U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRCRAFT WIRING SYSTEMS TRAINING PROGRAM	**Date: 03/21/02**	**AC No: 120-YY**
	Initiated By: WG8	**Change: DRAFT**

Table of Contents:

1. PURPOSE.

This Advisory Circular (AC) provides guidance for developing an enhanced wiring systems training program. The guidance in this AC is based on recommendations submitted to the FAA from the Aging Transport Systems rulemaking Advisory Committee (ATSRAC). The guidance and recommendations in this AC are derived from the best practices training developed through extensive research by ATSRAC Industry Working Groups 5 and 8. This AC is an effort by the FAA to officially endorse these best practices and to dispense this information industry wide so the benefits of this information can be effectively realized. Adoption of the recommendations in this AC will result in a training program that will improve the awareness and skill level of the aviation personnel in wiring system production, modification, maintenance, inspection,

alterations and repair. This AC promotes a philosophy of training for all personnel who come into contact with aircraft wiring systems as part of their job and tailors the training for each workgroup to their particular needs.

To fully realize the objectives of this AC, air carriers, air operators, type certificate holders, STC holders, maintenance providers, repair stations and persons performing field approval modifications or repairs, 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 wiring systems should be maintained with the same level of 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 insulations, 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.

2. APPLICABILITY.

This AC provides acceptable, but not inclusive, means of complying with the Federal Aviation Regulations. The information in this AC is based on lessons learned by joint FAA, JAA, ATSRAC, and industry, manufacturers and airline working groups. The recommendations in this AC can be applied to any aircraft training program.

3. 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 119, Certification: Air Carriers and Commercial Operators.

f. Part 121, Operating Requirements: Domestic, Flag, and Supplemental Operations.

g. 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.

h. Part 129, Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage.

i. Part 135, Operating Requirements: Commuter and On-demand Operations.

j. Part 145,

4. ADVISORY CIRCULARS.

a. AC 20-53A, Protection Of Airplane Fuel Systems Against Fuel Vapor Ignition Due To Lightning

b. AC 20-13, Protection Of Aircraft Electrical/Electronic Systems Against The Indirect Effects Of Lightning

c. AC 25-16, Electrical Fault and Fire Protection and Prevention.

d. AC 25.981-1B, Fuel Tank Ignition Source Prevention Guidelines

e. AC 43-3, Nondestructive Testing in Aircraft.

f. AC 43-4A, Corrosion Control for Aircraft.

g. AC 43-7, Ultrasonic Testing for Aircraft.

h. AC 43-12A, Preventive Maintenance.

i. AC 43.13-1A, Acceptable Methods, Techniques and Practices--Aircraft Inspection and Repair.

j. AC 43.13-1B, Acceptable Methods, Techniques and Practices for Repairs and Alterations to Aircraft.

k. AC 43-204, Visual Inspection For Aircraft

l. AC 65-15A, Airframe & Powerplant Mechanics Airframe Handbook, Chapter 11. Aircraft Electrical Systems

m. AC 120-XX, Program to enhance aircraft wiring system maintenance

5. REPORTS.

a. Aging Systems Task Force Aging Transport Systems Task 1 and Task 2 Final Report.

b. Transport Aircraft Intrusive Inspection Project, Final Report.

c. Aging Transport Systems Rulemaking Advisory Committee, Task 3 Working Group, Final Report.

d. The Standard Wiring Practices Task 4 Working Group, Final Report.

e. Aircraft Wiring Systems Training, Task 5 Working Group, Final Report.

f. ATA Specification 117 (Wiring Maintenance Practices/Guidelines).

g. National Transportation Safety Board, Safety Recommendation, September 19, 2000, A-00-105 through -108.

6. OTHER DOCUMENTS.

a. 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.

b. Handbook Bulletin 91-15 "Origin and propagation of inaccessible aircraft fire under in-flight airflow conditions."

7. DEFINITIONS.

Arc tracking. A phenomenon that occurs in electrical wiring when leakage currents on a wet insulation surface are great enough to vaporize the moisture, resulting in the formation of dry spots, which offer a high amount of resistance to current flow. In turn, an induced voltage will develop across these spots and result in the occurrence of small surface discharges.

