially damage the foam insulation. Applicants should provide justification for why the chosen identification method would damage the cable.

(d) Identification of user EWIS modification or repair (operator's identification coding). Repairs or modifications to EWIS should follow the identification guidance given in the above paragraphs for airplane manufacturers. This helps ensure that the original airplane manufacturer's identification scheme is not compromised by future modifications or repairs and is maintained throughout the service life of the airplane. A temporary repair identification with a non-hydraulic-resistant material could remain in a hydraulic bay for some days, but such material would not be a suitable marking method for the long term.

g. § 25.1713 FIRE PROTECTION: EWIS. The intent of this requirement is to help ensure that the EWIS does not propagate fire and produce hazardous quantities of smoke and toxic fumes.

(1) § 25.1713(a). This paragraph requires that all EWIS components meet the applicable fire and smoke protection requirements of § 25.831(c). This requirement was formerly located in § 25.869(a)(1). After reasonably probable failures or malfunctions, EWIS components should not cause harmful or hazardous concentrations of gases or vapors in excess of the levels prescribed in § 25.831(b)(1) and (2).

(2) § 25.1713(b). This requirement was formerly located in § 25.869(a)(2). It requires that EWIS components that are located in designated fire zones and used during emergency procedures must be at least fire resistant. This requirement is intended to help ensure that emergency services are available in the event of a fire.

(a) The definition of "fire resistant" is found in 14 CFR 1.1 *General definitions*. As applied to EWIS components it is defined as follows:

To be fire resistant means that EWIS components must have the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.

(b) EWIS components in regions immediately outside fire zones and in engine pod attachment structures should be made of such materials and installed at such a distance from the firewall that they will not suffer damage that could hazard the airplane if the surface of the firewall adjacent to the fire is heated to 1100° C (2012° F) for 15 minutes.

(3) § 25.1713(c). This section was formerly located in § 25.869(a)(4). It requires that insulation on electrical wire and electrical cable installed anywhere in the airplane be self-extinguishing when tested in accordance with the applicable portions of part I Appendix F of part 25.

(a) In addition, to protect against propagation of a fire, EWIS components other than wire and cable should be designed using non-flammable and self-extinguishing materials as tested to the equivalent of part I Appendix F or equivalent.

(b) Maximum physical or spatial separation is especially important above the component, or downstream of any consistent, known airflow. See paragraph 5.d**.**, System Separation EWIS, of this advisory circular, for guidance on demonstrating compliance with the separation requirements of § 25.1707.

h. § 25.1715 ELECTRICAL BONDING AND PROTECTION AGAINST STATIC ELECTRICITY: EWIS. The build-up and subsequent discharge of static electricity has the potential to create hazardous conditions for both airplane systems and people. It can injure people, interfere with installed electrical/electronic equipment, and cause ignition of flammable vapors. All EWIS components used for bonding and protection against static electricity play a vital role in ensuring the integrity of the bonds.

(1) § 25.1715(a). This section requires that EWIS used for electrical bonding and protection against static electricity meet the requirements of § 25.899. To minimize the hazardous effects of static discharge, EWIS components should be selected, designed, and installed so that the cross-sectional area of bonding paths used for primary and secondary bonding ensure that an appropriately low electrical impedance is obtained and maintained throughout the expected service life of the components.

(a) The maximum resistance for electrical bonds varies depending on the type of bond, e.g., ground stud, between connector shell and structure. A typical value is 1 milliohm, but this can vary from .01 milliohms to 3 milliohms. The airplane manufacturer's standard wiring practices manual (SWPM) provides guidance on maximum bonding resistance.

(b) The airplane manufacturer's SWPM provides guidance on proper surface preparation, materials, tooling, maximum torque values, and other variables important to ensuring an adequate bond. One airplane manufacturer's SWPM, for example, states that steel washers, dyed washers, and other washers with a non-conductive surface should not be used in the conductive path of a bond.

(2) § 25.1715(b). This section requires that EWIS components used for any electrical bonding purposes (not just those used for protection against static electricity) provide an adequate electrical return path under both normal and fault conditions. EWIS components should be selected, designed, and installed so that the cross-sectional area of bonding paths used for primary and secondary bonding paths ensure that an appropriately low electrical impedance is obtained and maintained throughout the expected service life of the components.

j. § 25.1717 CIRCUIT PROTECTIVE DEVICES: EWIS. This section requires that electrical wires and cable be compatible with the circuit protective devices required by § 25.1357. This means that when selecting wire and cables for a specific application, care must be taken to ensure selection of the proper type and rating of the circuit protective device (e.g., circuit breaker) so that the wire and cables are adequately protected from over-current situations. This section is based on the requirements that were formerly found in § 25.1353(d)(1).

k. § 25.1719 ACCESSIBILITY PROVISIONS: EWIS. This section requires that means be provided to allow for inspection of EWIS and replacement of their components as necessary for continued airworthiness.

(1) The intent of § 25.1719 is to ensure that EWIS components are installed so that inspections, tests, repairs, and replacements can be undertaken with a minimum of aircraft disassembly. When adjacent structures and aircraft systems components must be removed to allow access to wire installations, new possibilities for contamination, chafing, and other types of damage are introduced.

(2) As far as practicable, EWIS components should be installed so that inspections, tests, repair, and replacements can be done without undue disturbance to the EWIS installation or to surrounding aircraft systems. During the design phase, consider minimizing the amount of aircraft disassembly required to perform such tasks. For example, wiring inside conduit may incur damage from chafing against the sides of the conduit. If failure of wiring inside a conduit can lead to a hazardous or catastrophic condition, a means should be provided for inspection of those wires. As in the example, there may be other areas of the airplane where human physical access is not possible. In those situations, other types of inspection techniques should be developed. These "other" types of inspection may be by testing or other means acceptable to the Administrator and should be included in the maintenance requirements that are part of the Instructions for Continued Airworthiness.

l. § 25.1721 PROTECTION OF EWIS. The requirements of this section are intended to prevent damage to EWIS by passengers, crew members, baggage or cargo handlers, or maintenance and service personnel, or by movement of cargo or baggage. Section 25.1721(a) is applicable to EWIS located in cargo or baggage compartments, and §§ 25.1721(b) and (c) apply to EWIS located anywhere in the airplane.

(1) § 25.1721(a). The requirements of this paragraph, as they pertain to EWIS, were formerly located in § 25.855(e). Under section 25.1721(a), EWIS cannot be located in cargo or baggage compartments if its damage or failure may affect safe operation unless it cannot be damaged by movement of cargo or baggage in the compartment and unless its breakage or failure will not create a fire hazard. This means that any EWIS located in a cargo or baggage compartment must be protected against damage. It further means that EWIS must be designed and installed so that if it fails or breaks, for whatever reason, such as failed wire bundle support devices, damage to cargo liners, or chafed wires, such failure will not create a fire hazard. It does not matter if the EWIS located in the compartment is associated with a flight critical or essential system or a passenger convenience system, such as an IFE system. Failure of an EWIS component, no matter what system it is associated with, could cause a fire or other type of damage to aircraft systems or structure. EWIS in general and wiring in particular should be installed so the structure affords protection against its use as a handhold and damage from cargo. Wires and wire bundles should be routed or otherwise protected to minimize the potential for maintenance personnel stepping, walking, or climbing on them. Wire bundles should be routed along heavier structural members whenever possible. If the structure does not afford adequate protection, other protection means such as a mechanical guard should be provided. When EWIS is close to sharp metal edges, the edges should be protected by grommets to prevent chafing. Additionally, wires should not be routed between aircraft skin and fuel lines within the same plane.

(2) § 25.1721(b). This paragraph requires that EWIS be designed and installed to minimize its damage and risk of damage by movement of people in the airplane during all phases of flight, maintenance, and servicing. Some examples of areas of concern are the flight deck, passenger compartment, crew rest area, wheel wells, and wing leading and trailing edges.

(a) Special consideration should be given to EWIS that are routed to and on passenger seats. It should be protected so that passengers cannot damage it with their feet or access it with their hands.

(b) EWIS located in the lavatories should not be readily accessible by passengers or aircraft cleaners. It should be designed and installed so that it cannot be damaged by the removal and replacement of items such as trash containers.

(c) EWIS located in the galleys should not be readily accessible by cabin crew, aircraft cleaners, or passengers. It should be designed and installed so that galley equipment, including galley carts, cannot come into contact with it and cause damage. The design and installation of EWIS around and in galley areas should be such that galley equipment, such as chiller units, can be removed and reinstalled without coming into contact with EWIS components and damaging them.

(d) As with EWIS located in baggage and cargo compartments, EWIS in areas such as landing gear bays, the APU compartment, and electrical and electronic bays should be designed and installed to minimize potential for maintenance personnel stepping, walking, or climbing on them. Where the structure does not afford adequate protection, other protection such as a mechanical guard should be provided.

(3) § 25.1721(c). This paragraph requires that EWIS be designed and installed to minimize its damage and risk of damage by items carried onto the aircraft by passengers or cabin crew. This is intended to protect EWIS from items such as baggage that is carried on board by passengers and cabin crew and stowed beneath passenger seats or other places where luggage is likely to be stowed.

m. § 25.1723 FLAMMABLE FLUID FIRE PROTECTION: EWIS.

(1) This section requires that EWIS located in areas where flammable fluid or vapors might escape must be considered to be a potential ignition source. As a result, these EWIS components must meet the requirements of § 25.863. Section 25.863 requires that efforts be made to minimize the probability of ignition of fluids and vapors, and the hazards if ignition does occur. See § 25.1707 for the separation requirements between EWIS and flammable fluids. Paragraph 5d of this AC contains the advisory material for § 25.1707.

(2) The airplane manufacturer defines fuel vapor zones. EWIS components located in fuel vapor zones should be qualified as explosion proof (when applicable OR when appropriate) in accordance with Section 9 of RTCA

Document DO160 or EUROCAE ED-14, "Environmental Conditions and Test Procedures for Airborne Equipment," latest approved revision, or other equivalent approved industry standard.

(3) The possibility of contamination with flammable fluids due to spillage during maintenance action should also be considered.

n. § 25.1725 Powerplants: EWIS.

(1) § 25.1725(a). This paragraph requires that the failure of EWIS components must be considered when demonstrating compliance with the requirements of § 25.903(b). That means that when a powerplant fails or malfunctions, an EWIS component may not fail in such a way as to prevent continued safe operation of the remaining powerplants or require immediate action by any crewmember for continued safe operation.

(2) § 25.1725(b). This paragraph requires that design of EWIS must consider their damage from a powerplant rotor failure or from a fire originating in the powerplant that burns through the powerplant case. The design of EWIS must minimize hazards to the airplane when these events occur.

o. § 25.1727 Flammable fluid shutoff means: EWIS. This section requires that EWIS associated with each flammable fluid shutoff means and control be fireproof or be located and protected so that any fire in a fire zone will not affect operation of the flammable fluid shutoff means, in accordance with the requirements of § 25.1189.

p. § 25.1729 INSTRUCTIONS FOR CONTINUED AIRWORTHINESS: EWIS. Section 25.1729 requires applicants to prepare Instructions for Continued Airworthiness (ICA) in accordance with sections H25.4(a)(3) and H25.5. The guidance for those sections of Appendix H applicable to EWIS ICA are contained in paragraph 5.s. of this AC.

q. § 25.1731 POWERPLANT AND APU FIRE DETECTOR SYSTEMS: EWIS. To minimize occurrences of nuisance fire warnings, consider separately routing fire detection system wiring within the fire zone to allow optimal routing and ease of replacement. Exercise particular care regarding the environmental qualification of the system connectors (fire resistance, resistance to moisture and fluids, etc.).

r. § 25.1733 FIRE DETECTOR SYSTEMS, GENERAL: EWIS. The environmental qualification of the fire detector system components should include the use of fire resistant EWIS components and/or design to ensure that the system will detect fire if exposed to it.

s. APPENDIX H TO PART 25 INSTRUCTIONS FOR CONTINUED AIRWORTHINESS REQUIREMENTS FOR EWIS. Following is a discussion of the requirements for incorporating EWIS component information in the ICA for aircraft. Including EWIS in the ICA will promote proper maintenance, repair, and modification of EWIS components. Improper maintenance, repair, and modification often hastens the "aging" of EWIS. To properly maintain, repair, and modify airplane EWIS, certain information needs to be available to people who design, modify, install, and maintain it. Sections H25.4(a)(3) and H25.5 require applicants for both type certificates and supplemental type certificates to prepare ICA for EWIS. The EWIS-related ICA must be approved by the cognizant FAA office and be in the form of a document easily recognizable as EWIS ICA. The following paragraphs, 5.s.(1) through 5.s.(7), provide specific guidance on acceptable compliance methods for EWIS ICA.

