



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: AIRCRAFT ELECTRICAL
WIRING INTERCONNECTION
SYSTEMS TRAINING PROGRAM

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Initiated by:
AFS-300/ANM-100

AC No. 120-94

1. PURPOSE. This advisory circular (AC) provides guidance for developing an enhanced electrical wiring interconnection systems (EWIS) training program.

2. APPLICABILITY.

a. The guidance provided in this document is directed to air carriers, air operators, and repair stations. It may also be used by type certificate holders and supplemental type certificate (STC) holders. The recommendations in this AC can be applied to any aircraft training program.

b. 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 as a basis for finding compliance.

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

d. Terms used in this AC such as “shall” or “must” are used 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 the FAA’s Aging Systems Plan, either through rulemaking or through other means. The NTSB specifically cited the need for improved training of personnel to ensure adequate recognition and repair of potentially unsafe wiring conditions.

(Reference NTSB Safety Recommendations A-00-105 through -108, September 19, 2000.)
This AC responds to the NTSB training improvement recommendation.

b. To address the issues identified in our Aging Systems Plan, in 1998 we established 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. These recommendations address EWIS certification issues, development of a standard wiring practices manual, enhanced EWIS maintenance requirements, and EWIS training.

c. The guidance in this AC is based on recommendations submitted to us by ATSRAC. It is derived from the best practices training developed through extensive research by ATSRAC Industry Working Groups 5, 8, and 11. We endorse these best practices. Adoption of the recommendations in this AC will result in a training program that will improve the awareness and skill level of aviation personnel in electrical wiring interconnection systems production, modification, maintenance, inspection, and repair. This AC promotes a policy of providing wiring training for all personnel who come into contact with aircraft electrical wiring interconnection systems as part of their job and tailors the training for each workgroup to their particular needs.

d. To fully realize the objectives of this AC, air carriers, air operators, repair stations, type certificate holders, and STC holders will need to rethink their current approach to maintaining and modifying aircraft wiring and systems. This may require more than simply updating maintenance manuals and work cards and enhancing training. Maintenance personnel need to be aware that aircraft electrical wiring interconnection systems should be maintained with the same level of attention and intensity as any other system in the aircraft. They also need to recognize that visual inspection of wiring has inherent limitations. Small defects such as breached or cracked insulation, especially in small gage wire, may not always be apparent. Therefore effective wiring maintenance combines visual inspection techniques with improved wiring maintenance practices and training.

4. BACKGROUND.

a. Sections 121.1111 and 129.111 of 14 CFR, both titled *Electrical wiring interconnection systems (EWIS) maintenance program*, require operators to include in their maintenance program inspections and procedures for electrical wiring interconnection systems (EWIS).

b. Section 121.375 of 14 CFR requires that each certificate holder or person performing maintenance or preventative maintenance have a training program to ensure that each person (including inspection personnel) who determines the adequacy of work done is fully informed about procedures and techniques and new equipment in use. Although there is not a direct training requirement in part 129, § 129.14 requires that each foreign air carrier and each foreign person operating a U.S.-registered aircraft maintain that aircraft in accordance with a program approved by the FAA Administrator. Guidance for this requirement is provided by AC 129-4 Maintenance Programs for U.S.-Registered Aircraft Under FAR part 129. It is this guidance material and that of 14 CFR part 43 that we have traditionally used

to ensure that maintenance performed on aircraft operated under part 129 is accomplished by properly trained personnel.

c. This AC provides guidance for developing an EWIS training program as required by those sections. The training syllabus and curriculum for those personnel, identified in paragraph 6 of this AC as Target Groups 1 and 2, are in Appendix A to this AC.

d. This AC also provides guidance on the development of EWIS training programs for personnel who are not directly involved in the maintenance and inspection of EWIS.

(1) Although there is not a regulatory requirement for EWIS training for them, operators may choose to provide EWIS training. The training syllabus and curriculum for these personnel, identified in paragraph 6 of this AC as Target Groups 3 through 8, are in Appendix B to this AC.

(2) We believe that training personnel in these groups would greatly enhance awareness of the importance of EWIS safety in the overall safe operation of aircraft. Although these groups are not directly involved in the maintenance of EWIS, they have the potential to have an adverse impact on EWIS. This can occur through inadvertent contact with EWIS during aircraft cleaning or when individuals perform maintenance unrelated to EWIS that could impact the integrity of EWIS. Mechanics leaving drill shavings on wire bundles is one example of how this could occur. Some people prepare paperwork that guides mechanics, and training this target group in EWIS can ensure proper attention to EWIS issues.

5. DEVELOPING AN EWIS TRAINING PROGRAM.

a. The objective of this EWIS training program is to give operators or maintenance repair organizations a model for developing their own EWIS training program. This training can benefit personnel whether such training is required by regulation or developed and adopted voluntarily by an organization. It will help ensure that proper processes, procedures, methods, techniques, and practices are used when performing maintenance, preventive maintenance, inspection, alteration, repair, and cleaning of EWIS.

b. This program was developed for eight different target groups and may be used for initial and recurrent training. Depending on their duties, some personnel may fall into more than one target group and therefore would need to fulfill all objectives of each of their associated target groups. Paragraph 6 of this AC provides details of each target group.

6. TRAINING TARGET GROUPS.

Target Group 1: Personnel Performing Electrical Wiring Interconnection Systems Maintenance—These personnel work directly at maintaining or modifying EWIS.

