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L-3 MAS Canada



National Défense
Defence nationale



CF-18 Wire Harness Integrity Program

9th Joint FAA/DoD/NASA
Conference on Aging Aircraft
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Outline

Introduction

Background

CBR Wiring Condition Assessment Study

Testing Approach

Tests Conclusions

Risk Assessment

Study Outcome

Wire Harness Integrity Program

WHIP Validation Testing (QETE)

On-going Research (NRC)

Conclusions and Questions

Introduction

Personnel – who we are:

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Introduction (con't)

Wire Harness Integrity Program:

The WHIP is a major initiative to ensure the continued serviceability of CF-18 aircraft (F/A-18A and B) until the year 2017.

It was initiated in the context of the Center Barrel Replacement program, but has now taken a life of its own. In a nutshell, the WHIP covers two major aspects:

- Coordination of the manufacturing and replacement of selected Cable Harnesses; and
- On-going monitoring of wiring aging conditions through inspection, testing and trend analysis.

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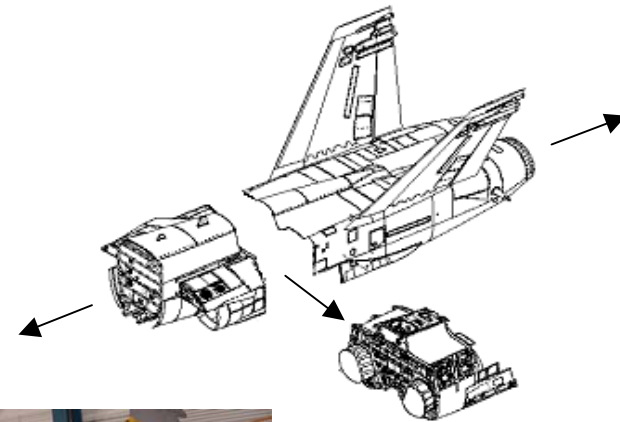
Background

The Dept. of National Defense (DND) is currently replacing the Center Barrel on a limited number of CF-18 aircraft as a means of extending their useful service life



Background

The intrusive nature of this structural modification raised the question of the impact on the existing cable assemblies which are being removed and reinstalled.



Background

- Cables are being pulled out and/or rolled back
- Splice points are being opened
- Connectors are being disconnected and disassembled
- Potential wear and tear on wire during CBR modification



CBR Wiring Condition Assessment Study

Can Kapton[®] wire undergo this modification without creating immediate or long-term safety implications.

CBR Wiring Condition Assessment Study

Kapton[®] has been extensively used in CF-18
53% of all wire types and **92%** in volume

With time, Kapton[®] insulation becomes brittle. Temperature variation, exposure to chemicals, poor maintenance techniques and bad wire handling, can accelerate or worsen the wire condition.

Primary problem with damaged Kapton[®] wiring is arc tracking



Clip is a Courtesy of Department of National Defense Quality Engineering Test Establishment (QETE)

Testing Approach

A cable assessment study was conducted in 5 phases over a period of 2 years, as follows:

- Phase 1: Test Definition
- Phase 2: Procure/Lease Test Equipment/Services
- Phase 3: Test Plan & Procedure Definition
- Phase 4: Testing
- Phase 5: Result Analysis

The study was conducted on two aircraft (study articles) using two types of testing:

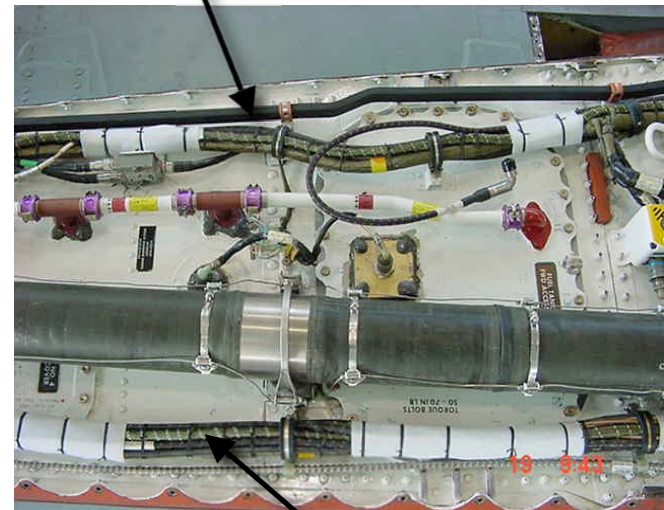
- Destructive testing
- Non-destructive testing