(1) H25.4(a)(3). This section requires the applicant to include in the Airworthiness Limitations section of the Instructions for Continued Airworthiness any mandatory replacement times for EWIS components. EWIS components are those defined by § 25.1701. Generally, EWIS components are designed and selected to last for the service life of the airplane. Any EWIS component that must be replaced at regular intervals to maintain the airworthiness of the associated system or airplane must be specified, with its required replacement interval, in the Airworthiness Limitations section of the ICA.

(2) H25.5(a). This section requires applicants to prepare ICA applicable to EWIS. The ICA must cover all EWIS components as defined in § 25.1701. The rule requires that the FAA approve the EWIS ICA.

(3) H25.5(a)(1). This paragraph requires applicants to prepare EWIS maintenance and inspection requirements using an enhanced zonal analysis procedure (EZAP). An EZAP is a specifically wire-focused version of the zonal analysis procedure widely used to analyze an airplane's physical areas or zones. It is used for developing maintenance tasks. One version of an EZAP is described in AC 25-27 *Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure*

(4) H25.5(a)(2). This paragraph requires applicants to document EWIS maintenance practices in a standard format. This is typically accomplished with publication of a standard wiring practices manual (SWPM). The rule is not intended to require that every manufacturer's SWPM be identical. The intent is to enable people performing EWIS maintenance and repairs to find needed information in the SWPM more quickly and easily, regardless of what airplane model they are currently working on. Standard wiring practices include procedures and practices for the installation, repair, and removal of EWIS components, including information about wire splices, methods of bundle attachment, connectors and electrical terminal connections, bonding, and grounding. A SWPM is not a design manual, and designers of EWIS modifications for specific airplane models should not use it as such. But it does provide the designer with insight into the types of EWIS components used by the TC holder and the procedures recommended by the manufacturer for maintenance or repair that supports continued airworthiness of the components. Advisory Circular 25-26, *Development of Standard Wiring Practices Documentation*, provides guidance on how to comply with the requirements of paragraph H25.5(a)(2) of Appendix H to part 25.

(5) H25.5(a)(3). This section requires applicants to include EWIS separation requirements in the ICA. EWIS separation requirements are important for maintaining the safe operation of the airplane. Maintenance and repair personnel need to be aware of the type certificate holder's separation requirements so they do not compromise separation in previously certified systems. This requirement will help maintenance, repair, and modification personnel easily determine EWIS separation requirements.

(a) Determination of EWIS separation requirements is required by § 25.1707. To comply with H25.5(a)(3), the applicant needs to develop a way to convey these separation requirements and place them in the ICA. For example, if an airplane has a fly-by-wire flight control system and a minimum of 2 inches of physical separation is needed between the EWIS associated with the flight control system and other EWIS, this information must to be available in the ICA. Similarly, the separation of certain wires in fuel tank systems may be critical design configuration control items and therefore qualify as an airworthiness limitation. Maintenance personnel need these separation requirements and limitations because many times wire bundles must be moved or removed to perform maintenance.

(b) The separation data included in the ICA can take many forms. If a particular airplane model has fly-by-wire flight controls, the manufacturer may designate the EWIS associated with the flight control systems by a certain identification scheme (as required by § 25.1711), and in the ICA state that EWIS so designated must be maintained with XX amount of separation from all other EWIS and YY amount of separation from other airplane systems and structure. The manufacturer can then repeat this information for other EWIS associated with other airplane systems. The ICA could indicate how EWIS associated with IFE and other passenger convenience systems is identified, and that this EWIS must be maintained XX inches from other categories of EWIS or structure.

(c) It is not the intent of the regulation to require a design approval holder or an applicant to divulge proprietary information in order to comply. Certain information, however, needs to be made available to modifiers and maintainers to ensure that future modifications and repairs do not invalidate previously certified designs.

(6) H25.5(a)(4). This paragraph requires that the ICA contain information explaining the EWIS identification method and requirements for identifying any changes to EWIS. This requirement is intended to ensure that future modifications adding EWIS identify those added EWIS with the same type of identification scheme used by the original airplane manufacturer. This information will help modification designers and modification personnel avoid improper modification and repair of existing EWIS or improper installation of new EWIS. These personnel need to review the applicable standard wiring practices, EWIS identification requirements, and electrical load data for the airplane they are modifying.

(7) H25.5(a)(5).

(a) This paragraph requires that the ICA contain electrical load data and instructions for updating that data. Electrical load data and the instructions for updating it are necessary to help ensure that future modifications or additions of equipment that consume electrical power do not exceed the generating capacity of the onboard electrical generation and distribution system. Maintaining a record of actual airplane electrical loads is important to ensure that modifications to the original design do not impose electrical loads on the electrical generating system in excess of the system's capability to provide the necessary power and maintain necessary margins. To comply with the requirements of this paragraph applicants need to provide:

1 Electrical generating capacity of each source of normal electrical power generation.

2 Electrical generating capacity of each source of emergency power generation.

3 Electrical load capacity of each electrical bus.

4 Actual electrical loading of each electrical bus.

(b) The airplane manufacturer is responsible for preparing, and including in the ICA, the electrical load data as required by this section for the "as-delivered" airplane. It is then the responsibility of subsequent modifiers to update the electrical load data when the proposed modification requires the data to be revised (i.e., when required by § 25.1351(a)).

The airplane manufacturer is responsible for preparing, and including in the ICA, the electrical load data as required by this section for the "as-delivered" airplane. It is then the responsibility of subsequent modifiers to update the electrical load data when the proposed modification requires the data to be revised (i.e., when required by § 25.1351(a)).

APPENDIX A

RELATED REGULATIONS AND DOCUMENTS

REGULATIONS. You can download an electronic copy of 14 CFR from the Internet at http://www.gpoaccess.gov/cfr/. A paper copy can be ordered by sending a request to the U.S. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-0001, or by calling telephone number (202) 512-1800; or by sending a request by facsimile to (202) 512-2250.

- § 25.773 Pilot compartment view.
- § 25.831 Ventilation.
- § 25.863 Flammable fluid fire protection.
- § 25.869 Fire protection: systems.
- § 25.899 Electrical bonding and protection against static electricity.
- § 25.903 Engines.
- § 25.981 Fuel tank ignition prevention.
- § 25.1165 Engine ignition systems.
- § 25.1189 Shutoff means.
- § 25.1203 Fire detector system.
- § 25.1301 Function and installation.
- § 25.1303 Flight and navigation instruments.
- § 25.1309 Equipment, systems, and installations.
- § 25.1310 Power source capacity and distribution.
- § 25.1316 System lightning protection.
- § 25.1331 Instruments using a power supply.
- § 25.1351 General.
- § 25.1353 Electrical equipment and installations.
- § 25.1355 Distribution system.
- § 25.1357 Circuit protective devices.
- § 25.1360 Precautions against injury.
- § 25.1362 Electrical supplies for emergency conditions.
- § 25.1365 Electrical appliances, motors, and transformers.
- § 25.1431 Electronic equipment.
- § 25.1529 Instructions for Continued Airworthiness.

OTHER RELATED CFR PARTS.

Part 21	Certification Procedures for Products and Parts
Part 43	Maintenance, Preventive Maintenance, Rebuilding, and Alteration
Part 91	General Operating and Flight Rules
Part 121	Operating Requirements: Domestic, Flag, and Supplemental Operations
Part 125	Certification and Operations: Airplanes having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More: and Rules Governing Persons on Board Such Aircraft
Part 129	Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage
Part 145	Repair Stations

ADVISORY CIRCULARS. You can download an electronic copy of the latest version of the following ACs from the FAA Internet at http://rgl.faa.gov.

- 25-10 Guidance for Installation of Miscellaneous, Nonrequired Electrical Equipment
- 25-16 Electrical Fault and Fire Protection and Prevention
- 43-13.1B Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair
- 25.773-1 Pilot Compartment View Design Considerations
- 25-869-1 Electrical Smoke and Fire Protection
- 25.981-1B Fuel Tank Ignition Source Prevention Guidelines
- 25.1309-1A System Design and Analysis
- 25.1310-1 Power Source Capacity and Distribution
- 25.1353-1 Electrical Requirements and Installations
- 25-1357-1 Circuit Protective Device Accessibility
- 25-1360-1 Electric Shock and Burns
- 25-1362 Electrical Supply for Emergency Service
- 25.1363-1 Electrical System Tests
- 25-26 Development of Standard Wiring Practices Documentation
- 25-27 Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure

POLICY MEMORANDA. You can download an electronic copy of the latest version of the following policy memoranda from the FAA Internet at http://rgl.faa.gov.

PS-ANM100-1999-0021	Requirements of FAR 25.1357(e)
PS-ANM100-2000-00105	Interim Policy Guidance for Certification of In-Flight Entertainment Systems on Title 14 CFR Part 25 Aircraft
PS-ANM100-2001-00113	Interim Summary of Policy and Advisory Material Available for Use in the Certification of Cabin Mounted Video Camera Systems with Flight Deck Displays on Title 14 CFR Part 25 Aircraft
PS-ANM111-2002-01-04	System Wiring Policy for Certification of Part 25 Airplanes

REPORTS.

"Task 6 Final Report" Aging Transport Systems Rulemaking Advisory Committee, dated October 29, 2002. (http://www.mitrecaasd.org/atsrac/final_reports/Task_6_Final_Report-10-29-2002.pdf)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) DOCUMENTS.
(http://www.sae.org/servlets/index)

NOTE: AS = Aerospace Standard
AIR = Aerospace Information Report
ARP = Aerospace Recommended Practice

AS4373	Test Methods for Insulated Electric Wire
AS50881	Wiring Aerospace Vehicle
AS70991	Terminals: Lug and Splice, Crimp Style, Aluminum, For Aluminum Aircraft Wire
AS7928	Terminals, Lug: Splices, Conductor: Crimp Style, Copper, General Specification For
AS81824	Splices, Electric, Permanent, Crimp Style Copper, Insulated, Environment Resistant

AIR5575 Hot Stamp Wire Marking Concerns for Aerospace Vehicle Applications

ARP5369 Guidelines for Wire Identification Marking Using the Hot Stamp Process

ARP4404 Aircraft Electrical Installations

EUROPEAN NORMS.

EN 34375 Aerospace Series – Cables, Electrical, Aircraft Use (http://en-standards.standardsdirect.org/EN-Sheet124_list_48.html)

prEN 2853 Current Ratings for Electrical Cables to be Installed on Aircraft (in development)

prEN 3197 Aerospace Series – Installation of Aircraft Electrical and Optical Interconnection Systems (in development)

OTHER DOCUMENTS.

RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment (http://www.rtca.org/downloads/DEC%202004%20-%2005-01-06.htm#_Toc92863870)

Eurocae ED-14 Environmental Conditions and Test Procedures for Airborne Equipment (http://www.eurocae.org/cgi-bin/home.pl?Target=va/documents/documents_general.html&Num=4)

International Organization for Standardization Document ISO 2574
Aircraft –Electrical Cables – Identification Marking
http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_detail_ics.htm?csnumber=7536&ICS1=1&ICS2=70)

APPENDIX B

NPRM PART 25 SUBPART H AND APPENDIX H DISCUSSION

Following are the discussions of the Part 25, Subpart H and Appendix H requirements published in the *Federal Register* on October 6, 2005, (70 FR 58508) in Notice of Proposed Rulemaking No 05-08, Enhanced Airworthiness Program for Airplane Systems/Fuel Tank Safety (EAPAS/FTS), at the time these rules were proposed.

NOTE: Some of the section numbers of the final rule are different than those proposed in the NPRM. Most of the proposed advisory circulars (AC) have been given final numbers. For ease of reference, the proposed section numbers have been replaced with the final section numbers, and the proposed ACs are identified with their final numbers, when available. Other than that, no other changes have been made to the preamble discussion that follows.

Part 25 Subpart H—Electrical Wiring Interconnection Systems (EWIS)

The proposed subpart H consists of relocated, revised, and new regulations about EWIS. Unless we say otherwise, our purpose in moving requirements to subpart H is to ensure their application to EWIS. We do not intend to change their legal effect in any other way.

Section 25.1701 Definition.

Proposed § 25.1701 would define what constitutes an EWIS for the purposes of complying with the proposed subpart H requirements and other EWIS-related requirements of parts 25, 121, and 129.

Current regulations do not provide a definition of a wiring system. Without this definition, the proposed rules could be inconsistently applied to various wire-related components. To completely address the safety issues associated with wiring systems, requirements must address not only the wiring itself, but also components and devices that are required to adequately install and identify each wire. Various components and devices needed to route and identify wires are critical in ensuring that a proper electrical interconnection is made and maintained.

For the purposes of this NPRM, the term “wire” means bare and/or insulated wire used for the purpose of electrical energy transmission, grounding, or bonding. This includes electrical cables, coaxial cables, ribbon cables, power feeders, and databuses.

A proper electrical interconnection between two or more points requires more than just wire. Making the connection in a manner that ensures both functionality and safety requires various types of components, of which wire is one. Therefore, a clear definition of an electrical interconnection is necessary. The proposed regulation provides this and at the same time introduces the term “electrical wiring interconnection system (EWIS)” to describe that interconnection. The term EWIS means any wire, wiring device, or combination of these, including termination devices, installed in the airplane for transmitting electrical energy between two or more termination points. The proposed regulation expands on this basic statement to clearly identify which wire-related components are included in the EWIS definition and which are not. Most wires are routed with other wires that make up wire bundles and cable assemblies (or “looms,” as they are sometimes called). A single wire may also be routed separately. The same definition of an EWIS is applied to a single wire or to a bundle containing hundreds of wires.

To complete an electrical connection, various types of connectors are necessary. Examples are MS connectors (MS means military specification), D-subminiature connectors, and rack and panel connectors. Any connector used to complete an electrical connection is included in the EWIS definition. The exception to this is the mating connection on those devices that are excluded from the proposed definition. The excepted devices are addressed later in this discussion.

Connector accessories fall under the definition of EWIS. Such accessories include, but are not limited to, backshells, strain reliefs, grommets, and sealing plugs. Electrical connections to devices such as relays, interrupters, switches, contactors, terminal blocks, and feed-through connectors are parts of an EWIS. For example, the connection device on a relay is considered part of the EWIS, but the relay mechanism is not, because it is a termination point. A splice can be considered an electrical connector because it performs the same role as other connection devices by providing an electrical connection between two or more wires. The failure of a splice or relay connection could create a hazardous situation by exposing bare conductors or impairing system functionality.

Although a bus bar is not a “connector” in the traditional sense, it is a collector and distribution device for electrical energy and thus must be treated as part of an EWIS.

Wire or wire bundles require devices to physically route and support them, such as clamps, brackets, standoffs, and other such components. These are included in the EWIS definition. Cable ties are included because they are used to hold multiple wires together and in place. The failure of one or more of these EWIS components could affect the ability of the wire to perform its intended function. It could cause collateral damage to other wires in the same or adjacent bundles or cause the bundle to fail in a way that would cause structural damage or ignite flammable material, fluid, or vapors in the area.

Some wires must pass through pressure bulkheads, so a pressure seal is needed. Failure of a pressure seal could cause damage to the wires in the wire bundle and affect the functioning of the system they support. Some wire bundles use shields or braids to protect them from electromagnetic radiation, lightning, abrasion, and other types of physical damage. Failure of the shields or braid could cause, or allow, the wires to be damaged. It could also allow unwanted electrical energy to be coupled into systems and cause system malfunction. Thus, shields, braids, and pressure seals must be considered part of the EWIS and treated as such.

Sometimes adequate physical separation distance is not possible, and some sort of protective sleeving may be used. Since the sleeving is used to achieve separation, it must be considered part of the EWIS.

Conduits are included in the proposal because they are used to provide protection for wires as well as provide physical separation. Conduits that have electrical termination for bonding are considered part of an EWIS because the failure of the bonding could create a hazardous situation.

The definition of an EWIS includes labels or other means used for identification. This supports the proposed § 25.1711 requiring new identification criteria for wires and other EWIS components. Discussion of the proposed labeling requirements appears under the heading for § 25.1711.

The proposed regulation does not cover portable, carry-on, or other electrical equipment not certified for installation on the airplane under part 25. Examples of items not included are laptop computers and portable audio and/or video or other consumer devices typically carried on-board by passengers for personal use. Increasingly, flight and cabin crew are using laptop computers in the performance of their duties. As stated, laptops are not part of the

EWIS definition, but any electrical connection used to support power and/or signal transmission that is part of the airplane TC, and that is used for the laptop or other carry-on items, is covered by the proposed definition.

The proposed EWIS definition does not cover fiber optic cable because fiber optic cable does not transmit electrical energy. But since fiber optics can provide functions (for example, data transmission) similar to those provided by wire, it is being expressly eliminated from the EWIS definition to avoid confusion.

The proposed definition excludes electrical wiring interconnection system components inside avionics equipment (high-frequency communication radio or flight data recorder, for instance), or the mating electrical connectors mounted on that equipment. Such equipment is produced by various manufacturers for use on a broad range of airplane models and is designed and built to various performance and environmental specifications. Environmental testing, either by means of RTCA (Radio Technical Commission for Aeronautics) Document No. RTCA DO-160, EUROCAE 55 specification (specification of the European Organization for Civil Aviation Equipment), or other environmental qualification procedures approved by the FAA, ensures that the EWIS contained within avionics equipment is robust and well suited for the airborne environments in which it will be operated.

This proposal also does not apply to miscellaneous electrical equipment if that equipment has been adequately qualified to environmental conditions and testing procedures approved by the FAA, unless that equipment is specifically included in the proposed § 25.1701 as discussed in the following paragraph.

The definition of EWIS includes electrical wiring interconnection system components inside shelves, panels, racks, junction boxes, distribution panels, back-planes of equipment racks including circuit board back-planes, and wire integration units. We have included the components in this type of equipment because it, unlike avionics equipment, is typically designed and made for a particular airplane model or series of models. The same requirements that apply to airplane EWIS components must also be applied to the components inside that equipment. Avionics components must be sent back to their manufacturer or a specialized repair shop for service. But this type of equipment is maintained, repaired, and modified by the same personnel who maintain, repair, and modify the EWIS in the rest of the airplane. In an electrical distribution panel system, for example, separation must be designed and maintained within the panel just as in the EWIS leading up to that panel. Identification of components inside the panel is just as important as for those outside the panel since the wiring inside the panel is treated much the same. Also, while this type of equipment is designed for its intended function and is manufactured and installed to the same standards as other EWIS, it is typically not qualified to an environmental standard such as RTCA DO-160.

Section 25.1703 Function and installation: EWIS.

Proposed § 25.1703 would require that applicants select EWIS components that are of a kind and design appropriate to their intended function. Factors such as the components' design limitations, functionality, and susceptibility to arc tracking and moisture must be considered when selecting EWIS components.

Section 25.1301 requires that each item of installed equipment be of a kind and design appropriate to its intended function, be labeled (identified), be installed according to any limitations specified for it, and function properly when installed. This is a general "catch-all" regulation applicable to equipment and systems certified under subpart F. Because of its generality and the fact that the FAA has not published any advisory circular for this rule, § 25.1301 has not been applied in a standardized way. Currently, § 25.1301 is applicable to wire and its associated components but it does not provide sufficient wire-specific requirements to ensure proper function and installation of EWIS. It does not adequately cover all factors that need to be considered when selecting, identifying, and installing wiring components.

The requirements of § 25.1301 are the basis for the new § 25.1703, but those requirements are supplemented by new ones. Requirements from other existing sections are also moved into the new regulation, so that the proposed rule would specifically apply to EWIS components. Adoption would ensure that the selection of wires and other EWIS components, and their installation, are carried out in a safe, consistent, and standardized manner.

Section 25.1703(a)(1) would require that each EWIS component be of a kind and design appropriate to its intended function. While § 25.1301(a) contains the same requirements, § 25.1703(a)(1) is specific to EWIS components. In this context, the requirement means that components must be qualified for airborne use, or otherwise specifically assessed as acceptable for their intended use. To be "appropriate" means that the equipment is used in a manner for which it was designed. For example, a wire rated at 150 degrees Celsius would not be appropriate for installation in an airplane zone where the temperature exceeds 150 degrees Celsius. Wire and other components made for household or consumer products use would not be appropriate for airborne use because they are manufactured for the consumer market and not for use in an airborne environment. Exceptions to this would be wire or other consumer components shown to comply with all the applicable airworthiness requirements of part 25. In the past this showing of compliance has proven to be difficult because manufacturers of consumer products have been reluctant to modify their designs to accommodate aviation use. Aviation use of consumer products represents too small a market.

Other factors that must be considered for EWIS component selection are mechanical strength, voltage drop, required bend radius, and expected service life. Expected service life means the expected service lifetime of the EWIS. This is not normally less than the expected service life of the aircraft structure. If the expected service life requires that all or some of the EWIS components be replaced at certain intervals, then these intervals must be specified in the ICA as required by § 25.1529.

Section 25.1703(a)(2) requires that EWIS components be installed according to their limitations. As used here, limitations means the design and installation requirements of the particular EWIS component. Examples of EWIS component limitations are maximum operating temperature, degree of moisture resistance, voltage drop, maximum current-carrying capability, and tensile strength. Section 25.1301(c) contains that requirement, but fails to specifically address the unique characteristics of EWIS. EWIS component selection and installation design must take into account various environmental factors including, but not limited to, vibration, temperature, moisture, exposure to the elements or chemicals (de-icing fluid, for instance), insulation type, and type of clamp. For example, wire bundle adhesive clamps are known to work loose during aircraft operation. Attention must be given to the selection of and methods of affixing this type of wire bundle support and it must be shown that this type of clamp is appropriate for the environment in which it will be used.