Examples:

- FAA – Electricians, avionics/airframe and powerplant (A & P) technicians
- EASA – Part 66 Cat B1 and Cat B2 personnel (licensed technician, avionic) and avionic skilled workers

Target Group 2: Personnel Performing Maintenance Inspections on Electrical Wiring Interconnection Systems—These personnel perform EWIS inspections but do not directly maintain or modify EWIS.

Examples:

- FAA – Inspectors/A & P technicians
- EASA – Part 66 Cat B1 and Cat B2 licensed personnel

Target Group 3: Personnel Performing Electrical/Avionic Engineering on In-Service Aircraft—These are personnel authorized to design EWIS installations, modifications, and repairs.

Examples:

- FAA/EASA – Electrical/avionic engineers

Target Group 4: Personnel Performing General Maintenance/Inspections Not Involving Wire Maintenance—These personnel perform maintenance on aircraft that may require removal/reconnection of electrical connective devices such as removing and replacing line replaceable units.

Examples:

- FAA – A & P technicians
- EASA – Part 66 Cat A (licensed technician – minor maintenance and simple repair) or B1 (licensed technician – excluded avionics)

Target Group 5: Personnel Performing Other Engineering or Planning Work on In-Service Aircraft—These are personnel authorized to design mechanical/structural systems installations, modifications, and repairs, or personnel authorized to plan maintenance tasks.

Target Group 6: Other Service Staff with Duties in Proximity to Electrical Wiring Interconnection Systems—These are personnel whose duties would bring them into contact/view of aircraft EWIS. This group would include, but not be limited to, aircraft cleaners, cargo loaders, fuelers, lavatory servicing personnel, deicing personnel, and push-back personnel.

Target Group 7: Flight Deck Crew

Target Group 8: Cabin Crew

7. ESSENTIAL ELEMENTS FOR A TRAINING PROGRAM.

a. Initial Training—Initial training should be conducted for each designated work group. The initial training program content for Target Groups 1 and 2 is outlined in Appendix A. Initial training program content for Target Groups 3 through 8 is outlined in Appendix B. Curriculum and lesson plans for each dedicated module identified in Appendices A and B are given in Appendix C. A list of definitions for terms used in the curriculum and lesson plans is included in Appendix D.

(1) The most important criterion is to meet the objectives of the lesson plans (Appendix C), using classroom discussion, computer-based instruction, or hands-on practical training.

(2) Assessment means or criteria for achieving objectives should be at the discretion of the training organization. Examples of assessment means or achievement criteria are written tests, oral tests, or demonstration of skills.

(3) Supporting documentation such as advisory circulars is an integral part of training and should be used to support development of the curriculum and lesson plans.

b. Refresher Training—Refresher training should be conducted at least every two years. It could consist of a review of previously covered material plus any new material or revisions to publications. Refresher training would follow the Electrical Wiring Interconnection System Minimum Initial Training Program (Appendix A or B) for that particular target group.

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APPENDIX A**ELECTRICAL WIRING INTERCONNECTION SYSTEMS (EWIS) MINIMUM INITIAL TRAINING PROGRAM CONTENT FOR TARGET GROUPS 1 AND 2**

Target Group 1: Personnel Performing Electrical Wiring Interconnection Systems Maintenance

Target Group 2: Personnel Performing Maintenance Inspections on Electrical Wiring Interconnection Systems

TARGET GROUP	1	2
A - GENERAL ELECTRICAL WIRING INTERCONNECTION SYSTEM PRACTICES		
Know or demonstrate safe handling of airplane electrical systems, line replaceable units (LRU) and tooling, troubleshooting procedures, and electrical measurement.		
1. Safety practices	X	X
2. Electrostatic discharge sensitive (ESDS) device handling and protection	X	X
3. Tools, special tools, and equipment	X	
4. Verifying calibration/certification of instruments, tools, and equipment	X	
5. Required wiring checks using troubleshooting procedures and charts	X	
6. Measurement and troubleshooting using meters	X	
7. LRU replacement general practices	X	X
B – WIRING PRACTICES DOCUMENTATION	1	2
Understand how the applicable airplane wiring system overhaul or wiring practices manual is organized or constructed and demonstrate navigation through the documents to find information.		
8. Standard wiring practices manual structure/overview	X	X
9. Chapter cross-reference index	X	X
10. Important data and tables	X	X
11. Wiring diagram manuals	X	X
12. Other documentation as applicable	X	X
C – INSPECTION	1	2
Know the different types of inspections, zonal areas and typical damage, and how human factors affect inspections.		
13. General visual inspection (GVI), detailed inspection (DET), special detailed inspection (SDI), and zonal inspection, and their criteria and standards	X	X
14. Human factors in inspection	X	X
15. Zonal areas of inspection	X	X
16. Wiring system damage	X	X
D – HOUSEKEEPING	1	2
Know the contamination sources, materials, and cleaning and protection procedures.		
17. Airplane external contamination sources	X	X
18. Airplane internal contamination sources	X	X

TARGET GROUP	1	2
19. Other contamination sources	X	X
20. Contamination protection planning	X	
21. Protection during airplane maintenance and repair	X	
22. Cleaning processes	X	
E – WIRE Know or demonstrate correct identification of different wire types, their inspection criteria and damage tolerance, and repair and preventative maintenance procedures.	1	2
23. Wire identification, type and construction	X	X
24. Insulation qualities and damage limits	X	X
25. Inspection criteria and standards for wire and wire bundles		X
26. Wire bundle installation practices	X	X
27. Typical damage and areas found (airplane specific)	X	X
28. Maintenance and repair procedures	X	X
29. Sleeving	X	X
30. Unused wires-termination and storage	X	X
31. Electrical bonding and grounds	X	X
F – CONNECTIVE DEVICES Know or demonstrate the procedures to identify, inspect, and find the correct repair for typical types of connectors found on the applicable airplane.	1	2
32. General connector types and identification	X	X
33. Cautions and protections	X	X
34. Visual inspection procedures	X	X
35. Typical damage found	X	X
36. Repair procedures	X	X
G – CONNECTIVE DEVICE REPAIR Demonstrate replacement procedures for all parts of typical types of connectors found on the applicable airplane.	1	2
37. Circular connectors	X	
38. Rectangular connectors	X	
39. Terminal blocks-modular	X	
40. Terminal blocks- non-modular	X	
41. Grounding modules	X	
42. Pressure seals	X	

