

# InterConnect & Lectromec

## *Evaluation of Wire Harnesses Recently Removed from F-16 Aircraft*

Aging Aircraft Conference

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- Background
- Selection of Wiring Harnesses
- Falcon Wire Program
- Laboratory Test Results of Removed Wiring Harnesses
- Analysis of Laboratory Test Results of Removed Wiring Harnesses
- F-16 EWIS Risk Assessment
- Summary

# Background

- Prior to 2003, the primary insulation used on F-16 wiring harnesses was Kapton insulation.
- F-16's are now made with TKT insulation.
- After many years of use, Kapton insulation becomes old and brittle and can lead to wet and/or dry arcing. Arcing can lead to intermittent or catastrophic failures.
- The only solution for this potential problem is to replace the wiring harnesses with new wiring harnesses.
- The Falcon Wire program was designed and implemented to solve this issue.

# Selection of Wiring Harnesses

- Primarily based on over 20 years of problem reports from the field.
- Secondarily based on yearly demand requirements for spare F-16 wiring harnesses.
- Main areas where wiring harnesses are replaced.

1	AC Power Panel RH Strake	7	Gun Drum Bay	13	LOX Bottle Bay
2	Aerial Refuel Bay	8	Hydraulic Gun Motor Bay	14	Main Landing Gear
3	ECS Bay	9	Hydraulic Reservoir A Bay	15	Nose Wheel Landing Gear
4	Engine Bay	10	Hydraulic Reservoir B Bay	16	PDU Bay
5	EPU Bay	11	JSF/EPU Controller Bay	17	Right Hand Strake
6	Flaperon Actuator Bays	12	Left Hand Strake		

## Optional Areas for Replacement

- Leading Edge of the Wings.
- Fuel Cell Areas (Replace with Injection Molded Harnesses).
- Power Panels and Relay Panels.
- All Wiring for the Entire Aircraft.

# Falcon Wire Program

- Implementation Time
  - Lead Time to Purchase Material and Assemble Wiring Harnesses: 6 to 8 Months
    - Assembly Work Completed in Fort Worth, Texas at the OEM, InterConnect Wiring
  - Wiring Harness Removal, Installation, and Testing Duration – 1 to 2 Months
    - Removal, Installation and Testing Work Performed In-Country.

# Falcon Wire Program

- Implementation Process
  - Determine configuration of aircraft.
    - Wiring harness dash numbers
    - Wiring harness installation drawings
  - Assemble replacement wiring harnesses.
  - Procure installation hardware and tools.
  - Remove panels and equipment from aircraft.
  - Remove old wiring harnesses.
  - Install new wiring harnesses.
  - Reinstall panels and equipment.
  - Perform operational checks.
  - Perform Functional Check Flight (FCF).



# Falcon Wire Program (Cont.)





# Falcon Wire Program (Cont.)



## Laboratory Test Results of Removed Wiring Harnesses

- Independent Test Laboratory Conducted Tests
- Tests Performed
  - Insulation Breaches - Electrical tests for breaches in the insulation (results measured in failures per 1000 feet of wire per harness).
  - Inherent viscosity – Measures the relative age of a wire compared to the expected life of a new wire. Goal is to determine if there is significant environmental aging found in the harnesses.

Insulation Breach  
No Conducting Fluid

**No Current**

## DelTest™

No Insulation Breach  
Conducting Fluid

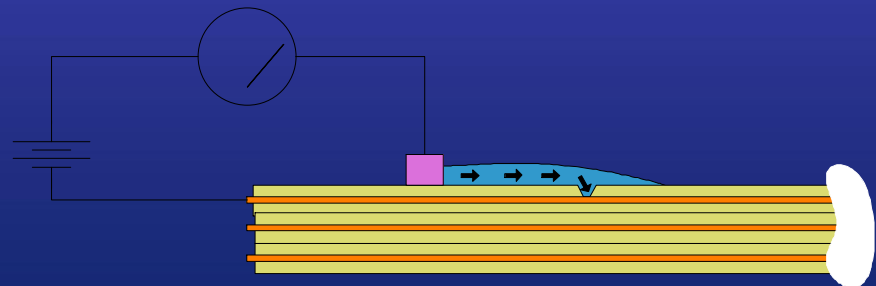
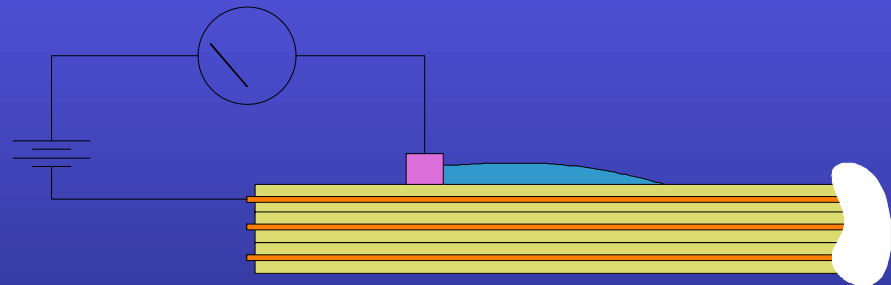
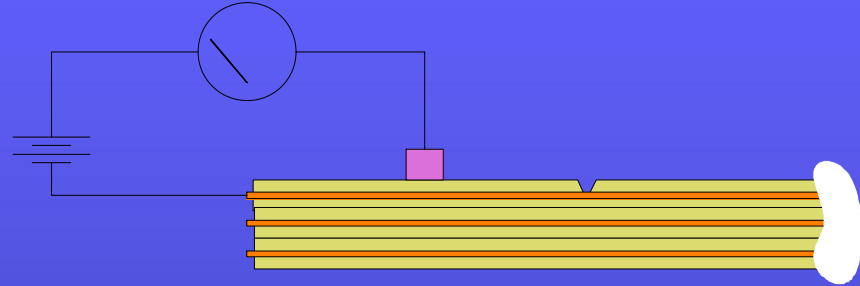
**No Current**