Section 25.1703(a)(3) would require that EWIS function properly when installed. This is the same requirement as § 25.1301(d). However, the § 25.1301(d) requirement is so general that it is applied in a nonstandardized manner. Sometimes the term “function properly when installed” has been interpreted to mean that even non-safety-related functions of a given system must function in the manner for which it was designed. The key word in understanding the intent of this proposed section is “properly,” as that relates to airworthiness of the airplane in which the electrical wiring interconnection systems are installed. For an EWIS component to function properly means that it must be capable of safely performing the function for which it was designed. For example, the fact that an airplane’s in-flight entertainment (IFE) system fails to deliver satisfactory picture or sound quality is not what the term “properly” refers to and is not a certification issue. However, the failure of an EWIS component has the potential for being a safety hazard whether it is part of a safety-related system or an IFE system. Therefore, EWIS components must always function properly when installed, no matter what system they are part of. The guidance material being prepared to accompany the subpart H AC 25.1701-1, “Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes,” will clarify these distinctions.

Section 25.1703(a)(4) is a new requirement to ensure that EWIS components be designed and installed so mechanical strain is minimized. This means the EWIS installation must be designed such that strain on the wires would not be so great as to cause wire or other components to fail. This requirement would ensure that adequate consideration is given to mechanical strain when selecting wire and cables, clamps, strain reliefs, stand-offs, and other devices used to route and support the wire bundle.

Proposed § 25.1703(b) would require that selection of wires for installation takes into account known characteristics of different wire types in relation to each specific application, to minimize risk of damage. It is important to select the aircraft wire type whose construction matches the application environment. The wire type selected must be constructed for the most severe environment likely to be encountered in service. Among other things, the proposed section would ensure that insulation types susceptible to arc tracking be used only in environments that will minimize the likelihood of that phenomenon. Arc tracking is a phenomenon in which a conductive carbon path forms across an insulating surface. A breach in the insulation allows arcing. The arcing carbonizes the insulation. The carbon residue is electrically conductive. The carbon path then provides a short circuit path through which current can flow. This can occur on either dry or wet wires. Certain types of wire insulation are more susceptible to arc tracking than others. Wire insulated with aromatic polyimide is one type that is susceptible to arc tracking. While this type of insulation is well suited for use in very low or high temperature environments, it generally should not be used in areas of an airplane prone to excessive moisture or vibration, such as those areas designated as severe wind and moisture problem (SWAMP) areas without taking into account this insulation property's unique characteristics. Installations exposed to vibration and constant flexing in a moisture-prone area would need wire type suitable for that environment. Proposed § 25.1703(c) would require that design and installation of the main power cables allow for a reasonable degree of deformation and stretching without failure. This requirement now resides in § 25.869(a)(3).

Proposed § 25.1703(d) requires that EWIS components located in areas of known moisture build-up be adequately protected to minimize moisture's hazardous effects. This is to ensure that all practical means are used to ensure damage from fluid contact with components does not occur. Wires routed near a lavatory, galley area, hydraulic lines, severe wind and moisture problem areas such as wheel wells and wing trailing edges, and any other area of the airplane where moisture collection could be a concern must be adequately protected from possible adverse effects of exposure to the types of moisture in these areas.

If a TC includes subpart H in its certification basis, the TC holder would have to show compliance with the proposed EWIS requirements. For future modifications of those TCs, use of the same design practices as those used by the TC holder will enable the modifier to substantiate compliance with the subpart H requirements based on a comparison with the TC holder's methods. If modifiers choose to deviate from those design practices, they would have to substantiate compliance independently. They would also have to consider the design practices used by the TC holder in order to justify their own choice of components.

In summary, these new rules would require the designer and installer to be careful in wire type choices, system design, and installation design. The existing § 25.1301 would be amended to contain a reference to § 25.1703 for EWIS component requirements.

Section 25.1709 System safety: EWIS.

Proposed § 25.1705 would require applicants to perform a system safety assessment of the EWIS. The safety assessment must consider the effects that both physical and functional failures of EWIS would have on the airplane's safety. Based on that safety assessment, it must be shown that each EWIS failure considered to be hazardous is extremely remote. Each EWIS failure considered to be catastrophic must be shown to be extremely improbable and not result from a single failure.

The current regulation requiring system safety assessments is § 25.1309. But current § 25.1309 practice does not lead to the type of analysis that fully ensures all EWIS failure conditions affecting airplane-level safety are considered. This is because the current § 25.1309(a) only covers systems and equipment that are “required by this subchapter,” and wiring for nonrequired systems is sometimes ignored. The current safety analysis requirements of § 25.1309(b) and (d) have not always been applied to wire associated with the airplane systems that are covered by the same rule. When they are, there is evidence of inadequate and inconsistent application. This is especially true for miscellaneous electrical equipment that is not required, such as IFE systems. Traditional thinking about these nonrequired systems has been that, since they are not required, and the function they provide is not necessary for the safety of the airplane, their failure could not affect the safety of the airplane. This is not a valid assumption because failure of an electrical wire can have hazardous or even catastrophic results regardless of the system it is associated with. Wire failure can cause serious physical and functional damage whether the wire or other EWIS components are associated with an autoland system or an IFE system. An example of this is arcing from a shorted wire cutting through flight control cables.

The Aviation Rulemaking Advisory Committee (ARAC), based on the work of its System Design and Analysis Harmonization Working Group, has made recommendations to the FAA for changes to the current § 25.1309. We are evaluating those recommendations. (A copy of those recommendations has been placed in the docket for reference.) We have considered the ARAC recommendations in developing the proposed § 25.1705.

One of the factors we considered in developing the proposed § 25.1705 is that the proposed ARAC revisions to § 25.1309 would exempt certain airplane systems, including the EWIS components associated with those systems, from having to comply with its requirements. Specifically, ARAC recommends that jamming of flight control surfaces or pilot controls covered by § 25.671(c)(3) be exempt from the requirements of § 25.1309. Single failures covered by § 25.735(b)(1) and the failure effects covered by §§ 25.810(a)(1)(v) and 25.812 would also be excepted from the revision to § 25.1309(b) recommended by ARAC. This includes wiring or other EWIS components associated with those systems. In part, proposed § 25.1705 would ensure coverage of the EWIS associated with those systems.

There are many examples of inadequate EWIS designs that have later been determined to be unsafe. Adoption of proposed § 25.1705 would help ensure that those unsafe design practices are not repeated in the future by requiring that EWIS failure conditions affecting airplane-level safety are fully considered. The current § 25.1309 does not provide that assurance.

The FAA has issued over 100 wire-related airworthiness directives (AD) since 1998. Over 50 of those were issued since 1999 to correct wiring deficiencies on the Model MD-11 airplane as delivered by the manufacturer. Airplanes as delivered from all transport category airplane manufacturers have been the subject of mandatory corrective action to correct safety-related wiring problems.

Similarly, the FAA has issued many ADs to correct unsafe EWIS installations because of postdelivery modifications. One example of this involves the IFE system installed on the Swissair MD-11 airplane that crashed off the coast of Nova Scotia and was discussed previously in this document. That modification is a clear case of not considering the effect that EWIS failures can have on airplane safety. The airplane was modified using the supplemental type certification process to add the IFE system. That system contained roughly 750 separate electronic boxes and was installed without an adequate safety assessment per § 25.1309. Although this IFE system consumed relatively large amounts of electrical power and its components and wiring were distributed throughout, below, and above the entire passenger cabin, the applicant did not thoroughly address the safety implications of routing the system wire in the same bundles as wire from other airplane systems, thus raising a concern for common cause failure to multiple essential systems. In many instances the applicant could not identify what airplane systems were associated with the wire in the bundles modified to route the IFE wiring. With the adoption of the proposed § 25.1705, this IFE system, as designed and installed on an airplane with the proposed subpart H in its type certification basis, would be subjected to a more rigorous safety assessment that would identify any inappropriate routing and force a design change.

Many other examples of type design modifications provide evidence that modifiers do not always give due consideration to the impact on safety that installation of a new or modified system may have. Modifiers continue to route the EWIS needed for modifications with, or in close proximity to, wiring from other airplane systems without identifying protection mechanisms for those systems. The current § 25.1309 and revisions to it recommended by ARAC do not contain sufficient requirements to ensure such modifications maintain the level of safety intended by the regulation.

Accordingly, a more comprehensive and specific safety assessment regulation for EWIS is necessary. The objective of the proposed § 25.1705 is to focus attention on EWIS and the safety issues associated with them by using the concepts of § 25.1309 to provide for consistent use of a more thorough and structured analysis of aircraft wiring and its associated components.

The integrated nature of wiring and the potential severity of failures demand a more structured safety analysis approach than that traditionally used under the current, or the ARAC's proposed revision to, § 25.1309. There are more failure modes that need to be addressed than have been addressed previously with traditional analyses (arcing events that occur without tripping circuit breakers, resulting in complete wire bundle failures and fire; or wire bundle failures that lead to structural damage, for example). Current § 25.1309 system safety assessments typically evaluate effects of wire failures on system functions. But they have not considered physical wire failure as a cause of the failure of other wires within the EWIS. The traditional assessments look at external factors like rotor burst, lightning, and hydraulic line rupture, but not at internal factors, like a single wire chafing or arcing event, as the cause of the failure of functions supported by the EWIS. Compliance with the proposed § 25.1705 would require addressing those failure modes at the airplane level. This means that EWIS failures would need to be analyzed to determine what effect they would have on the safe operation of the airplane.

The proposed rule language is consistent with § 25.1309 and is meant to work in conjunction with the § 25.1309 assessments performed on airplane systems. It would require that the probability of a hazardous failure condition be extremely remote and that the probability of a catastrophic failure condition be extremely improbable and not result from a single failure. The terminology and meaning of the classifications of EWIS failure conditions are identical to those proposed by ARAC in August 2002. The proposed AC produced by that working group discussing this, titled "System Design and Analysis," is in the docket for this NPRM. The following table identifies and explains the failure condition terms.

Classification of Failure Conditions

Term	Explanation
No Safety Effect	Failure conditions that would have no effect on safety; for example failure conditions that would not affect the operational capability of the airplane or increase flightcrew workload.
Minor	Failure conditions that would not significantly reduce airplane safety, and involve flightcrew actions that are well within their capabilities. Minor failure conditions may include, for example: • a slight reduction in safety margins or functional capabilities; • a slight increase in flightcrew workload, such as routine flight plan changes; or • some physical discomfort to passengers or cabin crew.
Major	Failure conditions that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions to the extent that there would be, for example: • a significant reduction in safety margins or functional capabilities; • a significant increase in flightcrew workload or in conditions impairing flightcrew efficiency; • discomfort to the flightcrew; or • physical distress to passengers or cabin crew, possibly including injuries.
Hazardous	Failure conditions that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions to the extent that there would be, for example: • a large reduction in safety margins or functional capabilities; or • physical distress or excessive workload such that the flightcrew cannot be relied upon to perform their tasks accurately or completely; or • serious or fatal injuries to a relatively small number of persons other than the flightcrew.
Catastrophic	Failure conditions that would result in multiple fatalities, usually with the loss of the airplane. (NOTE: A catastrophic failure condition was defined differently in previous versions of § 25.1309 and in accompanying advisory material as "a failure condition that would prevent continued safe flight and landing.")

The proposed § 25.1705 would complement the § 25.1309 assessments by raising the quality of the safety assessment with respect to EWIS failures that would not be identified using the traditional methods of compliance with § 25.1309. The analysis required to show compliance with the proposed regulation is based on a qualitative approach to assessing EWIS safety as opposed to a numerical probability-based quantitative analysis. The intent is not to examine each individual wire and its relation to other wires, but rather to ensure that there are no unacceptable hazards to the airplane. This does not preclude the possibility that, should the analysis identify a failure in a given wire bundle or component(s) that may lead to a catastrophic failure condition, the design mitigation process may lead to performing a complete analysis of each wire in the relevant bundle.