NOTE: For Target Group 2, items A3, A4, A6 may not be required, but as new inspection tooling becomes available it may be appropriate to require tooling training. In addition, these items would be valuable for voluntary training for inspector awareness.

APPENDIX B**ELECTRICAL WIRING INTERCONNECTION SYSTEMS (EWIS) MINIMUM INITIAL TRAINING PROGRAM CONTENT FOR TARGET GROUPS 3 THROUGH 8**

Target Group 3: Personnel Performing Electrical/Avionic Engineering on In-Service Aircraft

Target Group 4: Personnel Performing General Maintenance/Inspections Not Involving Wire Maintenance

Target Group 5: Personnel Performing Other Engineering or Planning Work on In-Service Aircraft

Target Group 6: Other Service Staff with Duties in Proximity to Electrical Wiring Interconnection Systems

Target Group 7: Flight Deck Crew

Target Group 8: Cabin Crew

	Target Groups	3	4	5	6	7	8
A - GENERAL ELECTRICAL WIRING INTERCONNECTION SYSTEM PRACTICES							
Know or demonstrate safe handling of airplane electrical systems, line replaceable units (LRU), and tooling, troubleshooting procedures, and electrical measurement.							
1. Safety practices			X		X	X	X
2. Electrostatic discharge sensitive (ESDS) device handling and protection			X				
7. LRU replacement general practices			X				
B – WIRING PRACTICES DOCUMENTATION							
Understand how the applicable airplane wiring system overhaul or wiring practices manual is organized or constructed and demonstrate navigation through the documents to find information.							
8. Standard wiring practices manual structure/overview		X					
9. Chapter cross-reference index		X					
10. Important data and tables		X					
11. Wiring diagram manuals		X					
12. Other documentation as applicable		X					
C – INSPECTION							
Know the different types of inspections, zonal areas and typical damages, and how human factors affect inspections.							
13. General visual inspection (GVI), detailed inspection (DET), special detailed inspection (SDI), and zonal inspection and their criteria and standards		X	X	X			
14. Human factors in inspection		X		X			
15. Zonal areas of inspection		X		X			
16. Wiring system damage		X	X	X	Low level	Low level	Low level

D – HOUSEKEEPING		Target Groups	3	4	5	6	7	8
Know the contamination sources, materials, and cleaning and protection procedures.								
17. Airplane external contamination sources			X	X		X	X	X
18. Airplane internal contamination sources			X	X		X	X	X
19. Other contamination sources			X	X		X	X	X
20. Contamination protection planning			X	X	X			
21. Protection during airplane maintenance and repair			X	X	X			
22. Cleaning processes			X	X	X	X		
E – WIRE		Target Groups	3	4	5	6	7	8
Know or demonstrate correct identification of different wire types, their inspection criteria and damage tolerance, and repair and preventative maintenance procedures.								
23. Wire identification, type and construction			X					
24. Insulation qualities and damage limits			X					
25. Inspection criteria and standards of wire and wire bundles			X					
26. Wire bundle installation practices			X					
27. Typical damage and areas found (airplane specific)			X	X	X	Low level	Low level	Low level
28. Maintenance and repair procedures			X					
29. Sleeving			X					
30. Unused wires-termination and storage			X					
31. Electrical bonding and grounds			X	X Bond	X			
F – CONNECTIVE DEVICES		Target Groups	3	4	5	6	7	8
Know or demonstrate the procedures to identify, inspect, and find the correct repair for typical types of connectors found on the applicable airplane.								
32. General connector types and identification			X					
33. Cautions and protections			X					
34. Visual inspection procedures			X					
35. Typical damage found			X					
36. Repair procedures			X					

APPENDIX C

ELECTRICAL WIRING INTERCONNECTION SYSTEMS CURRICULUM AND LESSON PLANS

Overview

This training is targeted at each person who performs airplane maintenance, inspections, alterations, or repairs on electrical wiring interconnection systems and/or structure. This course can be used by training providers for all maintenance persons at any stage in their careers. A person can be trained to the appropriate level using the applicable modules depending on that person's experience, work assignment, and operator's policy.

This curriculum is divided into the following training modules.

MODULE A: General Electrical Wiring Interconnection Systems Practices

This module lays the groundwork for safe, effective maintenance and repair of airplane electrical wiring interconnection systems and removal and replacement of line replaceable units (LRU), including built-in test equipment (BITE) testing, without damage to the airplane or injury to the student.

MODULE B: Wiring Practices Documentation

The intent of this module is to teach the student how to locate desired information in the standard wiring practices manual (SWPM), wiring diagram manuals, and other applicable documentation.

MODULE C: Inspection

This module teaches students the skills of inspection to identify wiring system damage.

MODULE D: Housekeeping

This module teaches the student housekeeping strategies to keep the electrical wiring interconnection system free of contamination.

MODULE E: Wire

This module teaches the student about wire selection and inspection strategies.