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 contamination refers to either of the following situations:

a. The presence of a foreign material that is likely to cause degradation of wiring.
b. The presence of a foreign material that is capable of sustaining combustion after removal of ignition source.

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. Is the protection of airplane electrical systems and structure from indueced 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, but may include aircraft specific devices, e.g., RF 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).

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

A. could affect safety (on ground or in flight) and/or
B. is undetectable during operations, and/or
C. could have significant operational impact, and/or
D. 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.

Stand-alone GVI. A General Visual Inspection which is not performed as part of a zonal inspection.

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.

Wire System. 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. (See Appendix C, Wire System.)

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.

8. BACKGROUND.

The NTSB has recommended that the FAA address all wiring issues identified in the Aging Systems Plan, either through rulemaking or through other means. The NTSB specifically cited the need for improved training of maintenance personnel to ensure adequate recognition and repair of potentially unsafe wiring conditions.

To address the issues identified in the Aging Systems Plan, in 1998 the FAA established the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC). The ATSRAC provides the forum for the airlines, manufacturers, and other regulatory authorities to make recommendations to the FAA based on the Aging Systems Plan. This Advisory Circular addresses only the training program. It does not attempt to deal with the condition of the fleet's wiring, or develop performance tests for wiring. This advisory circular captures, in FAA guidance form, the aircraft wiring training program developed by ATSRAC. This includes a training syllabus, curriculum, training target groups and a matrix outlining training for each training group.

For more information see Appendix D – History.

9. OBJECTIVE.

The objective of this wiring maintenance training program is to give the operators or maintenance repair organizations a model for the development of their own wiring maintenance training program. This will ensure that proper procedures, methods techniques, and practices are used when performing maintenance, preventive maintenance, inspection, alteration, and cleaning of wiring systems.

This program was developed for eight different target groups and may be used for the minimum requirements for initial and recurrent training (see training matrix). Depending on the duties some may fall into more than one target group and therefore must fullfill all objectives of the associated target groups.
The target groups are:

1 Qualified staff performing wire systems maintenance
These staff members are personnel who perform wire systems maintenance and their training is based on their job description and the work being done by them.
(e.g. FAA: electricians/avionics / A/P mechanics
JAA: Cat A or B2)

2 Qualified staff performing maintenance inspections on wiring systems
These staff members are personnel who perform wire systems inspections (but not maintenance) and their training is based on their job description and the work being done by them.

(e.g. FAA: Inspectors / A/P mechanics
JAA: Cat B2)

3 Qualified staff performing electrical/avionic engineering on in service aircraft
These staff members are personnel who are authorized to design wire systems installations, modifications and repairs.
(e.g. FAA/JAA: electric/avionic engineers)

4 Qualified staff performing general maintenance/inspections not involving wire maintenance.(LRU change is not considered wire maintenance)
These staff members are personnel who perform maintenance on aircraft that may require removal/reconnection of electrical connective devices
(e.g. FAA: A/P mechanics
JAA: Cat A or B1)

5 Qualified staff performing other engineering or planning work on in service aircraft
These staff members are personnel who are authorized to design mechanical/structure systems installations, modifications and repairs, or personnel who are authorized to plan maintenance tasks.

6 Other service staff with duties in proximity to wire systems
These staff members are personnel who's duties would bring them into contact/view of aircraft wire systems.
This would include, but not be limited to, aircraft cleaners, cargo loaders, fuelers, lavatory servicing personnel, deicing personnel, push back personnel.

7 Flight Deck Crew
e.g. Pilots, Flight Engineers

8 Cabin Crew

10. ESSENTIAL ELEMENTS FOR WIRING SYSTEMS TRAINING PROGRAM.

a. Initial Training.