The type of analysis used to show compliance with the proposed § 25.1705 can vary depending on the knowledge of the designers or modifiers of an EWIS. As stated earlier, it is important that there is thorough knowledge of what systems and functions the other wires in the same and surrounding bundles support. In the case of a post-TC modification, without this information it would be impossible to state that the modified system could not fail in a way that would cause a hazardous or catastrophic event. If this information is not available to the modifier, then the EWIS system must be designed to accommodate this lack of knowledge. This would typically mean that wire being added for the modification would need to be routed separately from existing airplane wiring.

Flowchart 1 and Flowchart 2, contained in Appendix E of this notice, illustrate the type of analysis necessary to show compliance with the proposed § 25.1705. Two separate cases are considered. Flowchart 1 is applicable to pre-type-certification work and to TCs and STCs when the modifier has all the data necessary to perform the analysis. If the analysis is conducted according to this flowchart, the available data must include identification of systems supported by the EWIS under consideration for modification and the functions associated with them. The original aircraft manufacturer has most of this data and would normally follow the Flowchart 1 method. However, this may not always be the case when the manufacturer modifies an airplane that has been previously modified by another party.

The analysis depicted in Flowchart 2 would apply to modifiers for post-TC modification who cannot identify the systems or functions contained in EWIS being considered for modification.

In both analyses, EWIS functional and physical failures are addressed. It is the physical portion that has been neglected in past system safety analyses. The proposed regulation would require an applicant to identify any physical failure of EWIS that can cause damage to co-located EWIS or other surrounding systems or structure, or injury to people. Once those physical failures are identified, their severity can be determined and design mitigation strategies can be developed and applied. The process is repeated until all known unsafe features are eliminated. The difference between the processes identified in the two flowcharts is that in Flowchart 1, all the systems and associated functions whose wires are in a bundle are known. In Flowchart 2, new wire is routed separately from existing wire. Otherwise, the analysis is the same.

In summary, the need for this new regulation is shown by experience on the part of the FAA and other governmental regulatory authorities and by service histories. Many wire-related incidents and accidents have occurred. Post-TC modifications have repeatedly introduced wiring safety problems. Airplane manufacturers have delivered airplanes that have wiring problems when they leave the factory, or such problems have later developed in service, as evidenced by resulting mandatory corrective actions. Adoption of this proposal would ensure that such problems are fully considered and addressed as part of the type certification process.

Section 25.1709 System separation: EWIS.

Proposed § 25.1709 would require applicants to design EWIS with appropriate separation to minimize the possibility of hazardous effects upon the airplane or its systems.

Safe operation of airplanes depends in part on the safe transfer of electrical energy, a function provided by airplane EWIS. If an EWIS failure should occur, the separation between the failed EWIS and other EWIS and airplane systems plays an important role in ensuring that any hazardous effects of the failure are mitigated to an acceptable level. Thus, it is vital to design and install wiring systems with adequate separation from those systems whose interaction with the wire could create hazardous effects. Currently, part 25 certification rules do not adequately address wire system separation. The rules currently used to require system separation are § 25.1353(a), (b), and (c), but service experience has shown that compliance with these requirements, with regard to wiring systems, has not always been adequate. This is due in part to their lack of specific wording about which wiring systems are covered and which systems those wires are meant to be separated from. The proposed rule corrects these inadequacies by stating specifically that it applies to each EWIS on the airplane, and mandating specific separation requirements for certain airplane systems known to have potential for creating a hazardous condition. The term “hazardous condition” in this proposed rule is used in a different context than it is used in the proposed § 25.1705. Proposed § 25.1705 uses the terms “hazardous” and “catastrophic” in the context of assigning a numerical probability to failures that can cause a failure condition. Hazardous failure conditions and catastrophic failure conditions are defined in the discussion of the proposed § 25.1705. In proposed § 25.1709, the term hazardous condition means that the applicant must perform a qualitative design assessment of the installed EWIS. This assessment would involve using reasonable engineering and manufacturing judgment and assessing relevant service history to decide whether an EWIS, any other type of system, or any structural component could fail in such a way that a condition affecting the airplane's ability to continue safe operation could result. A numerical probability assessment may still be required under the requirements of the proposed § 25.1705 if the airplane-level functional hazard assessment identifies failures that could affect safe operation of the airplane.

To illustrate the type of assessment required by proposed § 25.1709, consider the following simple example involving the use of wire bundle clamps. Clamps are used to secure a wire bundle to structure in order to hold the bundle in place and route the bundle from one location to another along a predetermined path. An airplane manufacturer, using the criteria contained in the proposed advisory material for § 25.1709, determines that a 2-inch separation from hydraulic lines is necessary. The manufacturer further decides that one clamp every 10 inches is needed to maintain that separation. However, there is one localized area where a single clamp failure would potentially create a hazard. This is because the area in question is a high vibration, high temperature area, subject to exposure to moisture. So the clamp in this particular area is exposed to severe environmental conditions that could lead to its accelerated degradation. The manufacturer decides that using just a single clamp every 10 inches in this area would not suffice to preclude a hazardous event. The manufacturer prescribes use of double clamps every 10 inches in that area.

The requirements of proposed § 25.1709 do not preclude use of valid component failure rates if the applicant chooses to use a probability argument in addition to the design assessment to demonstrate compliance. It also does not preclude the FAA from requiring such an analysis if the applicant cannot adequately demonstrate that hazardous conditions will be prevented solely by using the qualitative design assessment.

As used in the proposed rule, the term "separation" is a measure of physical distance. The purpose of separation is to prevent hazards of arcing between wires in a single bundle, between two or more bundles, or between an electrical bundle and a non-electrical system or structure. In some cases, the proposal would allow separation to be achieved with a barrier or other means shown to be at least equivalent to the necessary physical distance. However, distance separation is preferred because service experience shows that use of barriers such as conduits can cause wire damage or lead to maintenance errors. In some cases, wire bundle sleeving is used to provide separation, although the sleeving itself is susceptible to the same types of damage as wire insulation.

Determining the necessary amount of physical separation distance is essential. However, the proposed rule does not mandate specific separation distances because each system design and airplane model can be unique, and because manufacturers have differing design standards and installation techniques. Instead it requires that the chosen separation be adequate so that an EWIS component failure will not create a hazardous condition. The following factors must be considered when determining the separation distance:

(1) The electrical characteristics, amount of power, and severity of failure condition of the system functions performed by the signals in the EWIS and adjacent EWIS.

(2) Installation design features, including the number, type, and location of support devices along the wire path.

(3) The maximum amount of slack wire resulting from wire bundle build tolerances and other wire bundle manufacturing variabilities.

(4) Probable variations in the installation of the wiring and adjacent wiring, including position of wire support devices and amount of wire slack possible.

(5) The intended operating environment, including amount of deflection or relative movement possible and the effect of failure of a wire support or other separation means.

(6) Maintenance practices as defined by the airplane manufacturer's standard wiring practices manual and the ICA required by § 25.1529 and proposed § 25.1739.

(7) The maximum temperature generated by adjacent wire/wire bundles during normal and fault conditions.

The FAA recognizes that some airplane models may have localized areas where maintaining the minimum physical separation distance is not feasible. In those cases, other means of ensuring equivalent minimum physical separation may be acceptable, if testing or analysis demonstrates that safe operation of the airplane is not jeopardized. The testing or analysis program must be conservative and consider the worst possible conditions.

Paragraphs (a), (b), (c), and (d) of proposed § 25.1709 contain EWIS-related requirements derived from the existing regulations applying to electrical power generation systems and electrical equipment and installations (§§ 25.1351 and 25.1353). Section 25.1351 does not need any revision to support the proposed § 25.1709, but § 25.1353 is amended to reference § 25.1709.

The proposed requirements of § 25.1709(a) were derived from existing § 25.1353(a). While the requirements of § 25.1353(a) are retained, the portion of that requirement applicable to wiring has been moved to the proposed § 25.1709(a). Further clarification of the requirement is also included in the proposal. Section 25.1353(a) states " … wiring must be installed so that *operation* of any one unit or system of units…." Proposed section 25.1709(a) expands on the term "operation" to state that it means "operation under normal and failure conditions as defined by § 25.1309."

Proposed section 25.1709(b) would require that each EWIS be designed and installed so that any electrical interference likely to be present in the airplane will not result in hazardous effects on the airplane or its systems. This proposed requirement is based on new text recently added to § 25.1353(a) to harmonize part 25 with the existing text of the JAA JAR 25.1353(a)[1]. The text of JAR 25.1353(a) requires that any electrical interference likely to be present in the airplane must not result in hazardous effects on the airplane or its systems except under extremely remote conditions. The proposed § 25.1709(b) is recognition of the fact that electrical interference can be introduced into airplane systems and wiring by coupling between electrical cables or between cables and coaxial lines, as well as by the other equipment that is the subject of § 25.1353(a). The proposed requirement does not adopt the JAR clause "except under extremely remote conditions." This is because the intent of the requirement is not to require a numerical probability assessment of the likelihood of electrical interference or its consequences as described previously. Rather it is meant to convey that under failure conditions that may be caused by electrical inference, the resultant effects should not be such as to prevent continued safe flight of the airplane.

Proposed section 25.1709(c) contains the wire-related requirements of the current § 25.1353(b). These requirements have been expanded to add that not only wires and cable carrying heavy current are covered, but their associated EWIS components are covered as well. The proposal prescribes that any required physical separation must be achieved either by separation distance or by barrier or other means shown to be at least equivalent to an adequate separation distance.

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[1] The JAA is the Joint Aviation Authority of Europe and the JAR is its Joint Aviation Requirements, the equivalent of our Federal Aviation Regulations. In the time since these proposals were developed, in 2003, the European Aviation Safety Agency (EASA) was formed. EASA is now the principal aviation regulatory agency in Europe, and we intend to continue to work with them to ensure our proposal is also harmonized with its Certification Specifications (CS). But since the harmonization efforts involved in developing this proposal occurred before EASA was formed, it was the JAA that was involved with them. So while the JAR and CS are essentially equivalent, and in the future we will be focusing on the CS, it is the JAR that will be referred to in the historical background discussions in this proposal.

Proposed section 25.1709(d) contains wire-related requirements of existing §§ 25.1351(b)(1) and (b)(2) and would introduce additional requirements. To show compliance with § 25.1709(d), EWIS components associated with the generating system must be considered with the same degree of attention as other components of the system, such as the electrical generators. The proposal prescribes that any required physical separation must be achieved either by separation distance or by a barrier or other means shown to be at least equivalent to an adequate separation distance. Paragraph (d)(1) would introduce a requirement to prohibit the airplane's independent electrical power sources from sharing a common ground terminating location. Paragraph (d)(2) would prohibit the airplane's static grounds from sharing a common ground terminating location with any of the airplane's independent electrical power sources. These two new requirements would help to ensure the independence of separate electrical power sources and to prevent introduction of unwanted interference into airplane electrical power systems from other airplane systems.

Paragraphs (e), (f), (g), and (h) of proposed § 25.1709 contain EWIS-related requirements from § 25.1353(d)(3). These paragraphs contain specific separation requirements for the airplane's fuel, hydraulic, oxygen, and waste/water systems. They require that EWIS have adequate separation from those systems except to the extent necessary to provide any required electrical connection to them. These paragraphs require that EWIS be designed and installed with adequate separation so a failure of an EWIS component will not create a hazardous condition and any leakage from those systems (i.e., fuel, hydraulic, oxygen, waste/water) onto EWIS components will not create a hazardous condition. The proposed requirements recognize the potential catastrophic hazard that could occur should an arcing fault ignite a flammable fluid like fuel or hydraulic fluid. An arcing fault has the potential to puncture a line associated with those systems if adequate separation is not maintained. If there is leakage from one of those systems and an arcing event occurs, fire or explosion could result. Similarly, leakage from the water/waste system can cause damage to EWIS components and adversely affect their integrity. An EWIS arcing event that punctures a water or waste line could also introduce fluids into other airplane systems and create a hazardous condition.