MODULE F: Connective Devices

This module teaches the student about identification, inspection, and repair of connective devices found on the airplane.

MODULE G: Connective Devices Repair

This module is primarily a hands-on class, emphasizing the repair and replacement of connective devices found on the airplane. The list of types of connective devices in this module, and the training for them, can be used to cover typical connectors for airplanes and can be adjusted to suit training requirements.

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN**MODULE A: GENERAL ELECTRICAL WIRING INTERCONNECTION
SYSTEMS PRACTICES****Overview**

With Module A, the instructor lays the groundwork for safe, effective maintenance and repair of airplane electrical wiring interconnection systems and removal and replacement of LRUs, including built-in test equipment (BITE) testing, without damage to the airplane or injury to the student.

The instructor may vary the depth and scope of the topics to be covered, depending on the type of airplane to be maintained and skills of the students.

Objectives

After completion of this module the student is able to demonstrate the following:

1. Knowledge of safety procedures for normal and non-normal maintenance procedures so the student can protect him/herself and the airplane.
2. Recognizing electrostatic discharge sensitive (ESDS) equipment and demonstrating standard anti-static procedures so that no damage occurs to that equipment.
3. Correct use of hand tools, including specialized and automated tools and equipment.
4. Verification of calibration of electrical measuring instruments, tools, and equipment so that correct maintenance procedures may be carried out.
5. The process and procedures for successfully using troubleshooting procedures and charts of current airplane faults and knowledge of re-occurring problems causing "no fault found" on removed LRUs.
6. Correct use of electrical meters for measuring voltage, current, resistance, continuity, insulation, and short to ground.
7. Knowledge of removal and replacement techniques for LRUs, so that no damage will occur to the LRU or airplane connector.

Hands-on Equipment and Teaching Aids

Normal classroom lecture can be used for the majority of this training. The following hands-on equipment, teaching aids, and training exercises are recommended to expedite learning.

Equipment

- Airplane manuals
- Meters and circuits
- Company policy

Teaching Aids

- Multi-media/training aids

Training Exercises

- LRU removal and replacement
- ESDS device handling and protection
- Calibration/certification of instruments, tools, and equipment
- Wiring checks using troubleshooting procedures and charts
- Measurement and troubleshooting using meters

MODULE A**GENERAL ELECTRICAL WIRING INTERCONNECTION SYSTEMS PRACTICES**

1. Safety practices
 - a. Current is lethal - first aid
 - b. Applying power to the airplane
 - c. Isolating the circuit
 - d. Airplane warnings
 - e. Human factors
2. Electrostatic discharge sensitive (ESDS) device handling and protection
 - a. ESDS devices
 - b. Sources of electrostatic discharge
 - c. Soft and hard failures
 - d. ESDS safety procedures
 - e. ESDS handling/packing procedures
3. Tools, special tools, and equipment
 - a. General hand tools
 - b. Specialized tools
 - c. Automated tools and equipment
4. Verifying calibration/certification of instruments, tools, and equipment
 - a. Tools requiring calibration/certification
 - b. Determining calibration/certification requirements
 - c. Typical problems
5. Required wiring checks using troubleshooting procedures and charts
 - a. Troubleshooting procedures manuals, including fault isolation manual (all chapters)
 - b. Aircraft maintenance manual / illustrated parts catalog
 - c. Wiring schematics / troubleshooting graphics

- d. Wiring diagrams
 - e. The troubleshooting process
 - f. Testing of LRU connectors
 - g. Troubleshooting exercises
 - h. Company “no fault found” policy and data
6. Measurement and troubleshooting using meters
- a. Voltage, current, and resistance
 - b. Continuity
 - c. Insulation
 - d. Short to ground
 - e. Loop impedance
7. LRU replacement general practices
- a. Different retention devices
 - b. Certification considerations (e.g., CAT 2/CAT3 landing)
 - c. LRU re-racking procedures
 - d. “No fault found” data (airplane specific)
 - e. Built-in test equipment (BITE)

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN

MODULE B: WIRING PRACTICES DOCUMENTATION

Overview

With Module B, the instructor lays the groundwork for safe, effective maintenance and repair of airplane electrical wiring interconnection systems. The intent of this module is to teach how to locate desired information in the standard wiring practices manual (SWPM), wiring diagram manuals, and other applicable documentation. The instructor may vary the depth and scope of the topics to be covered depending on the type of airplane to be maintained and the skills of the students.

Objectives

After completion of this module the student is able to demonstrate the following:

1. Knowledge of applicable sub-chapters and sections to follow during normal and non-normal electrical maintenance procedures.
2. How to use cross-reference indexes, chapter tables of contents, and subject tables of contents to find specific material within each sub-chapter and section.
3. How to use the associated tables for replacement of wire, connective devices and contacts, and associated components, including approved replacements.
4. How to use wiring diagram manuals.
5. How to use other documentation (as applicable).

Hands-on Equipment and Teaching Aids

Normal classroom lecture can be used for the majority of the training. The SWPM, wiring diagram manuals, and other applicable documentation should be made available to the class for hands-on exploration of the material.

