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of Transportation
**Federal Aviation
Administration**

Advisory Circular

**Subject: Development of Electrical
Standard Wiring Practices
Documentation**

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1. PURPOSE.

This Advisory Circular (AC) provides guidance for developing an electrical standard wiring practices document for air carriers, air operators, holders of type certificates, holders of supplemental type certificates (STCs), maintenance providers, and repair stations. The guidance in this AC is based on recommendations submitted to the FAA from the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC). The information in this AC is derived from the maintenance, inspection, and alteration best practices identified through extensive research by ATSRAC working groups and Federal government working groups. This AC provides a means, but not the only means of creating a document that meets the requirements of FAR 25-1529, Appendix H.

2. OBJECTIVE.

The objective of this AC is to promote a common format for documents containing standard practices for electrical wiring, and to provide a summary of the minimum content expected to be contained within that document. Although the title of the document or manual is left to the discretion of the organization,

such a document will be referred to in this AC as the electrical standard wiring practices manual (ESWPM).

3. APPLICABILITY

The guidance provided in this AC is applicable to all air carriers, air operators, holders of type certificates, holders of supplemental type certificates (STCs), maintenance providers, and repair stations operating under FARs 21, 25, 43, 91, 121, 125, 129, 135, and 145

4. RELATED 14 CFR PARTS.

- a. Part 21, Certification procedures for products and parts
- b. Part 25, Airworthiness standards: Transport category airplanes
- c. Part 43, Maintenance, preventive maintenance, rebuilding, and alteration
- d. Part 91, General operating and flight rules
- e. Part 121, Operating requirements: Domestic, flag, and supplemental operations
- f. 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
- g. Part 129, Operations: Foreign air carriers and foreign operators of u.s.-registered aircraft engaged in common carriage
- h. Part 135, Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft
- i. Part 145, Repair stations

5. RELATED READING MATERIAL.

- a. Advisory Circulars (ACs).
 - (1) AC 25-16 Electrical Fault and Fire Protection and Prevention
 - (2) AC 25.981-1B Fuel Tank Ignition Source Prevention Guidelines

- (3) AC 43-12A Preventive Maintenance
- (4) AC 43.13-1B Acceptable Methods, Techniques and Practices for Repairs and Alterations to Aircraft
- (5) AC 43-204 Visual Inspection For Aircraft
- (6) AC 43-206 Avionics Cleaning and Corrosion Prevention/Control
- (7) AC 65-15A Airframe & Powerplant Mechanics Airframe Handbook, Chapter 11, Aircraft Electrical Systems

b. Reports.

- (1) Aging Transport Systems Rulemaking Advisory Committee, Task 1 and 2, Aging Systems, Final Report.
- (2) Aging Transport Systems Rulemaking Advisory Committee, Task 3, Final Report.
- (3) Aging Transport Systems Rulemaking Advisory Committee, Task 4, Final Report, Standard Wiring Practices.
- (4) Transport Aircraft Intrusive Inspection Project, (An Analysis Of The Wire Installations Of Six Decommissioned Aircraft), Final Report, The Intrusive Inspection Working Group, December 29, 2000.

c. Other Documents.

- (1) ATA Specification 117 (Wiring Maintenance Practices/Guidelines).
- (2) FAA Policy Statement Number ANM-01-04; System Wiring Policy for Certification of Part 25 Airplanes, June 25, 2001

6. DEFINITIONS.

Consumable materials – Materials consumed during the maintenance or repair of EWIS which are not an eventual component of the EWIS.

Drip loop – the practice of looping a wire or wire bundle to provide a point lower than the adjacent connector for moisture to collect.

Electrical Wire Interconnection System (EWIS). An electrical connection between two or more points including the associated termination devices (e.g.,

connectors, terminal blocks, splices) and the necessary means for its installation and identification. Does not include airplane system components (line-replaceable units), relays, lights, etc.

Hazardous materials – Materials necessitating special handling in their use, storage or disposal.

Separation – Defined as either spatial distance, or physical barrier, between wiring from adjacent structure, systems or wiring; or the practice of installing wiring supporting redundant or multi-channel systems.

Standard practices – Industry-wide methods for the repair and maintenance of electrical wire, cable bundles and coaxial cables. Procedures and practices for the inspection, installation and removal of electrical systems components including, but not limited to; wire splices, bundle attachment methods, connectors and electrical terminal connections, bonding/grounding, etc.