Initial training should be conducted for each designated work group.
The initial training for each designated work group is outlined in Wiring Systems Minimum Initial Training Program - Appendix A. Curriculum and Lesson Plans for each dedicated module are included in Appendix B.
The most important criteria is to meet the objectives of the Lesson Plans – Appendix B. The method of reaching the objectives should be at the discretion of the training organization. However, supporting documentation such as Advisory Circular **120-XX** and TBD are 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 in a period not to exceed two years. It could consist of a review of previously covered material plus any new material or revisions to publications. Refresher training will follow the Wiring Systems Minimum Initial Training Program - Appendix A for that particular target group.

APPENDIX A - WIRING SYSTEMS MINIMUM INITIAL TRAINING PROGRAM

Please see: Appendix A.xls

APPENDIX B - CURRICULUM AND LESSONS PLAN

Table of Contents:

AGING TRANSPORT SYSTEMS RULEMAKING ADVISORY COMMITTEE (ATSRAC)

CURRICULUM AND LESSON PLANS

WIRING SYSTEMS CURRICULUM

Overview

This training is targeted to the person who performs airplane maintenance, inspections, alterations or repairs on structure and/or wiring systems. After training the person is able to properly evaluate the wiring system and effectively use the manufacturers Chapter 20 Wiring System overhaul manual for that airplane. This must include; wiring system condition, applicable repair schemes, wiring modifications and ancillary repairs to wiring systems and components. All of the training components are integrated to maintain wiring system quality and airworthiness in the airplane.

Objectives

Depending on the modules taught, the person demonstrates competency in the following skills:

A. Demonstrate the safe handling of airplane electrical systems, Line Replaceable Units (LRU's), tooling, troubleshooting procedures, and electrical measurement.
B. Know the construction and navigation of the applicable airplane wiring system overhaul or wiring practices manual
C. Know the different types of inspections, human factors in inspections, zonal areas and typical damages.
D. Know the contamination sources, materials, cleaning and protection procedures.
E. Demonstrate the correct identification of different wire types, their inspection criteria, and damage tolerance, repair and preventative maintenance procedures.
F. Know the procedures to identify, inspect and find the correct repair for typical types of connective devices found on the person's airplane.
G. Demonstrate the procedures for replacement of all parts of typical types of connective devices found on the person's airplane.

Scope

The course is to be used by training providers for all maintenance persons at any stage in their careers. The person can be trained to the appropriate level using the applicable

modules, depending the persons experience, work assignment and operators policy. The time stated for each module is a minimum.

MODULE A – INTRODUCTION: 4 hours

1. Safety practices
2. Electrostatic Discharge Sensitive (ESDS) Device handling and protection
3. Tools, special tools and equipment
4. Verify calibration/certification of instruments, tools, and equipment
5. Required wiring checks using the Troubleshooting Procedures and Charts (incl. No Fault Found Data)
6. Measurement and troubleshooting using meters.
7. LRU replacement general practices

MODULE B – WIRING PRACTICES DOCUMENTATION: 5 hours

1. Chapter 20 structure/overview
2. Chapter 20 cross-reference Index
3. Chapter 20 important Data and Tables
4. Wiring Diagram Manual
5. Other Documentation as applicable

MODULE C – INSPECTION: 3 hours

1. General Visual Inspection (GVI), Detailed Inspection (DET) and Special Detailed Inspection (SDI), Zonal Inspection, Enhanced Zonal Analysis Procedure (EZAP)
2. Human factors in inspection
3. Zonal areas of inspection
4. Wiring system damage

MODULE D – HOUSEKEEPING: 3 hours

1. Airplane external contamination sources
2. Airplane internal contamination sources
3. Other contamination sources
4. Contamination protection planning
5. Protection during airplane maintenance and repair
6. Cleaning processes

MODULE E – WIRE: 6 hours

1. Identification, type and construction
2. Insulation damage limits
3. Inspection criteria and standards of wire and wire bundles
4. Wire bundle installation practices
5. Typical damage and areas found (airplane specific)
6. Maintenance and repair procedures
7. Sleeving
8. Unused wires-termination and storage
9. Electrical bonding and grounds