MODULE B
WIRING PRACTICES DOCUMENTATION

1. Standard Wiring Practices Manual (SWPM) structure/overview
 - a. Table of contents
 - b. Sub-chapter titles
 - c. Section structure
 - d. General procedures
2. SWPM cross-reference index
 - a. Cross-reference index – alphanumeric
 - b. Cross-reference index – standard part number
 - c. Cross-reference index – suppliers
 - d. Equivalence tables – standard part numbers
3. SWPM important data and tables
 - a. Contact crimp tools, insertion/extraction tools
 - b. Wire insulation removal tools
 - c. Electrical cable binding
 - d. Wire type codes and part numbers identification
 - e. Connective devices types and contacts
 - f. Terminal blocks and terminations
 - g. Terminal blocks modules, grounding modules, and contacts
 - h. Cleaning procedures
 - i. Repair procedures
4. Wiring diagram manuals (WDM)
 - a. Front matter
 - b. Diagrams
 - c. Charts
 - d. Lists
5. Other documentation (as applicable)

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN

MODULE C: INSPECTION

Overview

With Module C, the instructor lays the groundwork for safe, effective maintenance and repair of airplane wiring systems by teaching the inspection skills for identifying wiring system damage. The instructor may vary the depth and scope of the topics to be covered depending on the type of airplane to be maintained and the skills of the students.

Objectives

After completion of this module the student is able to demonstrate the following:

1. Knowledge of the different types of inspections.
 - General visual inspection (GVI).
 - Detailed inspection (DET).
 - Special detailed inspection (SDI).
 - Zonal inspection.
 - Enhanced zonal analysis procedure (EZAP).
2. Knowledge of criteria and standards of inspection and the correct tools to use to ensure inspection procedures and standards are achieved so that all defects will be found.
3. Knowledge of how human factors (for example fatigue and complacency on the part of the inspector) can affect inspection and how to combat their effects.
4. Knowledge of specific zonal inspection requirements related to system affiliation and environmental conditions.
5. How to recognize typical electrical wiring interconnection system damage such as hot gas damage, external mechanically-induced damage, fluid contamination, chafing, corrosion, and signs of overheating of wire, wire bundles, and connective and control device assemblies.

Hands-on Equipment and Teaching Aids

Normal classroom lecture can be used for the majority of this training. The ATA (Air Transport Association of America) specification 117 video on wire maintenance and color photos of actual wiring system damage could be used to show typical problems found on the airplane. Examples of discrepancies should be made available to the students. AC 25-27, Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure, is recommended as a source for typical aircraft wiring installations and areas of concern.

MODULE C

INSPECTION

1. Types of inspections
 - a. General visual inspection (GVI)
 - b. Detailed inspection (DET)
 - c. Special detailed inspection (SDI)
 - d. Zonal inspection
 - e. Enhanced zonal analysis procedure (EZAP)
2. Criteria and standards
 - a. Tools
 - b. Criteria/standards
 - c. Inspection procedures
3. Human factors in inspection

Examples:

 - a. Fatigue
 - b. Complacency
4. Zonal areas of inspection
 - a. Zonal areas of inspection
 - b. Zonal inspection procedures and standards
5. Electrical wiring interconnection systems damage
 - a. Damage from swarf¹/metal shavings and other foreign objects
 - b. External mechanically-induced damage
 - c. Hot-gas-induced damage
 - d. Fluid contamination
 - e. Vibration/chafing
 - f. Corrosion
 - g. Signs of overheating

¹ See Appendix D for definition.

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN

MODULE D: HOUSEKEEPING

Overview

With Module D, the instructor lays the groundwork for safe, effective maintenance and repair of airplane electrical wiring interconnection systems by teaching housekeeping strategies to keep the electrical wiring interconnection system free of contamination. The instructor may vary the depth and scope of the topics to be covered depending on the type of airplane to be maintained and the skills of the students.

Objectives

At the completion of this module the student is able to demonstrate the following:

1. How to recognize external contamination and other damage due to external environmental conditions.
2. Knowledge of airplane internal contamination sources, so that inspection processes can be effectively carried out and contamination damage easily recognized.
3. How to recognize other possible contamination sources.
4. Knowledge of planning procedures to be followed on electrical wiring interconnection system areas in different parts of the airplane.
5. Knowledge of procedures and processes to protect the electrical wiring interconnection system during maintenance and repair.
6. Knowledge of the process of cleaning electrical wiring interconnection systems during maintenance and repair.

Hands-on Equipment and Teaching Aids

Normal classroom lecture can be used for the majority of the training. The ATA specification 117 wire maintenance video and color photos of actual electrical wiring interconnection system contamination could be used to show typical problems found on the airplane. Relevant aircraft maintenance manual and/or standard wiring practices

manual (SWPM) procedures should be used. The ATSRAC Working Group 1 Non-Intrusive Inspection Final Report could be used to identify typical housekeeping issues. AC 25-27, Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zone Analysis Procedure, is recommended as a source for typical aircraft wiring installations and areas of concern.

MODULE D

HOUSEKEEPING

1. Airplane external contamination sources
 - a. De-icing fluids
 - b. Water and rain
 - c. Snow and ice
 - d. Miscellaneous contamination (e.g. cargo / beverage spillage)
 - e. Air erosion

2. Airplane internal contamination sources
 - a. Hydraulic oils
 - b. Engine and auxiliary power unit (APU) oils
 - c. Fuel
 - d. Greases
 - e. Contaminants from galleys and toilets
 - f. Lint/dust
 - g. Bleed air and hot areas
 - h. Hazardous materials

3. Other contamination sources
 - a. Paint
 - b. Corrosion inhibitor
 - c. Metal shavings/Swarf
 - d. Foreign objects (screws, washers, rivets, tools, etc.)
 - e. Animal waste

4. Contamination protection planning
 - a. Have a plan – types of plans / area mapping
 - b. Protection and caution recommendations
 - c. Procedures
 - d. Keep cleaning

- 5. Protection during airplane maintenance and repair
 - a. Recommended general maintenance protection procedures
 - b. Recommended airframe repair protection procedures
 - c. Recommended powerplant repair protection procedures

