Transport Aircraft Intrusive Inspection Project

(An Analysis Of The Wire Installations Of Six Decommissioned Aircraft)

Final Report

Prepared by

The Intrusive Inspection Working Group

Christopher Smith, Chairman

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This report is submitted to Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) in accordance with that committee's request for a joint FAA/ATA effort to complement and extend the results of the ATA/ATSRAC Non-Intrusive Inspection Project. Release of this report will be in accordance with rules established by ATSRAC.

Executive Summary

Select wire installations[1] on six recently decommissioned aircraft (having four different general purpose wire types) were subject to an intensive, detailed visual inspection, followed by nondestructive testing and laboratory analysis. Results of the detailed visual inspection, nondestructive testing, and laboratory analysis were analyzed to determine the state of wire on aged aircraft as a function of wire type and service history. In addition, the results of visual inspection were compared with the nondestructive testing and laboratory analysis to determine the efficacy of visual inspection for the detection of age-related deterioration.

Nearly one thousand conditions were observed in the field with visual inspection. On-aircraft NDT and laboratory testing resulted in many additional findings on selected specimens. Most of the field-detected conditions could be classified as mis-installation or traumatic damage. There was, however, non-negligible degradation on wire, connectors, and terminals. The working group choose to focus on six important categories of wire degradation: degraded wire repairs or splices, heat damaged or burnt wire, vibration damage or chafing, cracked insulation, arcing, and insulation delamination.

It was determined that visual inspection can be effective in identifying certain conditions (heat damaged or burnt wire and vibration damage or chafing), but could probably not be relied upon to find other conditions (cracked insulation, arcing, insulation delamination, and degraded repairs or splices).

This report contains 28 specific conclusions regarding the risk associated with uncorrected degenerative conditions and recommends options for prevention or mitigation of failure. The working group recommends that these conclusions and recommendations be considered when revising best practice documentation and advisory material. The conclusions are not sufficiently specific to serve as mandatory design or maintenance requirements.

The Intrusive Inspection Working Group was responsible for execution or oversight of all activities enabling the generation this report, and its members are the primary authors.

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[1] "Installation" as used in this document refers to the electrical interconnect components and ancillary components such as clamps, wire ties, etc. It does not refer specifically to the process of installing wire in aircraft.

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The groups small size would, however, have limited the extent of the project were it not for the resources made available to it by the FAA, ATSRAC, and ATA.. This assistance came in the form of additional manpower for our inspections, advice and guidance from aviation community, and access to our subject aircraft.

Nomenclature

ATSRAC	Aging Transport Systems Rulemaking Advisory Committee
ATA	Air Transport Association
ASTF	Aging Systems Task Force (co sponsored by the ATA and ATSRAC)
AFCB	Arc-Fault Circuit Breaker
FAA	Federal Aviation Administration
PVC	Poly-vinyl chloride
XL-ETFE	Cross-linked Ethylene-tetrafluoroethylene
XL	Cross-linked, used as prefix before polymer designation
PVDF	Poly-vinylidene fluoride
SAE	Society of Automotive Engineers
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
AC	Advisory Circular
FHA	Failure Hazard Analysis
PSSA	Preliminary System Safety Analysis
FMEA	Failure Modes and Effects Analysis
NDT	Nondestructive Testing
DVI	Detailed Visual Inspection
SWAMP	Severe Wind and Moisture Problem (mil spec) or Severe Weather and Moisture Prone (Airbus)
PSU	Passenger Service Unit, aircraft appliances at each passenger seat location (e.g. reading lights)
FEP	Fluoro Ethylene Propylene

Note on trade names: This report does not use trade names to describe wire insulation. Instead we use the more generic polymer name. However, because the aviation community is more familiar with trade names, their descriptions are included below.

Kapton	Dupont, aromatic polyimide
Kynar	Elf Autochem, poly-vinyl-idene fluoride
Spec 44	Raychem, Crosslinked polyalkene and XL PVDF
Qaud 4	McDonnell Douglas 748<u>4444</u>, PVC inner layer, glass braid, with a polyamide jacket
Spec 55	Raychem, crosslinked ETFE
Stilan	Raychem, Polyarylene
Tefzel	Dupont, ETFE
Poly X	crosslinked alkane-imide (aliphatic imide)

Nylon Dupont, polyamide

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Arcing is the most severe of the conditions. Moisture is not considered in this fault tree since (by virtue of the condition itself) the potential for shorting and arcing already exists.

Sustained intermittent arcing is usually only a threat when the short-circuit current is below the circuit breaker trip threshold.

- This simplified fault tree approach is not based on FAR 25.1309.
- The fault tree does not take into account the aircraft system design, architecture, materials, which are implemented and used by aircraft manufacturers in compliance with the FAR 25.1309.
- The terms *undesirable, severe, critical* are as defined in this document. Although their definition are related to terms definitions used in SAE ARP4761, they are not identical and must not be misconstrued.