MODULE F – CONNECTIVE DEVICES: 3 hours

1. General types and identification
2. Cautions and protections
3. Visual inspection procedures
4. Typical damage found
5. Repair procedures

MODULE G – CONNECTIVE DEVICE REPAIR: 6 hours

1. Circular Connectors
2. Rectangular Connectors
3. Terminal Blocks-Modular
4. Terminal Blocks- Non-modular
5. Grounding Modules
6. Pressure Seals

WIRING SYSTEMS LESSON PLAN
MODULE A: INTRODUCTION

Overview

Through Module A, the instructor lays the groundwork of safe effective maintenance and repair of the airplane wiring systems and LRU removal and replacement, including BITE, 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 persons.

Objectives

After this module is complete the student is able to demonstrate the following skills:

1. Know the safety procedures of normal and non-normal maintenance procedures so the person can protect him/herself and the airplane.
2. Recognize ESDS equipment and demonstrate standard anti-static procedures so that no damage occurs to that equipment.
3. Demonstrate the correct use of hand tools including specialized and automated tools and equipment.
4. Verify the calibration of electrical measuring instruments, tools and equipment so that correct maintenance procedures may be carried out.
5. Demonstrate the process and procedures to successfully use the Troubleshooting Procedures and charts of current airplane faults and know re-occurring problems causing “No Fault Found” on removed LRU’s.
6. Demonstrate the correct use of electrical meters for measuring voltage, current, resistance, continuity, insulation and short to ground.
7. Know the removal and replacement techniques so that no damage will occur to the LRU or airplane connector.

Strategies

Normal classroom lecture is used for the majority of the training. The following strategies can be used to expedite learning and are recommended to the instructor.

Electrostatic Discharge Sensitive (ESDS) Device
handling and protection ..... Video/Training Aids
Calibration/certification of instruments, tools, and equipment ..... Company Policy
Wiring checks using the Troubleshooting Procedures and Charts ..... Airplane manuals
Measurement and troubleshooting using meters ..... Meters and circuits
LRU removal and replacement ..... Airplane manuals

MODULE A - INTRODUCTION:

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. Sources of electrostatic discharge
    b. Soft and hard failures
    c. ESDS safety procedures
    d. ESDS packing procedures

3. Tools, special tools and equipment

    a. General hand tools
    b. Specialized tools
    c. Automated tools and equipment

4. Verify calibration/certification of instruments, tools and equipment

    a. Tools requiring certification
    b. Determining certification requirements
    c. Typical problems

5. Required wiring checks using the Troubleshooting Procedures and Charts and “No Fault Found”.

    a. Troubleshooting procedures manual (all chapters)
    b. Aircraft Maintenance Manual/ Illustrated Parts Catalog
    c. Wiring schematics / Troubleshooting graphics
    d. Wiring diagrams
    e. The process of troubleshooting
    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 removal and replacement techniques

a. Different retention devices
b. Certification considerations (e.g. CAT 2/CAT3 Landing)
c. LRU re-racking procedures
d. Built in test equipment (BITE)

WIRING SYSTEMS LESSON PLAN
MODULE B: WIRING PRACTICES DOCUMENTATION

Overview

Through Module B, the instructor lays the groundwork for safe effective maintenance and repair of airplane wiring systems. The intent of this module is to teach the person how to locate desired information in the Chapter 20 Wiring Systems overhaul manual, Wiring Diagram Manual 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 skills of the persons.

Objectives

After this module is complete the person is able to demonstrate the following skills:

1. Know the applicable Sub-Chapters and Section to follow during normal and non -normal electrical maintenance procedures.
2. Demonstrate the use of the Cross-Reference Index, Chapter Table of Contents, and Subject Tables of Contents so as to find specific material within each sub-chapter and section.
3. Demonstrate the use of the associated tables for replacement of wire, connective devices and contacts, and associated components, including approved replacements.
4. Demonstrate the use of the Wiring Diagram Manual.
5. Demonstrate the use of other Documentation (as applicable).