- 6. Cleaning processes
 - a. Fluid contamination
 - (1) Snow and ice
 - (2) De-icing fluid
 - (3) Cargo spillage
 - (4) Water and rain
 - (5) Galley contaminants
 - (6) Toilet water waste
 - (7) Oils and greases
 - (8) Pressure wash
 - b. Solid contamination
 - (1) Metal shavings/swarf
 - (2) Foreign objects (screws, washers, rivets, tools, etc.)
 - c. Environmental contamination
 - (1) Lint and dust
 - (2) Paint
 - (3) Corrosion inhibitor
 - (4) Animal waste

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN

MODULE E: WIRE

Overview

With Module E, the instructor lays the groundwork for safe, effective maintenance, alteration, and repair of airplane electrical wiring interconnection systems by teaching wire selection and inspection strategies. The instructor may vary the depth and scope of the topics to be covered depending on the type of airplane to be maintained and the skills of the students.

Objectives

At the completion of this module the student is able to demonstrate the following:

1. The procedure for identifying specific wire types using airplane manuals.
2. Knowledge (from approved data) of different insulation types and their relative qualities.
3. Knowledge of inspection criteria for wire and wire bundles.
4. Knowledge of standard installation practices for wire and wire bundles (airplane specific).
5. Knowledge of typical damage that can be found (airplane specific).
6. Repair procedures for typical damage found on the student's type of airplane.
7. Procedures for fitting different types of sleeving (airplane specific).
8. Knowledge of procedures for termination and storage of unused wires.
9. Knowledge of correct installation practices for electrical bonds and grounds (airplane specific).

Hands-on Equipment and Teaching Aids

Normal classroom lecture can be used for the majority of this training, with hands-on practice for the repair procedures in section 6. Standard wiring practices manuals (SWPM) and wiring diagram manuals should be made available to the class for hands-on use so that wire identification, inspection, installation, and repair procedures can be fully explored. Examples of wire discrepancies should also be made available to the student. The ATSRAC Working Group 1 Intrusive Inspection Final Report could be used to identify typical wire issues. AC 25-27, Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure, is recommended as a source of information on typical aircraft wiring installations and areas of concern.

MODULE E**WIRE**

1. Identification, type, and construction
 - a. Wire type codes – alphanumeric
 - b. Wire type codes – specification and standard part number
 - c. Wire type codes – specified wire and alternate
 - d. Manufacturer identification
2. Insulation qualities
 - a. Types of insulation
 - b. Typical insulation damage and limitations
 - c. Carbon arcing
3. Inspection criteria and standards for wire and wire bundles
 - a. Inspection of individual wiring
 - b. Inspection of wire bundles
4. Wire bundle installation practices
 - a. Routing
 - b. Segregation rules
 - c. Clearance
 - d. Clamp inspection
 - e. Clamp removal and fitting
 - f. Conduit types and fitting
 - g. Raceways
 - h. Heat shields and drip shields
5. Typical damage from different causes and areas found (airplane specific)
 - a. Vibration
 - b. Heat
 - c. Corrosion
 - d. Contamination
 - e. Personnel traffic passage

6. Maintenance and repair procedures
 - a. Wire damage assessment and classification
 - b. Approved repairs/improper repairs
 - c. Shielded wire repair
 - d. Repair techniques
 - e. Terminals and splices
 - f. Preventative maintenance procedures

7. Sleeving
 - a. Identification sleeves
 - b. Shrink sleeves
 - c. Screen braid grounding crimp sleeves
 - d. Screen braid grounding solder sleeves

8. Unused wires - termination and storage
 - a. Termination – end caps
 - b. Storage and attachment

9. Electrical bonding and grounds
 - a. Inspection standards
 - b. Primary bonding (HIRF protection)
 - c. Secondary bonding (system grounding)
 - d. Lightning strikes

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN

MODULE F: CONNECTIVE DEVICES

Overview

With Module F the instructor lays the groundwork for safe, effective maintenance, alteration, and repair of airplane electrical wiring interconnection systems by teaching identification, inspection, and repair of connective devices found on the airplane. The instructor may vary the depth and scope of the topics to be covered depending on the type of airplane to be maintained and the skills of the students.

Objectives

At the completion of this module the student is able to demonstrate the following:

1. Knowledge of the general types of connective devices and how to identify them (airplane specific).
2. Knowledge of the various safety procedures, cautions, and warnings prior to inspection.
3. Knowledge of the relevant visual inspection procedures for each type of connector so that any internal or external damage can be found.
4. How to recognize typical external and internal damage to the connector.
5. Where to find the relevant repair schemes from the standard wiring practices manual for connector repair.

Hands-on Equipment and Teaching Aids

Normal classroom lecture can be used for the majority of this training. The standard wiring practices manual should be made available to the class for hands-on use. Connector identification, inspection, and repair procedures should be fully explored. Color photographs of typical external damage and internal damage could be used to show problems on the airplane. The ATSRAC Task Group 1 Non-Intrusive Inspection Report and chapter 7 of ATSRAC's Intrusive Inspection Final Report could be used to identify typical connector issues. AC 25-27, Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure, is recommended as a source for typical aircraft wiring installations and areas of concern.