To prevent chafing, jamming, or other types of interference or other failures that may lead to loss of control of the airplane, EWIS in general and wiring in particular must be physically separated from flight or other control cables. Mechanical cables have the potential to cause chafing of electrical wire if the two come into contact. This can occur either through vibration of the EWIS and/or mechanical cable or because of cable movement in response to a system command. A mechanical cable could also damage other EWIS components, such as a wire bundle support, in a way that would cause failure of that component. Also, if not properly designed and installed, a wire bundle or other EWIS component could interfere with movement of a mechanical control cable by causing jamming or otherwise restricting the cable's movement. An arcing fault could damage or sever a control cable, or a control cable failure could cause damage to EWIS if not adequately separated. Therefore, proposed paragraph (i) would require an adequate separation distance or barrier between EWIS and flight or other mechanical control systems cables and their associated system components. It would further require that failure of an EWIS component must not create a hazardous condition and that the failure of any flight or other mechanical control systems cables or systems components must not damage EWIS and create a hazardous condition.

EWIS in general and wiring in particular must be routed away from high-temperature equipment, hot air ducts, and hydraulic, fuel, water, and other lines. There must be adequate separation distance in order to prevent damage to the EWIS caused by extreme temperatures and so that an EWIS failure will not damage the equipment, ducts, or lines. High temperatures can deteriorate wire insulation and other parts of EWIS components, and if the wire or component type is not carefully selected, this deterioration could lead to wire or component failure. Similarly, should an arcing event occur, the arc could penetrate a hot air duct or line and allow the release of high pressure, high temperature air. Such a release could damage surrounding components associated with various airplane systems and potentially lead to a hazardous situation. Paragraph (j) would require that EWIS be designed and installed with an adequate separation distance or barrier between the EWIS components and heated equipment, hot air ducts, and lines.

The needed reliability of some airplane systems, such as an autoland system, requires that independent, redundant systems be used. Loss of one channel of a redundant system would not decrease the ability to continue safe operation. However, if both channels of a two-channel system were lost because of a common failure, the results could be catastrophic. To maintain the independence of redundant systems and equipment so that safety functions required for safe operation are maintained, adequate separation and electrical isolation between these systems must be ensured. Paragraph (k) would require that EWIS associated with any system that requires redundancy to meet certification requirements be separated with an adequate separation distance or barrier.

Paragraph (l) of proposed § 25.1709 would require that EWIS be designed and installed so they are adequately separated from aircraft structure and protected from sharp edges and corners. The purpose of this proposal is to minimize the potential for abrasion/chafing, vibration damage, and other types of mechanical damage. Such protection is necessary because over time the insulation on a wire that is touching a rigid object, such as an equipment support bracket, will fail and expose bare wire. This can potentially lead to arcing that could destroy that wire and other wires in its bundle. Depending on the amount of electrical energy being carried by the failed wire, structural damage may also occur.

Section 25.1711 Component identification: EWIS.

Proposed § 25.1711 would require applicants to identify EWIS components using consistent methods that facilitate easy identification of the component, its function, and its design limitations. For EWIS associated with flight-essential functions, identification of the EWIS separation requirement would also be required.

An important aspect of ensuring safe operation of airplanes is making sure that EWIS components are properly identified. This is necessary so that modification designers, maintenance personnel, and inspectors can easily determine the function of the associated system, together with any associated separation requirements and design limitations. Clear labeling of EWIS components and easy-to-understand identification aids allow installers, inspectors, and maintainers to readily ascertain that correct system components are installed as designed, and allow modifiers to add systems with due regard to the existing protection and separation requirements.

The current part 25 certification requirement for equipment identification is § 25.1301(b) and it is applicable to “each item of installed equipment.” This rule is inadequate for EWIS because it does not provide the specific requirements that have been determined necessary for identifying EWIS components. Specific EWIS component identification needs to be done to prevent modifiers from unintentionally introducing unsafe design or installation features on previously certified airplanes when they install new or modified systems. Component identification would also make those performing maintenance and inspections more aware of what systems are associated with specific EWIS in the areas undergoing maintenance or inspection.

When the FAA first certifies an airplane type design, its systems are designed and installed to ensure safe operation of the airplane. Systems essential to that safe operation are often designed and installed to ensure redundancy of the system function. They have two or more circuits, or channels, that can perform the same function in case one of them malfunctions. Separate circuits (channels) typically have their own sensors, wiring, and equipment. This helps ensure that a common failure cannot cause failure of the entire system.

An example of this is the autoland system on modern transport category airplanes. The autoland system allows airplanes to land during adverse weather conditions that would otherwise prevent landing with manual techniques that rely on the flightcrew's ability to see the runway. Typically the autoland system has three channels that are physically separated and electrically segregated, so if one channel fails, the airplane can safely continue the autoland procedure. The failure of an autoland system at a critical phase of flight can be catastrophic to the airplane and its passengers. The integrity of an autoland system's design could be compromised by systems installed after certification of the autoland system. One way to prevent this is to clearly identify EWIS associated with the autoland in a way that makes it easy to see that it is associated with a critical system. Such identification would aid the designers and installers of the new system by alerting them to the presence of the critical system and allow appropriate design and installation decisions, preventing degradation of the safety of the autoland system.

The reverse is also true. For example, suppose an in-flight entertainment system is installed on an airplane and, after that installation, an autoland system is to be installed. The designers and installers of the autoland system would need to be able to identify EWIS associated with the IFE system so they do not mix IFE system EWIS with the autoland system EWIS. The IFE system is a passenger convenience item and its functionality is not important to the continued safe operation of the airplane. When the zone containing the autoland system EWIS is undergoing inspections or maintenance, easy identification of the EWIS will alert inspection or maintenance personnel to use extra caution in the area.

Proposed § 25.1711(a) uses language that is similar to existing § 25.1301(b) but is specifically applicable to EWIS components. The proposal adds the word "consistent" to stress the need for consistency in EWIS identification to avoid confusion and mistakes during airplane manufacturing, modification, and maintenance. This means the FAA expects airplane manufacturers to develop an EWIS identification method that facilitates easy identification of the systems that any specific EWIS component supports and use that identification method in a consistent manner throughout the airplane. The consistent identification method must be used for new type certifications and changes to those designs. Proposed § 25.1711(e) would require that modifications to type designs use EWIS identification methods that are consistent with the identification method of the original type design. The proposed requirements of paragraph (e) are discussed later in this document.

Paragraph (b) would impose additional requirements for identification detail, when assessed in accordance with the proposed requirements of § 25.1705, for EWIS components associated with:

- Systems required for safe flight and landing.
- Systems required for egress.
- Systems with potential to affect the flightcrew's ability to cope with adverse operating conditions.

Paragraph (c) would require that identifying markings required by paragraphs (a) and (b) of the proposal remain legible throughout the design life of the component. As most wire installations are designed to remain on the airplane throughout the airplane's service life, this means the identification marks must be able to be read to support the intended purpose of the markings for the life of the airplane. The method of marking must take into account the environment in which the EWIS component will be installed.

Paragraph (d) would require that the means used to identify an EWIS component does not have an adverse effect on the component's performance throughout its design life. Certain wire marking methods have the potential to damage the wire's insulation. Hot-stamp marking is one such method. According to SAE (Society of Automotive Engineers) aerospace information report AIR5575, "Hot Stamp Wire Marking Concerns for Aerospace Vehicle Applications," a copy of which is included in the docket, the hot-stamp marking method is not well suited for today's generation of aircraft wiring. As noted in the SAE document, wire insulation has become markedly thinner over the years since the procedure was first introduced in the 1940s. Because of this, problems have arisen over wire damage from excessive penetration by the hot-stamp process. The document further states: "The frequent need for adjustments in temperature, pressure, and swell time inherent to achieving legible hot stamp wire marking provides many opportunities for error. The controls, methods, and guidance necessary to achieve satisfactory performance with hot stamp marking are often not made available to operators in smaller wire shops."

The FAA concurs with this assessment. If damage to the insulation occurs during the marking process, it may fail later in service after it has been exposed to the sometimes-harsh environmental conditions of aircraft use. While the proposed regulation does not prohibit use of hot-stamp marking, its use is not encouraged. To comply with this paragraph, if the hot stamp marking process is used, the guidelines of SAE recommended practice ARP5369, "Guidelines for Wire Identification Marking Using the Hot Stamp Process" or equivalent must be followed. A copy of this document is in the docket.

In some cases it may not be practicable to mark an EWIS component directly, because of component size or identification requirements. In this case other methods of identification such as a label or sleeve must be used.

Paragraph (e) would require that EWIS modifications to the type design take into consideration the identification scheme of the original type design. This is to ensure that the consistency required by proposed § 25.1711(a) is maintained when a modification is installed. The intent of this requirement is to provide continuity in the methods used for EWIS identification on a particular model. It is not the intent of the requirement to impose on the modifier the exact wire identification methods of the airplane manufacturer. However, since the purpose of proposed § 25.1711 is to make it easy to identify those airplane systems essential to the safe operation of the airplane, it is in the best interest of safety that designers of any modifications to the original design consider the approved type design identification methods. For example it would not be appropriate for a modifier to use purple wire to identify a specific flight critical system when the approved type design used the color green, especially if the type design already uses purple wire to identify non-essential systems. Such a scheme could cause confusion and lead future modifiers or maintainers to believe that the routing of purple wires with green wires is acceptable. This is just an example and should not be construed to say that flight critical systems should use green wire or non-essential systems purple wire. The regulation does not prescribe a particular method for identification, but is meant to ensure that the consistency of the identification method required by paragraph (a) is maintained throughout the life of the airplane.

Section 25.1713 Fire protection: EWIS.

Proposed § 25.1713 would require that EWIS components meet the applicable fire and smoke protection requirements of § 25.831(c). It would further require that EWIS located in designated fire zones be at least fire resistant. Insulation on electrical wires and cables would also be required to be self-extinguishing when tested in accordance with the applicable portions of Appendix F, Part I, of part 25.

During an emergency situation it is important that airplane systems needed by the flightcrew to effectively deal with the emergency be operative. To help ensure this, § 25.869 requires that electrical systems components meet certain flammability requirements and be designed and installed to minimize probability of ignition of flammable fluids and vapors. Currently, § 25.869(a) is applicable to wiring. The proposal is to move the requirements of § 25.869(a) related to protection of wiring from fire and put them into the proposed § 25.1713. This will allow easy identification of the requirements for fire protection of EWIS, because they will be found in the proposed new subpart H, which is dedicated to EWIS regulations. Requirements of § 25.869 dealing with isolation from flammable fluid lines have been moved to the new § 25.1709 and requirements for allowance for deformation and stretching have been moved to § 25.1703. As a result, we are amending § 25.869 to accommodate this change.

Section 25.1717 Electrical bonding and protection against static electricity: EWIS.

Proposed § 25.1717(a) would require that EWIS used for electrical bonding and protection against static electricity meet the requirements of § 25.899. Proposed § 25.1717(b) would require that EWIS components used for any electrical bonding purposes (not just that used for protection against static electricity) provide an adequate electrical return path under both normal and fault conditions.