Testing Approach - Destructive Testing

Lectromec's Wire Insulation Deterioration Analysis (WIDAS)

- Total of 107 wire samples taken from different aircraft zones.
- First aircraft (L/H)
 - 29 wires taken before CBR
 - 26 wires taken after CBR
- Second aircraft (R/H)
 - 26 wires taken before CBR
 - 26 wires taken after CBR



Testing Approach - Destructive Testing (con't)

Wiring placed in an environment testing chamber capable of accelerated aging under pre-established controlled conditions

Specimen were aged until the insulation fails

Failure criterion was insulation breakdown at a specific voltage

Time until failure compared with baseline determined the percentage of wire insulation life used

Testing Approach - Destructive Testing (con't)

WIDAS Results Analysis:

- Some cable assemblies are significantly aged; and
- Aging tests have demonstrated that new breaches will appear.

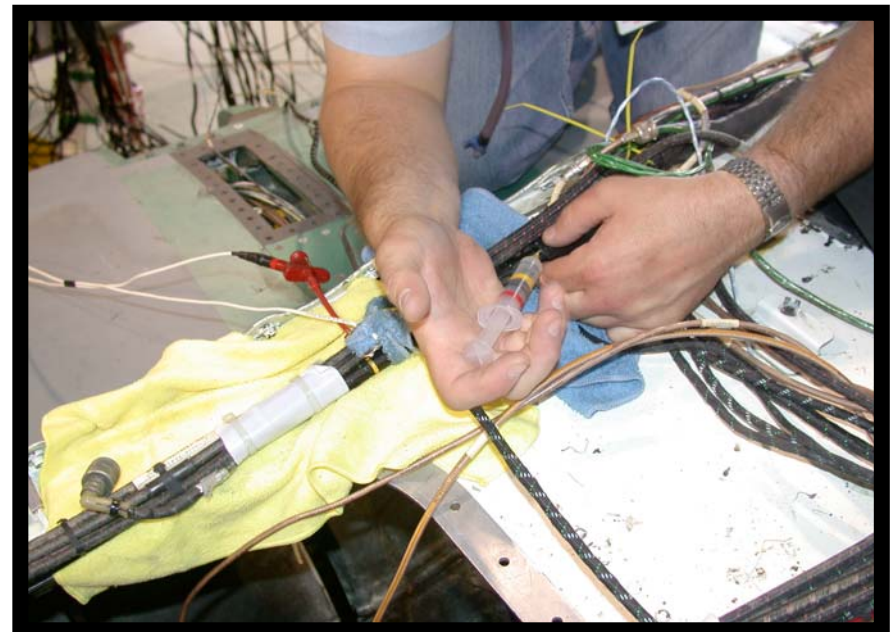
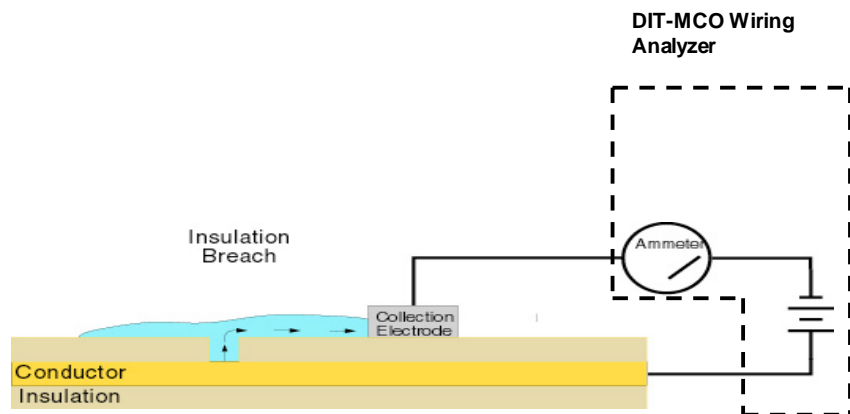
Testing Approach - Non-Destructive Testing