MODULE F

CONNECTIVE DEVICES

1. General types and identification
 - a. Part number identification
 - b. Reference tables
 - c. Specific connective devices chapters
2. Cautions and protections
 - a. Safety precautions
 - b. Maintenance precautions
3. Visual inspection procedures
 - a. Inspection criteria for installed connectors
 - b. Inspection criteria for removed connectors
4. Typical damage found
 - a. Exterior damage
 - b. Internal damage
5. Repair procedures
 - a. Finding the correct section
 - b. Finding the correct part
 - c. Finding the correct tooling
 - d. Confirming the correct repair

ELECTRICAL WIRING INTERCONNECTION SYSTEMS LESSON PLAN

MODULE G: CONNECTIVE DEVICES REPAIR

Overview

With Module G, the instructor lays the groundwork for safe, effective maintenance, alteration, and repair of airplane electrical wiring interconnection systems. This module is primarily a hands-on class, emphasizing the repair and replacement of connective devices found on the airplane. The list of replacement procedures can be used to cover typical connectors for airplanes, and can be adjusted to suit training requirements. The instructor may vary the depth and scope of the topics to be covered, depending on the type of airplane to be maintained and the skills of the students.

Objective

At the completion of this module the student is able to demonstrate the following:

1. Replacement of components for circular connectors.
2. Replacement of components for rectangular connectors.
3. Replacement of components for terminal blocks-modular.
4. Replacement of components for terminal blocks-non-modular.
5. Replacement of components for grounding modules.
6. Replacement of pressure seals.

Hands-on Equipment and Teaching Aids

This is primarily a hands-on class to give students motor skills in the repair of connective devices from their airplane. The standard wiring practices manual and the appropriate connective devices should be available to the class so repair procedures can be fully explored. Photographs of typical internal conditions and external damage could be made available. It is recommended that MODULE F: CONNECTIVE DEVICES precede this module. AC 25-27, Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure, is recommended as a source for typical aircraft wiring installations and areas of concern.

MODULE G

CONNECTIVE DEVICES REPAIR

1. Circular connectors
 - a. Disassembly
 - b. Back-shell maintenance
 - c. Contact extraction and insertion
 - d. Contact crimping
 - e. Assembly and strain relief
2. Rectangular connectors
 - a. Disassembly
 - b. Back-shell maintenance
 - c. Contact extraction and insertion
 - d. Contact crimping
 - e. Assembly and strain relief
3. Terminal blocks - modular
 - a. Disassembly
 - b. Contact extraction and insertion
 - c. Contact crimping
 - d. Assembly and strain relief
4. Terminal block – non-modular
 - a. Disassembly
 - b. Terminal lug crimping
 - c. Terminal lug stacking
 - d. Assembly, torque, and strain relief
5. Grounding modules
 - a. Disassembly
 - b. Contact extraction and insertion
 - c. Contact crimping
 - d. Assembly and strain relief

6. Pressure seals
 - a. Disassembly
 - b. Maintenance
 - c. Assembly and strain relief

APPENDIX D

DEFINITIONS

Arc Tracking – A phenomenon in which a conductive carbon path is formed across an insulating surface. This carbon path provides a short circuit path through which electrical current can flow. Arc tracking is normally the result of electrical arcing. Also referred to as “carbon arc tracking,” “wet arc tracking,” or “dry arc tracking.”

Electrical Wiring Interconnection System (EWIS) – is defined by § 25.1701 as follows:

§ 25.1701 Definition.

(a) As used in this chapter, electrical wiring interconnection system (EWIS) means 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. This includes:

- (1) Wires and cables.
- (2) Bus bars.
- (3) The termination point on electrical devices, including those on relays, interrupters, switches, contactors, terminal blocks and circuit breakers, and other circuit protection devices.
- (4) Connectors, including feed-through connectors.
- (5) Connector accessories.
- (6) Electrical grounding and bonding devices and their associated connections.
- (7) Electrical splices.
- (8) Materials used to provide additional protection for wires, including wire insulation, wire sleeving, and conduits that have electrical termination for the purpose of bonding.
- (9) Shields or braids.
- (10) Clamps and other devices used to route and support the wire bundle.
- (11) Cable tie devices.
- (12) Labels or other means of identification.
- (13) Pressure seals.
- (14) EWIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks, including, but not limited to, circuit board back-planes, wire integration units, and external wiring of equipment.

(b) Except for the equipment indicated in paragraph (a)(14) of this section, EWIS components inside the following equipment, and the

external connectors that are part of that equipment, are excluded from the definition in paragraph (a) of this section:

- (1) Electrical equipment or avionics that are qualified to environmental conditions and testing procedures when those conditions and procedures are—
 - (i) appropriate for the intended function and operating environment, and
 - (ii) acceptable to the FAA.
- (2) Portable electrical devices that are not part of the type design of the airplane. This includes personal entertainment devices and laptop computers.
- (3) Fiber optics.

Combustible – The ability of any solid, liquid, or gaseous material to cause a fire to be sustained after removal of the ignition source. The term is used in place of inflammable/flammable. It should not be interpreted as identifying material that will burn when subjected to a continuous source of heat as occurs when a fire develops.

Contamination – With regard to wiring, this term refers to either of the following situations:

- The presence of a foreign material that is likely to cause degradation of wiring.
- The presence of a foreign material that is combustible.

Detailed Inspection (DET) – 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 deemed appropriate. Inspection aids such as mirrors, magnifying lenses, or other means may be necessary. Surface cleaning and elaborate access procedures may be required.

Functional Failure – Failure of an item to perform its intended function within specified limits.

General Visual Inspection (GVI) – 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 unless otherwise specified. A mirror may be necessary to enhance visual access to all exposed surfaces in the inspection area. This level of inspection 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. Stands, ladders, or platforms may be required to gain proximity to the area being checked.