The buildup and subsequent discharge of static electricity has the potential to create hazardous conditions for both airplane systems and people. Static electricity can injure people. It can also interfere with installed electrical/electronic equipment and cause ignition of flammable vapors. We are proposing to adopt § 25.899 (as discussed in the section headed "Electrical System Harmonization Rules") to highlight the importance of considering electrical bonding and static electricity as a full aircraft requirement and to prevent hazardous effects of static electricity. The proper design and installation of EWIS components used to accomplish such protection is critical to ensure the hazardous effects of static discharge are minimized. For example, the cross-sectional area of bonding paths used for primary bonding paths is important in ensuring that a low electrical impedance is obtained, as is the method in which the bonding connection is made to the airplane structure. Thus, EWIS must be fully considered when designing and installing protection from the adverse effects of static electricity. The proposed § 25.1717 highlights the importance EWIS has in providing this protection and requires that EWIS components meet the same requirements as other components used to show compliance with § 25.899.

The ARAC Electrical Systems Harmonization Working Group recommended the adoption of JAR 25.1353(e) as paragraph (e) of § 25.1353. The JAR requires that electrical bonding provide an adequate electrical return path under both normal and fault conditions on airplanes with grounded electrical systems. ATSRAC recommended that the requirements of JAR 25.1353(e) be moved in their entirety to the proposed subpart H. We agree with that recommendation and, instead of adopting JAR 25.1353(e) as § 25.1353(e), we are proposing to adopt it as § 25.1717(b).

Section 25.1719 Systems and functions: EWIS.

Proposed § 25.1719 would require that EWIS components be considered in showing compliance with the certification requirements of specific airplane systems. Many of the current part 25 sections contain system specific requirements that apply to EWIS in an indirect way. The EWIS associated with such systems play an integral role in ensuring the safe operation of the system and of the airplane. In general, the EWIS associated with any airplane system needs to be considered an integral part of that system and must be given the same design and installation attention as the rest of the system. The proposed § 25.1719(a) contains this general requirement, while paragraph (b) of the proposal identifies specific sections of part 25 that are associated with airplane systems where wire and its associated components play an important part in ensuring safety. These specific part 25 sections contain requirements that do not lend themselves to creating a separate EWIS-based Subpart H requirement.

It is the intent of the proposed § 25.1719 to require that EWIS be designed and installed to support systems required for type certification or by operating rules, including those systems addressed by the regulations specifically listed in paragraph (b) of the proposal. They must be considered part of those systems, and be given the same design and installation considerations as the rest of the system. While paragraphs (a) and (b) may seem redundant, we have listed specific sections in (b) to ensure that applicants are aware of the need to give EWIS associated with those systems the same consideration as the other components of those systems. We consider the general requirements of (a) necessary because there may be other regulations where EWIS must be considered in showing compliance with those regulations. It also ensures that EWIS is given full consideration for any system-related regulation adopted in the future.

Section 25.1721 Circuit protective devices: EWIS.

Proposed § 25.1721 would require that electrical wires and cable be compatible with the circuit protective devices required by § 25.1357.

We recently adopted § 25.1353(d)(1) based on recommendations of ARAC, as part of the effort to harmonize the requirements of JAA JAR 25 and FAA 14 CFR part 25. Paragraph (d)(1) requires that electrical cables be compatible with the circuit protection devices required by § 25.1357, so that a fire or smoke hazard cannot be created under temporary or continuous fault conditions. That requirement would be moved from § 25.1353(d)(1) into the proposed § 25.1721 in its entirety. The proposal also adds the word “wire” to the requirement. This is because this requirement applies to all sizes of wire, not just heavy-current-carrying cables.

Section 25.1723 Instruments using a power supply: EWIS.

The proposed § 25.1723 would require that EWIS components associated with flight and navigation instruments using a power supply be designed and installed so that compliance with § 25.1331 is ensured.

Section 25.1331 requires that flight and navigation instruments using a power supply must, in the event of the failure of one power source, be supplied by another power source. No change is proposed to the wording of that section.

Section 25.1725 Accessibility provisions: EWIS.

The proposed new § 25.1725 would require that means be provided to allow for inspection of EWIS and replacement of their components as necessary for continued airworthiness.

Currently, § 25.611 requires that means must be provided to allow inspection, replacement of parts, adjustment, and lubrication as necessary for principal structural elements and control systems. While wiring systems are not specifically referred to in the existing rule, the “accessibility” concept is easily applied to EWIS. Many of the wiring systems on airplanes today are very difficult to access and inspect. We now have an increased awareness of the importance of inspecting wiring for separation and for contamination and damage in order to ensure proper functioning, maintenance, and safety. We also know that when adjacent structures must be removed to allow access to wire installations, new possibilities for contamination, chafing, and other types of damage are introduced. Section 25.611 would be amended to specify that EWIS must meet the accessibility requirements of § 25.1725.

The intent of proposed § 25.1725 is to ensure that EWIS components be installed so that inspections, tests, repairs, and replacements can be undertaken, and that these can be carried out with a minimum of aircraft disassembly. This proposal would facilitate the proposed implementation of the new wiring inspection programs developed under proposed § 25.1739 and the operating rules contained in this proposal.

Section 25.1727 Protection of EWIS.

Proposed § 25.1727 would require that cargo or baggage compartments not contain any EWIS whose failure would adversely affect safe operation.

It would also require that all EWIS be protected from damage by movement of people.

Section 25.855(e) requires that no cargo or baggage compartments may contain any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operation of the airplane unless they are protected so that they cannot be damaged by movement of cargo in the compartment and their breakage or failure will not create a fire hazard. The proposed regulations would remove the word "wiring" from the current language and move those requirements, as they apply to EWIS, to the proposed § 25.1727(a). Proposed § 25.855(j) would mandate that cargo or baggage compartment EWIS components must meet the requirements of § 25.1727(a).

The proposed § 25.1727(b) and (c) are new EWIS requirements that currently don't exist in part 25. Paragraph (b) would require that EWIS be designed so that damage and risk of damage from movement of people in the airplane during all phases of flight, maintenance, and service, be minimized. Paragraph (c) would require designers to minimize damage and risk of damage to EWIS by items carried onto the airplane by passengers, cabin crew, and flightcrew. These two new requirements are justified by service experience that shows wires can easily be damaged by movement of people on the airplane and by items carried on board.

Paragraph (b) would require that EWIS designers and installers consider such things as the routing of wires that could be damaged by personnel in the cargo compartments. For example, EWIS would have to be designed and installed in ways that prevent their use as hand- or footholds as much as practicable. It would further require that EWIS be protected from damage by people in the cabin or flight deck. More and more wiring is being routed to passenger seats to support increasingly complex passenger convenience features. If an airplane is equipped with seat-back monitors, for example, the electronic components necessary to support the monitor are typically mounted underneath the seat. This requires wire routing to the seats, usually through the seat tracks (structural channels used to fasten the seats to the floor) or from the side wall directly next to the seat. Many wires mounted on or under the seats have been damaged by passengers. In one case an airplane was operated with wires lying on the floor in the area where a passenger would put his feet. The wires had become dislodged from the seat track. This not only exposed the wires to damage but also posed a potential electrical shock risk to the passenger. In other cases, wires have been routed to the seats through holes cut into the cabin side wall, exposing them to damage from both passengers and carry-on items stored beneath the seat or between the side wall and seat.

Section 25.1729 Flammable fluid fire protection: EWIS.

The proposed § 25.1729 would require that EWIS components be considered a potential ignition source in each area where flammable fluid or vapors might escape by leakage of a fluid system and must meet the requirements of § 25.863.

The current § 25.863 mandates that, in each area where flammable fluids or vapors might escape by leakage of a fluid system, there must be means to minimize the probability of ignition, and resultant hazards if ignition does occur. Possible ignition sources, including overheating of equipment, malfunctioning of protective devices, and electrical faults must be considered in showing compliance with this rule. Many types of electrical faults could cause ignition. Among them are sparks emitting from an avionics component, overheated electrical component surfaces, and arcing from electrical wiring. The wording of § 25.863 would not change.

Section 25.1731 Powerplants: EWIS.

The proposed § 25.1731 specifies that EWIS associated with any powerplant must be designed and installed so that failure of an EWIS component will not prevent continued safe operation of the remaining powerplants or require immediate action by any crewmember for continued safe operation, in accordance with § 25.903(b). It would also mandate that design precautions be taken to minimize hazards to the airplane because of EWIS damage in the event of a powerplant rotor failure or a fire originating in the powerplant that burns through the powerplant case, in accordance with § 25.903(d)(1). The purpose of this section is to ensure proper consideration of EWIS in evaluating powerplant installation designs.

The current § 25.903(b) requires, among other things, that powerplants be arranged and isolated from each other to allow operation, in at least one configuration, so that failure or malfunction of any engine, or of any system that can affect the engine, will not prevent continued safe operation of the remaining engines or require immediate action by any crewmember for continued safe operation. Section 25.901(d)(1) requires that design precautions be taken to minimize hazards to the airplane in the event of an engine rotor failure or a fire originating within the engine that burns through the engine case.

Section 25.1733 Flammable fluid shutoff means: EWIS.

Proposed § 25.1733 would require that EWIS associated with each flammable fluid shutoff means and control be "fireproof" (as defined in § 1.1) or located and protected so that any fire in a fire zone will not affect operation of the flammable fluid shutoff means, in accordance with § 25.1189.

Section 25.1189 requires that each engine installation and fire zone have a means to shut off or otherwise prevent hazardous quantities of fuel, oil, deicer, and other flammable fluids from flowing into or through any designated fire zone. No change is proposed for that section.

Section 25.1735 Fire detector systems, general: EWIS.

Proposed § 25.1735 would require that EWIS associated with any installed fire protection system be considered in showing compliance with the applicable requirements for that particular system. This would be a new requirement. It does not currently exist in part 25. The current part 25 regulations contain fire detection system requirements for powerplants (§ 25.1203), lavatories (§ 25.854), and cargo compartments (§§ 25.855, 25.857 and 25.858). Each fire detection system requires electrical wire. Failure of this wire could lead to inability of the detection system to function properly. The wire and other associated EWIS components must be considered an integral part of the fire detection system and meet the requirements of the applicable regulation. The proposal would apply to all required fire protection systems with the exception of powerplants and APUs. Requirements for EWIS associated with powerplant and APU fire detection systems are contained in proposed § 25.1737.

Section 25.1737 Powerplant and APU fire detector system: EWIS.

Proposed § 25.1737 would require that EWIS that are part of a fire or overheat detector system located in a fire zone be at least fire-resistant, as defined in § 1.1. It would also require that EWIS components of any fire or overheat detector system for any fire zone may not pass through another fire zone unless:

- they are protected against the possibility of false warning caused by fire in the zone through which they pass, or
- each zone involved is simultaneously protected by the same detector or extinguishing system.

In addition, the proposal would require that EWIS that are part of a fire or overheat detector system in a fire zone meet the requirements of § 25.1203.

The current § 25.1203 requires approved, quick acting fire or overheat detectors in each designated fire zone, and in the combustion, turbine, and tailpipe sections of turbine engine installations, to provide prompt indication of fire in those zones. The present rule does contain requirements for wire used in the fire detection systems. But to increase visibility of the related EWIS requirements and to gather them into one central place, a new rule devoted specifically to fire detector system EWIS is proposed.

Existing § 25.1203 would be amended to reference the new § 25.1737, thus effectively closing the loop on requirements.

Section 25.1739 Instructions for Continued Airworthiness: EWIS.

Proposed § 25.1739 would require that applicants prepare EWIS ICA in accordance with the requirements of Appendix H to part 25. The proposed EWIS ICA requirements are discussed in the next section of this document.