- Wet isolation test - Lectromec's DelTest™
- Isolation test – DIT-MCO;
- High potential test – DIT-MCO; and
- Continuity and resistance measurement – DIT-MCO.

Testing Approach - Non-Destructive Testing (con't)

Lectromec's DelTest™

- A conducting fluid applied to a short wire bundle segment.
- A low voltage is applied to the wire.
- A meter measures any electric current leakage into the conductive fluid. If current is evident, there may be a crack in the insulation.



Testing Approach - Non-Destructive Testing (con't)

DelTest Results Analysis:

- Breaches in the isolation exist;
 - Location of DelTest™ detected failures observed in close proximity to cable securing clamps
 - Each additional localized breach will increase the risk of system failure and arc tracking

- Lectromec's Recommendations
 - Replace old harnesses
 - If old harnesses are re-installed:
 - Establish plan for monitoring wire condition deterioration; and
 - Proceed with periodic testing.

Testing Approach - Non-Destructive Testing (con't)

DIT-MCO Electrical Testing

- Isolation, Hi-pot and Continuity Tests performed using DIT-MCO Wire Analyzer model 2500 (GFE).

- First aircraft (L/H)
20 harnesses
- Second aircraft (R/H)
17 harnesses



Testing Approach - Non-Destructive Testing (con't)

DIT-MCO Isolation Test

- Allows detection of shorts or some leakage failure before high voltage is applied
- 500 VDC / 200 ms

Testing Approach - Non-Destructive Testing (con't)

DIT-MCO High-Potential Test

- To determine if insulating materials and spacing are adequate
- 500 to 1200 VDC / 200 ms
- Measured resistances values are digitized and stored

Testing Approach - Non-Destructive Testing (con't)

DIT-MCO Continuity and Resistance Measurement Test

- To verify connection between two points
- Low current (500 mA max)
- Measured resistances values are digitized and stored

Testing Approach - Non-Destructive Testing (con't)

DIT-MCO Results Analysis:

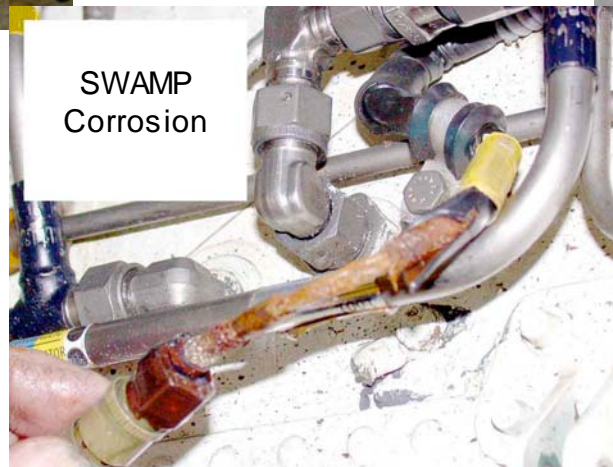
- 2 wires in one cable harness failed isolation test on first aircraft
- No critical fault found under tests conditions for the remaining harnesses.