Insulation Breach  
Conducting Fluid

**Current**

**Breach Indicated**

## Evaluation of Wire Harnesses Recently Removed from F-16 Aircraft



- 35 Harnesses Tested
  - 1,565 Wires
  - 10,782 Feet of Wire
- 58 Insulation Breaches Found – 5.4 Breaches per 1,000 feet

Laboratory Test Results of Removed Wiring Harnesses  
(cont)



Laboratory Test Results of Removed Wiring Harnesses  
(cont)





Laboratory Test Results of Removed Wiring Harnesses  
(cont)



Laboratory Test Results of Removed Wiring Harnesses  
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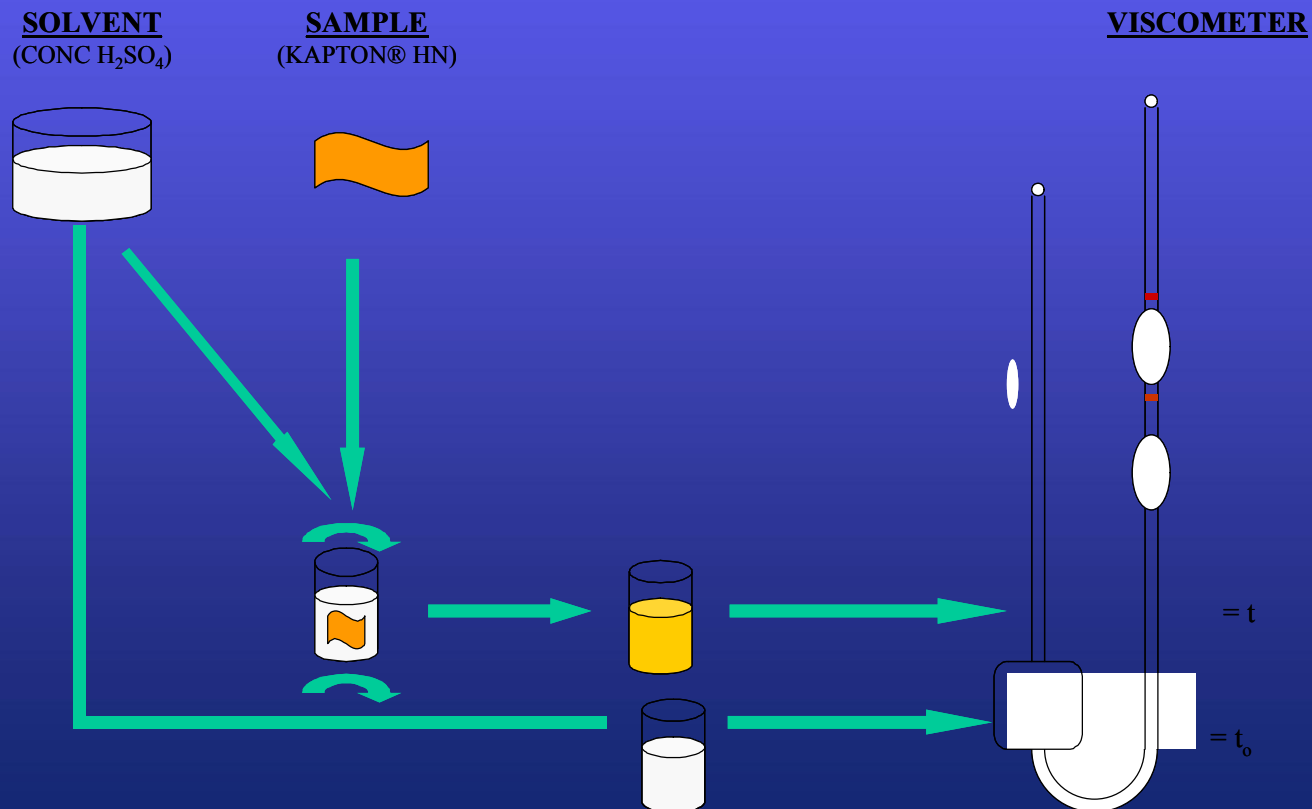
Laboratory Test Results of Removed Wiring Harnesses  
(cont)