Strategies

Normal classroom lecture is used for the majority of the training. The Chapter 20 Wiring Practices Manual, Wiring Diagram Manual, and other applicable documentation will be made available to the class so that hands-on exploration of the material can be achieved.

MODULE B - WIRING PRACTICES DOCUMENTATION:

1. Chapter 20 structure/overview

    a. Table of contents
    b. Sub-Chapter titles
    c. Section Structure
    d. General procedures.

2. Chapter 20 Cross-Reference Index

    a. Cross-reference index – Alphanumeric
    b. Cross-reference index – Standard Part number
    c. Cross-reference index – Suppliers
    d. Equivalence tables – Std Part Numbers EN-ASN-NSA

3. Chapter 20 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 Manual (WDM)

    a. Front matter
    b. Diagrams
    c. Charts
    d. Lists

5. Other Documentation (as applicable)

WIRING SYSTEMS LESSON PLAN
MODULE C: INSPECTION

Overview

Through Module C, the instructor lays the groundwork for safe effective maintenance and repair of airplane wiring systems, by teaching the skills of inspection so as to identify 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 skills of the persons.

Objectives

After this module is complete the person is able to demonstrate the following skills:

1. Know the different types of inspections: General Visual Inspection (GVI), Detailed Inspection (DET), Special Detailed Inspection (SDI), Zonal Inspection and Enhanced Zonal Analysis Procedure (EZAP), criteria and standards so that the person knows which tools are used to ensure inspection procedures and standards are achieved which leads to all defects being found.
2. Know the effects of fatigue and complacency during inspection and how to combat their effects (Human Factors).
3. Know the specific zonal inspection requirements related to system affiliation and environmental conditions.
4. Recognize typical wiring system damage, such as hot gas, fluid contamination, external mechanically induced damage, chafing, corrosion and signs of overheating of wire, wire bundles and connective and control device assemblies.

Strategies

Normal classroom lecture is used for the majority of the training. ATA 117 video and color photos of actual wiring systems damage could be used to show typical problems found on the airplane. Examples of discrepancies will be made available to the student.

MODULE C – INSPECTION

1. General Visual Inspection (GVI), Detailed Inspection (DET), Special Detailed Inspection (SDI), Zonal Inspection and Enhanced Zonal Analysis Procedure (EZAP)

2. Criteria and standards

    a. Tools

b. Criteria/standards
c. Procedures of inspection

3. Human Factors in Inspection

a. Fatigue
b. Complacency

4. Zonal areas of inspection

a. Zonal areas of inspection
b. Zonal inspection procedures and standards

5. Wiring system damage

a. Swarf / FOD / metal shavings
b. External mechanically induced damage
c. Hot gas
d. Fluid contamination
e. Vibration/chafing
f. Corrosion
g. Signs of overheating

WIRING SYSTEMS LESSON PLAN
MODULE D: HOUSEKEEPING

Overview

Through Module D, the instructor lays the groundwork for safe effective maintenance and repair of airplane wiring systems by teaching housekeeping strategies. This will keep the wiring system free of contamination and if contamination is found, techniques on removal or cleaning. 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 persons.

Objectives

After this module is complete the person is able to demonstrate the following skills:

1. Recognize external contamination and other damage due to external environmental conditions.
2. Know the airplane internal contamination sources, so that inspection processes can be effectively carried out and contamination damage easily recognized.
3. Recognize other possible contamination sources.
4. Know the procedures and processes to protect wiring systems during maintenance and repair.
5. Know the procedures to be followed when carrying out repairs on wiring systems in different parts of the airplane.
6. Know the process of cleaning wiring systems during maintenance and repair.

Strategies

Normal classroom lecture is used for the majority of the training. ATA 117 video and color photos of actual wiring systems contamination could be used to show typical problems found on the airplane. Relevant Aircraft Maintenance Manual and/or Chapter 20 Wiring Practices procedures will be used. The ATSRAC Task Group 1, Non-Intrusive Inspection Final Report could be used to identify typical housekeeping issues.