7. **BACKGROUND**

The Federal Aviation Administration (FAA) has developed the Aging Non-Structural Systems Plan to address the recommendation of the White House Commission on Aviation Safety and Security (WHCSS) that: In cooperation with airlines and manufacturers, the FAA's Aging Aircraft program should be expanded to cover non-structural systems

The Commission was concerned that existing procedures, directives, quality assurance, and inspections may not be sufficient to prevent safety related problems caused by corrosion and other deteriorating effects on non-structural components of commercial aircraft as they age.

As part of its recommendations, the Commission recommended that the FAA work with airlines and manufacturers to expand the aging airplane program to include non-structural components through steps including: full and complete tear-downs of selected aircraft scheduled to go out of service; the establishment of a lead-the-fleet research program; an expansion of the FAA-DOD-NASA cooperative aging aircraft program; an expansion of programs of the Airworthiness Assurance Working Group to include non-structural components; and encouraging the development of modern technical means to ensure and predict the continued airworthiness of aging non-structural components and systems.

In order to fully address the WHCSS recommendations on aging systems, an Aging Non-structural Systems Study team was formed. This team, led by the Transport Airplane Directorate (TAD), conducted an inspection of systems in

several aging airplanes and met with FAA Principal Maintenance Inspectors (PMI), who are tasked with oversight of major air carriers in order to make a preliminary evaluation of the need for additional work to address the Commission's concerns. The team concluded that additional work is warranted and that industry involvement in this work is essential.

The FAA chose to address these recommendations through an Administrator's Advisory Committee as the most appropriate way to provide a forum for the parties involved in addressing the WHCSS recommendations.

The elements of the aging systems plan were grouped into five major tasks, each incorporating one or more related elements of the plan. One of those tasks was to define standards for a simplified Chapter 20 to be created by the user organization and based on the manufacturer's omnibus Chapter 20, Standard Practices for Wiring; and to define a process for training development based on the airline's customized Chapter 20. This task was assigned to an industry-represented Task 4 Working Group

The tasking statement assigned to the Task 4 Working Group also required the group to consider the "simplification" of Wiring Diagram Manuals (WDM) Chapter 20. It appeared that a "simplified" Chapter 20 ESWPM manual created by the end-users was not recommended for several reasons:

1. It would result in different standards from one end-user to another,
2. Due to the lack of source data, it would not be practical for the end-users to do this, and
3. The end-user would need the details for inspection, maintenance and repair that are currently in the manufacturer's ESWPM.

At the conclusion of the FAA's *Aging Transport Non-Structural Systems Plan* Phase I, the Task 4 Working Group stated that the current presentation and arrangement of standard wire practices make it difficult for an aircraft maintenance technician to locate and extract pertinent and applicable data necessary to effect satisfactory electrical repairs.

Subsequent tasks assigned to the Standard Wire Practice Manual Harmonization Working Group required the development of a standardized ESWPM format and a definition of the minimum content to be included in an ESWPM.

8. STANDARDIZED ESWPM FORMAT

A representative example of the standard format and sequence of major topics included within an ESWPM is contained within Appendix A of this AC.

9. MINIMUM ESWPM CONTENT

A definition and description of ESWPM minimum content is necessary to ensure that operators and repair stations have at their disposal the information necessary to properly maintain their airplanes. Although the original airframe manufacturer's electrical installation design philosophy concerning components, installation procedures, segregation rules, etc. need not be included within the ESWPM sufficient minimum information should be provided to enable the end-user to maintain the aircraft in a condition that conforms to the electrical installation design philosophy of the original manufacturer.

The content of any ESWPM should include, at a minimum, the following:

Front Matter

Provide information regarding the content and use of the ESWPM. Describe changes to the document in a record of revisions. Ensure the document contains a table of contents or index to allow the user to readily retrieve necessary information.

Safety Practices

Provide general instruction, cautions and warnings which describe safe practices implemented prior to the start of any or all of the specific standard electrical practices contained within the core of the ESWPM. Safety cautions, warnings or notes specific to a procedure shall be placed within the body of the procedure.

Cleaning Requirements and Methods

"Protect, clean as you go" philosophy.

- Non-destructive methods for cleaning dust, dirt, foreign object debris (FOD), lavatory fluid, and other contaminants produced by an aircraft environment from wiring systems
- Wire replacement guidelines when an accumulation of contaminants, either on the surface and/or imbedded in a wire bundle, cannot be safely removed

Wire and Cable Identification

- a) Specify requirements for wire and cable identification and marking to facilitate safety of operation, safety to maintenance personnel, and ease of maintenance
- b) Specify methods of direct wire marking. Also, identify specific requirements and cautions associated with certain types of wire marking.

Wire and Cable Damage Limits

Specify limits to positively identify the thresholds where damaged wire/cable replacement may be necessary and where repairs can be safely accomplished. Establish limits for each applicable wire/cable type, if necessary.