Appendix H to Part 25 – Instructions for Continued Airworthiness

As previously noted, improper maintenance, repair, and modifications often hasten the "aging" of EWIS. To properly maintain, repair, and modify airplane EWIS, certain information must be available to the designer, modifier, and installer. This information should be part of the ICA as required by current § 25.1529 and the proposed § 25.1739.

This proposal would amend Appendix H by adding a new section, H25.5, to require TC applicants to develop maintenance information for EWIS as part of the ICA as a requirement for getting a design approval. The proposed rule would also apply to applicants for design change approvals (supplemental TCs and amended TCs).

The proposal would require applicants for TCs to prepare ICA for EWIS that are approved by the FAA Oversight Office, in the form of a document that is easily recognizable as an EWIS ICA. To prepare these instructions, they must use an EZAP such as the one described in AC 25-27 "Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure" to perform a review of their representative airplane covering all areas, including the flightdeck (also known as the cockpit), electrical power center, fuel tank wiring and powerfeeder cables, as well as the engine. Applicants for design change approvals would have to perform a similar review for their proposed design changes.

A zonal analysis procedure is an assessment of the structures and systems within each physical zone of the airplane. It is used to develop an inspection program to assess the general condition and security of attachment of all system components and structures items contained in the zone, using general visual inspections (GVI). An enhanced zonal analysis procedure (EZAP) is an enhanced version of the zonal analysis procedure. It focuses on EWIS components. An EZAP-generated inspection program might call for the use of stand-alone GVI and detailed inspections (DET). A stand-alone GVI is one that is performed separately from the regularly scheduled GVI (typically more frequently) and is focused on a particular area or component. In this case, the focus would be wiring. So while the zonal analysis procedure would result in a regularly scheduled GVI for the entire zone, in which each of its systems and structures are inspected at the same time, the EZAP could result in additional GVIs or DETs for the EWIS in that zone, which occur more frequently. These inspection techniques are discussed later in this section.

An EZAP identifies the physical and environmental conditions contained in each zone of an airplane, analyzes their effects on electrical wiring, and assesses the possibilities for smoke and fire. From such an analysis, maintenance tasks can be developed to prevent ignition sources and to minimize the possibilities for combustion by minimizing the accumulation of combustible materials. Such a procedure would involve dividing the airplane into physical areas, or zones, including actual physical boundaries such as wing spars, bulkheads, and cabin floor, and access provisions for the zone, and identifying which of those zones contain EWIS components. For those zones with EWIS components, characteristics and components of all systems installed in the zone would be listed. The EWIS in the zone would be described, including information on the full range of power levels carried in the zone. And the presence or possibilities for ignition sources or accumulation of combustibles would be noted.

Combustibles are any materials that could cause a fire to be sustained in the event of an ignition source. Examples of combustible materials would be dust or lint accumulation, contaminated insulation blankets, and fuel or other combustible liquids or vapors. Wire contaminants are foreign materials that are likely to cause degradation of wiring. Wire contaminants can also be combustibles. Some commonly used airplane liquids, like engine oils, hydraulic fluids, and corrosion prevention compounds, might be readily combustible, but only in vapor or mist form. In that case, an assessment must be made of conditions that could exist within the zone that would convert the liquid to that form. Combustibles appearing as a result of any single failure must be considered. An example would be leaks from connection sites of unshrouded pipes. For the purposes of this new requirement, the term combustible does not refer to material that will burn when subjected to a continuous source of heat as occurs when a fire develops. Combustibles, as used here, will sustain a fire without a continuous ignition source.

An EZAP must address:

- Ventilation conditions in the zone and the density of the installations that would affect the presence and build-up of combustibles and the possibilities for combustion. Avionics and instruments located in the flightdeck and equipment bays, which generate heat and have relatively tightly packed installations, require cooling air flow. The air blown into the area for that cooling tends to deposit dust and lint on the equipment and EWIS components.

- Liquid contamination on wiring. Most synthetic oils and hydraulic fluids, while they might not be combustibles by themselves, could be an aggravating factor for accumulation of dust or lint. This accumulation could then present fuel for fire. Moisture on wiring may increase the probability of arcing from small breaches in the insulation, which could cause a fire. Moisture on wires that contain insulation breaches can also lead to "arc tracking." As discussed previously, arc tracking is a phenomenon in which an electrical arc forms a conductive carbon path across an insulating surface. The carbon path then provides a short circuit path through which current can flow. Short circuit current flow from arc tracking can lead to loss of multiple airplane systems, structural damage, and fire.

- EWIS in close proximity to both primary and back-up hydraulic, mechanical, or electrical flight controls.

- The type of wiring discrepancies that must be addressed if they are identified by general visual or detailed inspections. A listing of typical wiring discrepancies that should be detectable during EZAP-derived EWIS inspections is given in AC 25-27 "Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure"

- Proper cleaning methods for EWIS components.

Once information about such contaminants and combustibles within an airplane zone is collected, each identified possibility for combustion would then be addressed to determine whether a specific task could be performed to reduce that possibility. An example of a specific task to reduce build-up of combustibles on EWIS components is the use of temporary protective covers (such as plastic sheeting) over EWIS components in a zone where corrosion prevention fluids are being used. This would minimize the amount of fluid contamination of the EWIS components. Preventing fluid contamination reduces the probability of other contaminants, like dust and dirt, accumulating on the EWIS components. If no task can be developed to prevent accumulation of combustibles in a zone, such as the dust blown through the air by cooler fans, then tasks must be developed to minimize their buildup, such as scheduled cleaning.

Developing an ICA to define such tasks would include assessing whether particular methods of cleaning would actually damage the EWIS components. Although regular cleaning to prevent potential combustible build-up would be the most obvious task for an EWIS ICA, other procedures might also be called for. A detailed inspection of a hydraulic pipe might be appropriate, for instance, if high-pressure mist from a pinhole caused by corrosion could accumulate on a wire bundle in a low ventilation area, creating a possibility for electrical arcing.

Proximity of EWIS to both primary and back-up hydraulic, mechanical, or electrical flight controls within a zone would affect the criticality of inspections needed, their level of detail, and their frequency. Even in the absence of combustible material, wire arcing could adversely affect continued safe flight and landing if hydraulic pipes, mechanical cables, or wiring for fly-by-wire controls are routed close to other wiring.

The EZAP-generated ICA must be produced in the form of a single document, easily recognizable as EWIS ICA for that specific airplane model. The single document is relevant to the maintenance and inspection aspects of the ICA, and not the standard wiring practices manual or electrical load analysis, etc.

The ICA must define applicable and effective tasks, and the intervals for performing them, to:

- Minimize accumulation of combustible materials.
- Detect wire contaminants.
- Detect wiring discrepancies that may not otherwise be reliably detected by inspections contained in existing maintenance programs.

As noted earlier, among the types of tasks to be developed from an EZAP are general visual inspections (GVI) and detailed inspections (DET). A GVI is defined as a visual examination of an interior or exterior area, installation, or assembly to detect obvious damage, failure, or irregularity. This level of inspection is made from within touching distance of the inspected object unless otherwise specified. It is made under normally available lighting conditions such as daylight, hangar lighting, flashlight, or droplight and may require removal or opening of access panels or doors. It may be necessary to use a mirror to improve visual access to all exposed surfaces in the inspection area. Stands, ladders, or platforms may be required to gain proximity to the area being checked. It is expected that the area to be inspected is clean enough to minimize the possibility that accumulated dirt, grease, or other contaminants might hide unsatisfactory conditions that would otherwise be obvious. It is also expected, as an outcome of the EZAP applied to EWIS, that any cleaning considered necessary would be performed in accordance with procedures that minimize the possibility of the cleaning process itself introducing anomalies. The EZAP must identify guidelines to assist personnel performing a GVI in identifying wiring discrepancies and in assessing what effect such discrepancies, if found, could have on adjacent systems, particularly if these include wiring. As discussed previously, a list of typical wiring discrepancies that should be addressed is contained in AC 25-27 "Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure."

A DET is an intensive examination of a specific item, installation, or assembly to detect damage, failure, or irregularity. Available lighting is normally supplemented with a direct source of good lighting at an intensity considered appropriate. Inspection aids, such as mirrors, magnifying lenses, or other means, may be necessary. Surface cleaning and elaborate access procedures may be required. A DET can be more than just a visual inspection. It may include tactile assessment to check a component or assembly for tightness and security. Such an inspection may be needed to ensure the continued integrity of installations such as bonding jumpers, terminal connectors, etc.

A DET would be required when the developer of the EZAP determines that a GVI is inadequate to reliably detect anomalies or degradation of EWIS components. Any detected discrepancies must be corrected according to the operator's approved maintenance procedures. It is not intended that the EZAP ICA identify how to correct detected discrepancies.

To prevent improper modification and repair of existing EWIS or the improper installation of a new EWIS, modification designers and modification personnel must know the applicable standard wiring practices, EWIS identification requirements, and electrical load data for the airplane undergoing modification. The proposed Appendix H 25.5 would also require that the following information be included in ICA applicable to EWIS:

- Standard wiring practices data.

- Wire separation design guidelines.

- Information to explain the airplane's EWIS identification method required by the proposed § 25.1711.

- Electrical load data and instructions for updating that data. Such information will help ensure that those modifying, repairing, or installing new EWIS will not perform any action that will adversely affect previously certified systems and unintentionally introduce potential hazards.

Standard wiring practices are defined as standards developed by the specific airplane manufacturer or industry-wide standards for the repair and maintenance of EWIS. They include procedures and practices for the installation, repair, and removal of EWIS components, including information about wire splices, methods of bundle attachment, connectors and electrical terminal connections, bonding, and grounding. Although a standard wiring practices manual is not a design manual, and those designing a new EWIS modification for a specific model airplane should not use it as such, it does provide the designer with insight into the types of EWIS components used by the TC holder and the procedures recommended by the manufacturer for maintenance or repair that supports continued airworthiness of the components.

EWIS separation guidelines are important for maintaining the safe operation of the airplane. Maintenance and repair personnel need to be aware of the type certificate holders' separation requirements so they do not compromise separation in previously certified systems. In fuel tank systems, the separation of certain wires may be critical design configuration control items and therefore qualify as an airworthiness limitation. Maintenance personnel need to be aware of these guidelines and limitations because many times wire bundles must be moved or removed to perform necessary maintenance. They must be able to readily identify EWIS associated with systems essential to the safe operation of the airplane.

Similarly, those who design and install new EWIS need to be aware of separation requirements so they can use the same methods to develop the required separation for the EWIS they are adding to the airplane. This would help to ensure both that newly added EWIS is adequately separated from other EWIS, airplane system components, and structure so they do not damage the added EWIS, and that the addition of the new EWIS does not invalidate separation for previously certified EWIS.

Electrical load data and the instructions for updating that data are necessary to help ensure that future modifications or additions of equipment that consume electrical power do not exceed the generating capacity of the onboard electrical generation and distribution system. The existing § 25.1351(a)(1) mandates that the required generating capacity, and the number and kinds of power sources, must be determined by an electrical load analysis. Typically, after an airplane is delivered and enters service, it is modified numerous times throughout its service life. Each addition or deletion of an electrical-power-consuming system changes the electrical load requirements. The only way to ensure that the capacity of the overall generating and distribution system, as well as individual electrical buses, is not exceeded is to have an up-to-date electrical load analysis. The best way to ensure that an up-to-date electrical load analysis is maintained is for the type certificate holder to include such data in the ICA provided with the airplane when it is first delivered to a customer, along with recommended practices for keeping it updated as electrical loads are deleted and added.