MODULE D – HOUSEKEEPING

1. Airplane external contamination sources

    a. De-ice fluids
    b. Water and rain
    c. Snow and ice
    d. Miscellaneous (e.g. cargo / beverage spillage)

e. Air erosion

2. Airplane internal contamination sources

   a. Hydraulic oils
   b. Engine and APU oils
   c. Fuel
   d. Greases
   e. 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. Drill shavings / Swarf
   d. Foreign objects (screws, washers, rivets, tools, etc.)
   e. Animal waste

4. Contamination protection planning

   a. Have a plan / types of plan / 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.
   d. Drip and Heat shield repair and installation procedures.

6. Cleaning Processes

    a. Fluid contamination
        1) Snow and ice
        2) De-ice fluid
        3) Cargo spillage
        4) Water and rain
        5) Galleys
        6) Toilets water waste
        7) Oils and greases
        8) Pressure washing

    b. Solid contamination
        1) Drill 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

WIRING SYSTEMS LESSON PLAN
MODULE E: WIRE

Overview

Through Module E, the instructor lays the groundwork for safe effective maintenance, alteration and repair of airplane wiring 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 skills of the persons.

Objectives

After this module is complete the person is able to demonstrate the following skills:

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

Strategies

Normal classroom lecture is used for the majority of the training with hands-on practice for Section 6. Chapter 20 Wiring Practices, Wiring Diagram Manual and WDM Lists will be made available to the class so that hands-on use of the manual can be utilized so that wire identification, inspection, installation and repair procedures can be fully explored. Examples of wire discrepancies will be made available to the student. The ATSRAC Task Group 1, Intrusive Inspection Final Report could be used to identify typical wire issues.

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
c. Carbon Arcing

3. Inspection criteria and standards of 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

5. Typical damage and areas found (airplane specific)

a. Vibration
b. Corrosion
c. Contamination
d. 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

WIRING SYSTEMS LESSON PLAN
MODULE F: CONNECTIVE DEVICES

Overview

Through Module F, the instructor lays the groundwork for safe effective maintenance, alteration and repair of airplane wiring systems by teaching the 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 skills of the persons.

Objectives

After this module is complete the person is able to demonstrate the following skills:

1. Know the general types and positive identification of connective devices and pressure seals (airplane specific).
2. Know the various safety procedures, cautions and warnings prior to inspection.
3. Know the relevant inspection procedures for each type of connector so that any internal or external damage can be found.
4. Recognize typical external and internal damage to the connector.
5. Demonstrate where to find the relevant repair schemes from Ch. 20 for connector repair.

Strategies

Normal classroom lecture is used for the majority of the training. The Chapter 20 Wiring Practices manual will be made available to the class so that hands-on use of the manual can be utilized. Connector identification, inspection and repair procedures will 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 and Intrusive Inspection Final Report, Chapter 7, could be used to identify typical connector issues.

MODULE F – CONNECTIVE DEVICES

1. General types and identification

    a. Part number identification
    b. Reference tables
    c. Specific connective devices and pressure seal chapters

2. Cautions and protections

    a. Safety precautions
    b. Maintenance precautions

3. Visual inspection procedures

    a. Installed inspection criteria
    b. Removed inspection criteria

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

WIRING SYSTEMS LESSON PLAN
MODULE G: CONNECTIVE DEVICES REPAIR

Overview

Through Module G, the instructor lays the groundwork for safe effective maintenance, alteration and repair of airplane wiring systems. This module is primarily a hands-on class, emphasizing the repair and replacement of connective devices found on the airplane. This list 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 skills of the persons.

Objective

After this module is complete the person will have the following skills.

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

Strategies

This class is primarily a hands-on class to give the student motor skills in the repair of connective devices from their airplane. The Chapter 20 Wiring Practices Manual and the appropriate connective devices will be made 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: CONNECTORS should precede this module.

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 C - WIRE SYSTEM

As stated in the definitions section of this Advisory Circular "Wire System" is defined as follows:

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.