Lightning/High Intensity Radiated Field (L/HIRF) Protection – The protection of airplane electrical systems and structure from induced voltages or currents by means of shielded wires, raceways, bonding jumpers, connectors, composite fairings with

conductive mesh, static dischargers, and the inherent conductivity of the structure. May include aircraft specific devices, e.g., RF (radio frequency) gaskets.

Maintenance – As defined in 14 CFR 1.1, “maintenance means inspection, overhaul, repair, preservation, and the replacement of parts, but excludes preventive maintenance.” For the purposes of this advisory circular, it also includes preventive maintenance as described in both § 1.1 and 14 CFR part 43, Appendix A(c). Section 1.1 of 14 CFR provides the following definition: “Preventive maintenance means simple or minor preservation operations and the replacement of small standard parts not involving complex assembly operations.” Appendix A(c) of 14 CFR part 43 lists the tasks that are considered preventive maintenance.

Maintenance Significant Item (MSI) – Items identified by the manufacturer whose failure –

- Could affect safety (on the ground or in flight).
- Is undetectable during operations.
- Could have significant operational impact.
- Could have significant economic impact.

Needling – The puncturing of a wire’s insulation to make contact with the core to test the continuity and presence of voltage in the wire segment.

Special Detailed Inspection (SDI) – An intensive examination of a specific item, installation, or assembly to detect damage, failure, or irregularity. The examination is likely to make extensive use of specialized inspection techniques and/or equipment. Intricate cleaning and substantial access or disassembly procedures may be required.

Stand-Alone GVI – A general visual inspection which is not performed as part of a zonal inspection. Even in cases where the interval coincides with the zonal inspection, the stand-alone GVI shall remain an independent step within the work card.

Structural Significant Item (SSI) – Any detail, element, or assembly that contributes significantly to carrying flight, ground, pressure, or control loads and whose failure could affect the structural integrity necessary for the safety of the aircraft.

Swarf – British term used to describe the metal particles generated from drilling and machining operations. Such particles may accumulate on and between wires within a wire bundle.

Zonal Inspection – A collective term comprising selected general visual inspections and visual checks that are applied to each zone, defined by access and area, to check system and power plant installations and structure for security and general condition.

APPENDIX E

RELATED REGULATIONS AND DOCUMENTS

a. 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 from 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 facsimile (202) 512-2250.

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| Part 21 | Certification Procedures for Products and Parts. |
| Part 25 | Airworthiness Standards: Transport Category Airplanes. |
| Part 43 | Maintenance, Preventive Maintenance, Rebuilding, and Alteration. |
| Part 91 | General Operating and Flight Rules. |
| Part 119 | Certification: Air Carriers and Commercial Operators. |
| 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 135 | Operating Requirements: Commuter and On-demand Operations and Rules Governing Persons On Board Such Aircraft. |
| Part 145 | Repair Stations |

b. 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>.

AC 20-53	Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning
AC 25-16	Electrical Fault and Fire Protection and Prevention
AC 25-26	Development of Standard Wiring Practices Documentation
AC 25-27	Development of Transport Category Airplane Electrical Wiring Interconnection Systems Instructions for Continued Airworthiness Using an Enhanced Zonal Analysis Procedure
AC 25.981-1	Fuel Tank Ignition Source Prevention Guidelines
AC 25.1701-1	Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes
AC 43-4	Corrosion Control for Aircraft
AC 43-12	Preventive Maintenance
AC 43.13-1	Acceptable Methods, Techniques, and Practices for Repairs and Alterations to Aircraft
AC 43-204	Visual Inspection For Aircraft
AC 65-15	Airframe & Powerplant Mechanics Airframe Handbook, Chapter 11, Aircraft Electrical Systems
AC 129-4	Maintenance Programs for U.S.-Registered Aircraft Under FAR Part 129

c. Reports.

- Task 1, Task 2, Task 3, Task 4, Task 5, Task 6, Task 7, Task 9, and Task 11 Working Group Final Reports, Aging Transport Systems Rulemaking Advisory Committee. (You can download an electronic copy of these reports from the “Final Reports” section of the ATSRAC website: www.mitrecaasd.org/atstrac.)
- ATA (Air Transport Association) Specification 117 (Wiring Maintenance

Practices/Guidelines).

(http://www.iasa.com.au/folders/Safety_Issues/Aircraft_Wire/ATAonwiring.html)

- National Transportation Safety Board Safety Recommendations A-00-105 through –108, September 19, 2000.
(http://www.nts.gov/recs/letters/2000/A00_105_108.pdf)

d. Other Documents.

- FAA Aging Transport Non-Structural Systems Plan, dated July 1998.
(<http://www.faa.gov/apa/PUBLICAT/fatnspcov.htm>)
- ATA Operator/Manufacturer Scheduled Maintenance Development as revised, ATA Maintenance Steering Group (MSG-3). (May be obtained from the Air Transport Association of America, Suite 1100, 1301 Pennsylvania Ave, NW, Washington, DC 20004-1707.)

APPENDIX F

Following is the discussion of training 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 this rule was proposed.

As a result of the revised maintenance programs that would be required for airplanes operating under part 121, maintenance personnel will be performing inspections and maintenance procedures to address safety issues specific to wiring systems. Although this NPRM does not specifically require new training, existing § 121.375 requires that certificate holders or persons performing maintenance have a training program to ensure that persons determining the adequacy of such work (including inspectors) are fully informed about the procedures and techniques involved and are competent to perform them. To comply with this requirement in relation to proposals for revised maintenance programs for EWIS included in this NPRM, certificate holders would be required to develop any additional training program needed to ensure that the appropriate personnel are adequately prepared to carry out the revised maintenance programs.