- a) Include damage limits for terminals, studs, connectors, and other wiring system components, as necessary.

Installation Clamping and Routing Requirements

- a) Specify the requirements for the installation of wiring systems with respect to physical attachment to the aircraft structure. These requirements must be compatible with the different environments applicable to the aircraft and its systems.
- b) Specify applicable methods of clamping, support, termination, and routing to facilitate installation, repair, and maintenance of wires, wire bundles, and cabling.
- c) Specify minimum bend radii for different types of wire and cable
- d) Specify minimum clearance between wiring and other aircraft systems and aircraft structure.
- e) Include the requirements for the installation of wiring conduit with respect to physical attachment, routing, bend radii, drain holes, and conduit end coverings.
- f) Emphasize special wiring protective features, such as spatial separation, segregation, heat shielding, and moisture protection that are required to be maintained throughout the life of the aircraft.
- g) Ensure necessary information for the maintenance of bonding, grounding and lightning, high-intensity radiated field (L/HIRF) provisions is included.
- h) Include information on the use and maintenance of wire protective devices, conduits, shields, sleeving, etc.

Repair and Replacement Procedures

Describe methods to safely repair and/or replace wiring and wiring system components.

- a) Include types and maximum numbers of splice repairs for wiring, and any limitations on the use of splices. When splicing wire, environmental splices are highly recommended over non-environmental splices. Guidance should be provided on how long a temporary splice may be left in the wire.
- b) Specify procedures for the repair, replacement, and maintenance of connectors, terminals, modular terminal blocks, and other wiring components.

Inspection Methods

In wiring inspection methods, include a general visual inspection (GVI), or a detailed inspection (DET), as determined by the enhanced zonal analysis procedure. Typical damage includes heat damage, chafing, cracked insulation, arcing, insulation delaminating, corrosion, broken wire or terminal, loose terminals, incorrect bend radii, contamination, and deteriorated repairs

- a) Identify detailed inspections and, where applicable, established and emerging new technologies non-destructive test methods to complement the visual inspection process.

Whenever possible, ensure that inspection methods can detect wiring problems without compromising the integrity of the installation.

Customized data

Provide a location and procedures that allow users to include customized or unique data such as that relating to supplemental type certificates, operator-unique maintenance procedures, etc.

A comprehensive listing of the typical content included within an ESWPM, including the minimum required content described above, is contained within Appendix B of this AC.

10. ALTERNATIVE PROCEDURE FOR LEGACY DOCUMENTS.

The definition of a new layout and chapter format may require each organization with an existing ESWPM to reformat and to republish using the standardized format. Whether the organization produces a standalone manual or provides the electrical standard practices as Chapter 20 of a wiring diagram manual, the resultant reorganization would result in a significant economical impact for both the authoring organization and their end users.

The use of a conversion tool, identified as a Master Breakdown Index (MBI) is one method of achieving a common format until existing legacy documents can be physically altered or digitized to an electronic format. The intent of the MBI is to supplement the TOC and existing indexes by providing to users a method of searching existing documents using topical information rather than by part number, alphabetic subject, or Chapter-Section-Subject reference. The arrangement of the MBI duplicates the standardized format described in Paragraph 8 of this AC, but does not require complete rearrangement of legacy documents to achieve a common format. The MBI acts as a conversion key used to effectively convert an existing document arrangement into the proposed arrangement. In essence the MBI duplicates in paper form for legacy documents the electronic search engine for HTML-based documents.

This is an example of an MBI which could be used to mitigate the need for legacy documents to be reformatted to achieve the standardized format described above:

GROUP	MAJOR TOPIC	APPEARS IN THIS DOCUMENT AS SUBJECT
GENERAL DATA	SAFETY PRACTICES	20-10-10
	AIRPLANE ENVIRONMENTAL AREAS	20-20-12
	CONSUMABLE MATERIALS	20-00-11
	WIRING MATERIALS	20-10-13
	COMMON TOOLS	20-00-13
ELECTRICAL WIRE INTERCONNECT SYSTEM (EWIS) MAINTENANCE	EWIS PROTECTION DURING MAINTENANCE	20-10-20
	EWIS CLEANING	20-10-20
	EWIS INSPECTION	20-10-20
	EWIS TESTING	20-10-13
	EWIS DISASSEMBLY	20-10-19 20-20-00
WIRING INSTALLATION	EWIS REPAIR AND REPLACEMENT	
	WIRE SEPARATION / SEGREGATION	20-10-11
	ELECTRICAL BONDS AND GROUNDS	20-10-12 20-30-60
	WIRE HARNESS INSTALLATION	20-10-17 20-10-18 Installation of Sleeves on Wiring
WIRING ASSEMBLY	WIRE AND CABLE TYPES	20-00-15
	WIRE MARKING	20-60-01
	WIRE HARNESS ASSEMBLY	20-50-01
ELECTRICAL DEVICES	WIRE INSULATION AND CABLE JACKET REMOVAL	20-90-12
	TERMINATION TYPE (SPECIFICS OF TERMINATIONS)	20-61-44
	DEVICE TYPE (SPECIFICS OF ELECTRICAL DEVICE)	20-80-09 Assembly of Leach Relay Sockets
SPECIFIC SYSTEM WIRING	UNIQUE WIRING ASSEMBLIES/INSTALLATIONS	20-73-00 Fuel Quantity Indicating System
AIRLINE CUSTOMIZED DATA	AIRLINE SPECIFIED	20-91-00