The definition of "wire system" includes the following:

- Wires (e.g., wire, cable, coax, databus, feeders, ribbon cable).
- Bus bars.
- Connection to electrical devices (e.g., relays, push button, interrupters, switches, contactors, terminal blocks, feed-through connectors).
- Circuit breakers or other circuit protection devices (not performance).
- Electrical contacts.
- Connector and accessories (e.g., backshell, sealing boot grommet sealing plugs).
- Electrical grounding and bonding devices (e.g., modules, straps, studs).
- Electrical splices.
- Shield or braids.
- Conduits that have electrical termination.
- Clamps and other devices used to route and support the wire bundle.
- Cable tie devices.
- Labels or other means of identification methods.
- Pressure seals associated with wiring systems.
- Wiring inside shelves, panels, racks, junction boxes, distribution panels, back-planes of equipment racks (including circuit board back-planes), wire integration units, etc.

The following wires and devices (along with the mating connections at the termination points of the wire on those devices) are not considered part of the "wire system":

- Wiring inside avionics equipment (e.g., flight management system computer, flight data recorder, VHF radio, primary flight display).
- Equipment qualified to the standards of RTCA Document DO-160 or shown to be equivalent (other than those specifically included in this definition).
- Equipment qualified to a technical standard order (TSO).
- Portable, carry on, or otherwise non-permanently mounted (not part of the certification basis) electrical equipment.
- Fiber optics.

APPENDIX D - HISTORY

BACKGROUND. Safety concerns about aging wiring systems in airplanes were brought to the forefront of the public and governmental attention by a fatal accident involving a Boeing Model 747-131 airplane on July 17, 1996. The National Transportation Safety Board (NTSB) determined that the probable cause of the accident was an explosion of the center wing fuel tank resulting from ignition of the flammable fuel/air mixture in the tank. Although the source of ignition energy for the explosion could not be determined with certainty, the NTSB believes the most likely source was a short circuit outside of the center wink fuel tank that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system. In its investigation the NTSB found several potentially unsafe conditions in and near the electrical wiring of the airplane, including cracked wire insulation, metal shavings adhered to a floor beam along which fuel quantity indication system wires would have been routed, other debris, and sulfide deposits. The NTSB also found evidence of several repairs to the accident airplane that did not comply with the guidelines in Boeing's Standard Wiring Practices Manual.

> Noncompliant repairs included the use of an oversized strain relief clamp on the terminal block of the No. 1 fuel tank compensator, which did not adequately secure the wires; numerous open-ended (rather than sealed) wire splices, which exposed conductors to possible water contamination; several wire bundles containing numerous wire splices on adjacent wires at the same location; and excessive solder on the connector pins inside the fuel totalizer gauge, which had connected the pins/wires from the right wing main fuel tank and the CWT FQIS.

Most alarming is the NTSB's finding that deterioration, damage, and contamination of aircraft wiring and related components and noncompliant repairs were common in the airline transport airplanes (especially in the older airplanes) that it inspected during the investigation. Therefore, the NTSB concluded that "the condition of the wiring system in the accident airplane was not atypical for an airplane of its age and one that had been maintained in accordance with prevailing industry practices."[1]

The NTSB found the unsafe conditions of aircraft wiring systems especially disturbing because the existence of these conditions revealed the general shortcomings of the current visual wiring inspection criteria. During its examinations the NTSB found that a large portion of the aircraft wiring is difficult, if not impossible, to inspect because of its inaccessibility and that wire damage or other potentially unsafe conditions may not be detected, even on visible and accessible portions of aircraft wiring. The NTSB therefore concluded that "insufficient attention has been paid to the condition of aircraft electrical wiring, resulting in potential safety hazards."