No	Area	Breaches	Wires	Breaches Per 100 Wires	Length (ft)	Breaches Per 1000 Feet
1	Nose Landing Gear	6	198	3.03	1729.8	3.47
2	Center Fuselage	21	896	2.34	5692.9	3.69
3	Refuel	2	69	2.90	257.5	7.77
4	Engine Bay	8	187	4.28	1018.1	7.86
5	Main Landing Gear	16	179	8.94	1972.2	8.11
6	Flaperon Bay	5	36	13.89	111.3	44.92
	Total	58	1565	3.71	10781.8	5.38

## Laboratory Test Results of Removed Wiring Harnesses (cont)

- Comparison of F-16 to FAA Intrusive Inspections:
  - 6 Commercial airplanes more than 20 years old.
  - 4 Different wire insulations including aromatic polyimide (Kapton).
  - FAA Intrusive Inspection – 1.63 Breaches per 1,000 Feet of Wire. F-16 is 5.4 Breaches.
  - F-16 is 3.3 Times Worse.

### Inherent Viscosity: Indirect Measurement of Molecular Weight.



## Analysis of Test Results of Removed Wiring Harnesses

### Inherent Viscosity Results.

- Inherent Viscosity of New wire is Normally 1.3 or Higher.
- Sample of Inherent Viscosity Tests for Each Area of the Aircraft Were Performed.
- All Areas Showed an Inherent Viscosity of 0.9 to 1.1.
- Inherent Viscosities Between 0.9 and 1.1 Suggest Significant Deterioration.



# Summary of Testing

- The F-16 is a "Fly by Wire" Aircraft. Wire Integrity is of the Utmost Importance.
- The Only Solution for Kapton Wiring Issue is Wire Harness Replacement. For the F-16, Kapton is Replaced with TKT.
- Falcon Wire Program Replaces the Wiring Harnesses that have caused the Most Problems over the Life of the Aircraft
- The Laboratory Tests Showed the Severity of the Problem. If the Wiring Harnesses were not Replaced, Serious Problems would have Resulted in the Future due to Wire Breaches and Aging of the Wire.

# Application of EWIS Risk Assessment Techniques

- EWIS RAT is the Electrical Wire Interconnection Systems Risk Assessment Tool that was developed by Lectromec with the FAA to help with type certification of aircraft EWIS
- Opportunity to apply the tool to a legacy aircraft that had limited available data
- Goal: Develop a method of prioritizing harness replacement using the EWIS RAT considering
  - Criticality of system and devices in harness
  - Probability of loss of the harness

## Available Data

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- Wire List data
- Wiring diagrams
  - System – Devices/Connector
- Impact of Loss of Device
- Limited Data on Harness Environments
  
- For Advanced Analysis: Harness Section information

## Data Relationships

- The EWIS RAT developed the different relationships between the wire segments
  - Circuit Element
  - Circuit Element Families
  - Circuit Element Controls
- Harness Report:
  - What devices would be affected by loss of that harness
  - Power in harness
  - Probability of wire failure

## Risk Hazard Index

- Score for the probability of loss for the harness based on
  - Wire probability of failure (Wire Failure Function)
  - 115 VAC wire in the harness
  - Percentage of power wires in the harness
  - Wire insulation arc tracking characteristics
- Score for Harness Loss based on number of
  - Flight Safety Critical Systems
  - Safety Critical Systems
  - Mission Critical Systems

### Risk Hazard Matrix

		Harness Loss Hazard					
		6	5	4	3	2	1
Probability Harness Loss Index	6	12	11	10	9	8	7
	5	11	10	9	8	7	6
	4	10	9	8	7	6	5
	3	9	8	7	6	5	4
	2	8	7	6	5	4	3
	1	7	6	5	4	3	2

- Harness W2601-
  - Loss Hazard-5
  - Probability Index-6

- Harness W736-
  - Loss Hazard-5
  - Probability Index-3

- Harness W698-
  - Loss Hazard-3
  - Probability Index-3

Red - Critical, immediate replacement considered essential  
 Amber - Significant threat, early replacement is highly desirable  
 Green - Low impact, routine replacement on an opportunity basis is recommended



**Evaluation of Wire Harnesses Recently  
Removed from F-16 Aircraft**

**Thank You**