Appendix A

TABLE 1: GROUPS, MAJOR TOPICS AND STANDARDIZED SEQUENCE

GROUP	MAJOR TOPIC	DESCRIPTION
GENERAL DATA	SAFETY PRACTICES	Safety regulations and general safety precautions to prevent injury to personnel and damage to the airplane
	AIRPLANE ENVIRONMENTAL AREAS	Definition of types of areas upon which wiring configuration and wiring component selection is constrained
	CONSUMABLE MATERIALS	Wiring maintenance processing materials (solvents, aqueous cleaners, lubricants, etc.)
	WIRING MATERIALS	Materials that become an integral part of the wiring configuration excluding wire and cable; e.g., sleeves, shield material, tie material, sealants, etc.
	COMMON TOOLS	Description and operation of common tools
EWIS MAINTENANCE	EWIS PROTECTION DURING MAINTENANCE	Procedures to protect EWIS during airplane maintenance and modification
	EWIS CLEANING	In support of inspection as well as prevention of degradation and preparation for repair; recommended cleaning materials and procedures based on type of contamination
	EWIS INSPECTION	Criteria for correct installation, correct wiring assembly configuration; damage conditions and limits for wiring components (wire and cable, termination types, electrical devices); factors that warrant disassembly for inspection; determination of cause of damage
	EWIS TESTING	Wiring integrity testing
	EWIS DISASSEMBLY	Data and procedures in support of inspection, cleaning when applicable; also supports new wiring installation
	EWIS REPAIR AND REPLACEMENT	Repair of wiring installation, wiring assembly configuration, wiring components (wire and cable, wiring terminations, electrical devices); wire and cable replacement; wiring functional identification
WIRING INSTALLATION	WIRE SEPARATION / SEGREGATION	Explanation of separation / segregation categories, separation / segregation identification, and necessary conditions for maintaining separation / segregation
	ELECTRICAL BONDS AND GROUNDS	Bond surface preparation, ground hardware configurations, bond integrity testing
	WIRE HARNESS INSTALLATION	Routing, supports; wiring protection, factors affecting wiring assembly configuration; connection to equipment, new wiring, removal from service
WIRING ASSEMBLY	WIRE AND CABLE TYPES	The principal material component of airplane wiring; includes type identification and basic description; alternative wire types (replacements, substitutions)
	WIRE MARKING	Marking; applicable conditions
	WIRE HARNESS ASSEMBLY	Wiring assembly configuration: assembly materials, layout, overall protection; factors affecting wiring installation
	WIRE INSULATION AND CABLE JACKET REMOVAL	Wire and cable: Insulation removal, jacket removal; associated damage limits, tool description and operation

TABLE 1: GROUPS, MAJOR TOPICS AND STANDARDIZED SEQUENCE

GROUP	MAJOR TOPIC	DESCRIPTION
	<<TERMINATION TYPE>> e.g., SOURIAU 8950 SERIES CONNECTORS	Wiring terminations and accessories (connectors, terminal lugs, splices, backshells, etc.) grouped by termination type from simple to complex: <ol style="list-style-type: none"> a. Common data or procedures by group (if any); e.g., tool description and operation, definition of internal damage and limits, internal cleaning, accessories b. By individual type - part numbers and description, definition of internal damage and limits (if not specified by common data), disassembly, assembly, installation
ELECTRICAL DEVICES	<<DEVICE TYPE>> e.g., KLIXON 7274 SERIES CIRCUIT BREAKER	Electrical devices (circuit breakers, relays, switches, filters, lamps, etc.) grouped by device type: <ol style="list-style-type: none"> a. Common data or procedures by group (if any); e.g., tool description and operation, definition of internal damage and limits, internal cleaning, accessories b. By individual type - part numbers and description, definition of internal damage and limits (if not specified by common data), disassembly, assembly, installation
SPECIFIC SYSTEM WIRING	SPECIFIC WIRING ASSEMBLY	For wiring that has a necessarily specific configuration (e.g., Primary Flight Control, Fuel Quantity Indicator System, etc.): <ul style="list-style-type: none"> - Applicable conditions for repair and replacement - Disassembly, assembly, installation, assembly integrity testing
AIRLINE CUSTOMIZED DATA	AIRLINE SPECIFIED	Reserved for airline use