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[1] *The widespread existence of such conditions was also corroborated by Boeing's service letter (SL) 747-SL-20-048 (dated January 25, 1995), which detailed similar conditions found in numerous 747s.*

The accident investigation into the 1996 fatal accident resulted in a heightened awareness of the importance of maintaining the integrity of aircraft wiring. The FAA began to investigate fuel tank wiring, and to strengthen its focus on aging wiring in general. Also in 1997 the White House Commission on Aviation Safety and Security (WHCSS) issued the following recommendation to the FAA: "In cooperation with airlines and manufacturers, the FAA's Aging Aircraft Program should be expanded to cover non-structural systems." In July 1998, the FAA issued the *Aging Transport Non-Structural Systems Plan*, (hereinafter "*Aging Systems Plan*") which addressed the WHCSS recommendation. The *Aging Systems Plan* focused specifically on wiring systems. In the *Aging Systems Plan* the FAA describes the results of its evaluation of five transport category airplanes deemed representative of the "aging fleet of transport airplanes." The FAA found conditions similar to those found by the NTSB during airplane inspections in connection with the 1996 Boeing accident investigation, including the following:

- Deterioration of wiring and related components.
- Stiff and cracked wire.
- Contamination of wire bundles with metal shavings, dust, and fluids.
- Cracked wire insulation.
- Corrosion on connector pins.
- Improper wire installation and repairs.

The FAA's *Aging Systems Plan* also detailed several tasks aimed at correcting these problems, including the following:

- Improving wiring inspection criteria and providing more detailed descriptions of undesirable conditions.
- Improving inspector training to ensure that it adequately addresses the recognition and repair of aging wiring components.
- Developing new methods for nondestructive testing of wiring.

The NTSB has recommended that the FAA address all wiring issues identified in the *Aging Systems Plan*, either through rulemaking or through other means. The NTSB specifically cited the need for improved training of maintenance personnel to ensure adequate recognition and repair of potentially unsafe wiring conditions.

To address the issues identified in the *Aging Systems Plan*, in 1998 the FAA established the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC). The ATSRAC provides the forum for the airlines, manufacturers, and other regulatory authorities to make recommendations to the FAA based on the *Aging Systems Plan*. The ATSRAC effort was divided into two phases; Non-intrusive inspections which utilized only the current visual inspections, and Intrusive inspections which involved opening up the wire bundles and subjecting the wires to non-destructive test equipment and laboratory analysis. The traditional arms-length examination method used in the first non-intrusive (visual only) effort, ultimately proved its inadequacy. The Non-Intrusive Inspection Final Report stated," Existing maintenance programs may benefit from

providing additional wiring inspection detail" (Non-Intrusive Inspection Final Report, Page 8). This Non-Intrusive report went on to say that discrepancies found during the survey did not appear to be wire-type dependent. These statements lead to the formation of the Intrusive Inspection Group that was to determine if visual inspections worked, and to assess the state of the wiring in the fleet of aging aircraft.

The results of the Intrusive inspection group found that wire type did matter, "That there are typical characteristic flaws for each type of wire" (Intrusive Inspection Group Final Report, Chapter 6, Page 53). The group also determined that mixing of different wire types within the same bundle could be hazardous, "The inherent differences in the performance and chemistry of the wire insulation types should be ample reason to conclude that mixing of certain wire types in the same bundle could be hazardous to aircraft safety due to the potential for arcing and fire" (Intrusive Inspection Group Final Report, Chapter 6 Page 54). The assessment of visual inspection proved it was inadequate alone, to discern the majority of degenerative conditions such as cracking and arcing. The report also concluded that Polyvinyl Chloride (PVC) wiring was considered a flammable material. The overall assessment on the state of the wiring in the fleet was subjected to fault tree analysis rather than in the Executive Summary . This General Threat Analysis (GTA) used "plausible, hypothetical situations" (Intrusive Inspection Group Final Report, Chapter 7, Page 67), but the report also declared the results of between .44 to 3.62 breaches per 1000 feet of wire, depending on aircraft type (Intrusive Inspection Group Final Report, Appendix 3.1.7 Table 3.2.7-2). This information was contained in the Specific Recommendations portion of the final report. The final statement was, "Unless a flaw type can be ruled out as impossible (e.g. delamination for non-tape-wrapped insulation) or highly unlikely (cracking in relatively new installations) all flaw types should be considered possible" (Intrusive Inspection Group Final Report, Chapter 7, Page 70).