Appendix B

TABLE 2: DESCRIPTION OF MAJOR TOPICS AS MINIMUM CONTENT

MAJOR TOPIC	DESCRIPTION
SAFETY PRACTICES	Safety regulations and general safety precautions to prevent injury to personnel and damage to the airplane
AIRPLANE ENVIRONMENTAL AREAS	Definition of types of areas upon which wiring configuration and wiring component selection is constrained
CONSUMABLE MATERIALS	Wiring maintenance processing materials (solvents, aqueous cleaners, lubricants, etc.)
WIRING MATERIALS	Materials that become an integral part of the wiring configuration excluding wire and cable; e.g., sleeves, shield material, tie material, sealants, etc.
COMMON TOOLS	Description and operation of common tools
EWIS PROTECTION DURING MAINTENANCE	Procedures to protect EWIS during airplane maintenance and modification
EWIS CLEANING	In support of inspection as well as prevention of degradation and preparation for repair; recommended cleaning materials and procedures based on type of contamination
EWIS INSPECTION	Criteria for correct installation, correct wiring assembly configuration; damage conditions and limits for wiring components (wire and cable, termination types, electrical devices); factors that warrant disassembly for inspection; determination of cause of damage
EWIS TESTING	Wiring integrity testing
EWIS DISASSEMBLY	Data and procedures in support of inspection, cleaning when applicable; also supports new wiring installation
EWIS REPAIR AND REPLACEMENT	Repair of wiring installation, wiring assembly configuration, wiring components (wire and cable, wiring terminations, electrical devices); wire and cable replacement; wiring functional identification
WIRE SEPARATION / SEGREGATION	Explanation of separation / segregation categories, separation / segregation identification, and necessary conditions for maintaining separation / segregation
ELECTRICAL BONDS AND GROUNDS	Bond surface preparation, ground hardware configurations, bond integrity testing
WIRE HARNESS INSTALLATION	Routing, supports, wiring heat, moisture, and vibration protection, factors affecting wiring assembly configuration; connection to equipment, new wiring, removal from service
WIRE AND CABLE TYPES	The principal material component of airplane wiring; includes type identification and basic description; alternative wire types (replacements, substitutions)
WIRE MARKING	Marking; applicable conditions
WIRE HARNESS ASSEMBLY	Wiring assembly configuration: assembly materials, layout, overall protection; factors affecting wiring installation
WIRE INSULATION AND CABLE JACKET REMOVAL	Wire and cable: Insulation removal, jacket removal; associated damage limits, tool description and operation
<<TERMINATION TYPE>> e.g., SOURIAU 8950 SERIES CONNECTORS	Wiring terminations and accessories (connectors, terminal lugs, splices, backshells, etc.) grouped by termination type from simple to complex: <ul style="list-style-type: none"> a. Common data or procedures by group (if any); e.g., tool description and operation, definition of internal damage and limits, internal cleaning, accessories b. By individual type - part numbers and description, definition of internal damage and limits (if not specified by common data), disassembly, assembly, installation

TABLE 2: DESCRIPTION OF MAJOR TOPICS AS MINIMUM CONTENT

MAJOR TOPIC	DESCRIPTION
<<DEVICE TYPE>> e.g., KLIXON 7274 SERIES CIRCUIT BREAKER	Electrical devices (circuit breakers, relays, switches, filters, lamps, etc.) grouped by device type: <ul style="list-style-type: none"> a. Common data or procedures by group (if any); e.g., tool description and operation, definition of internal damage and limits, internal cleaning, accessories b. By individual type - part numbers and description, definition of internal damage and limits (if not specified by common data), disassembly, assembly, installation
SPECIFIC WIRING ASSEMBLY	For wiring that has a necessarily specific configuration (e.g., Primary Flight Control, Fuel Quantity Indicator System, etc.): <ul style="list-style-type: none"> - Applicable conditions for repair and replacement - Disassembly, assembly, installation, assembly integrity testing
AIRLINE SPECIFIED	Reserved for airline use