Testing Approach - Visual Inspection

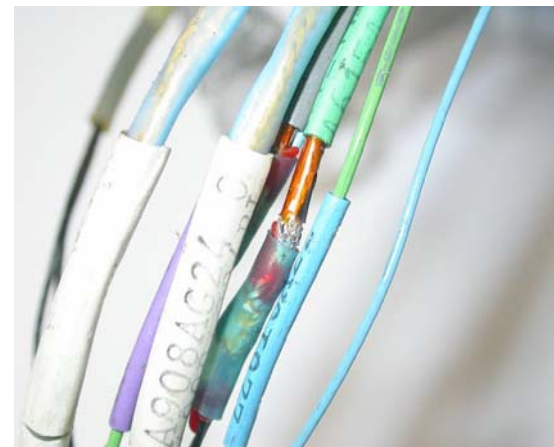
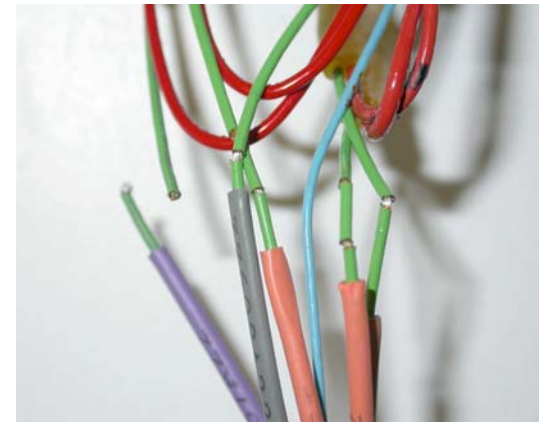
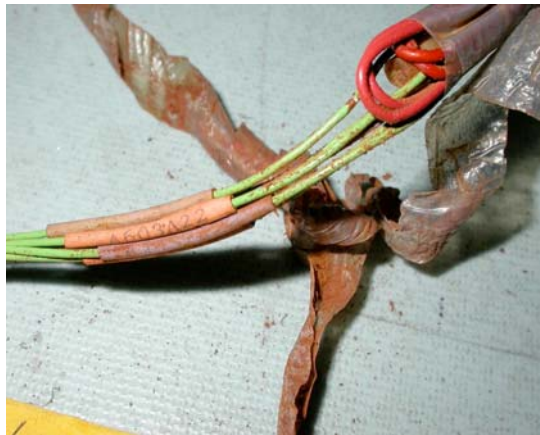
The two test articles and a third aircraft (operational aircraft) were visually inspected

- Evidence of Kapton[®] outer jacket flaking;
- Severe corrosion problems (connectors and wire mesh tape) found in wheel well area;
- Broken connector backshells;

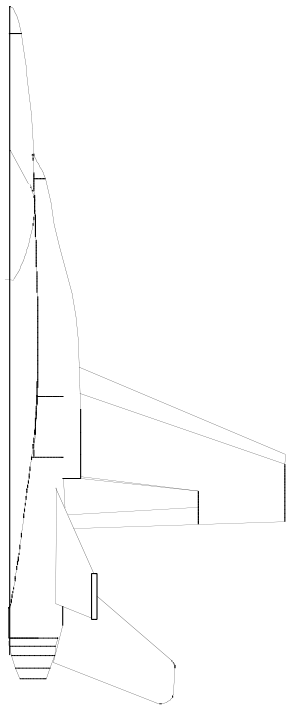
Testing Approach - Visual Inspection (con't)



Other Visual Inspection Examples



Testing Approach - Summary



Second aircraft R/H

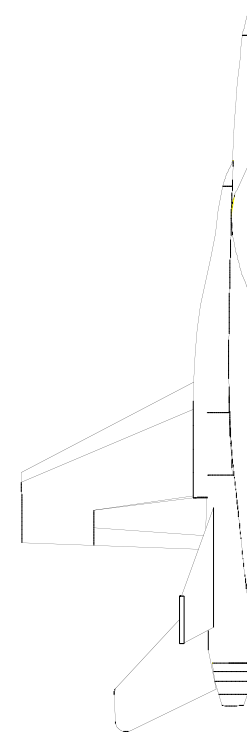
Before CBR

Hi-Potential test
Isolation Test
Continuity Test
DelTest™

CBR Simulation

After CBR

DelTest™
Hi-Potential test
Isolation Test
Continuity Test
Visual inspection



First aircraft L/H



Test Conclusions

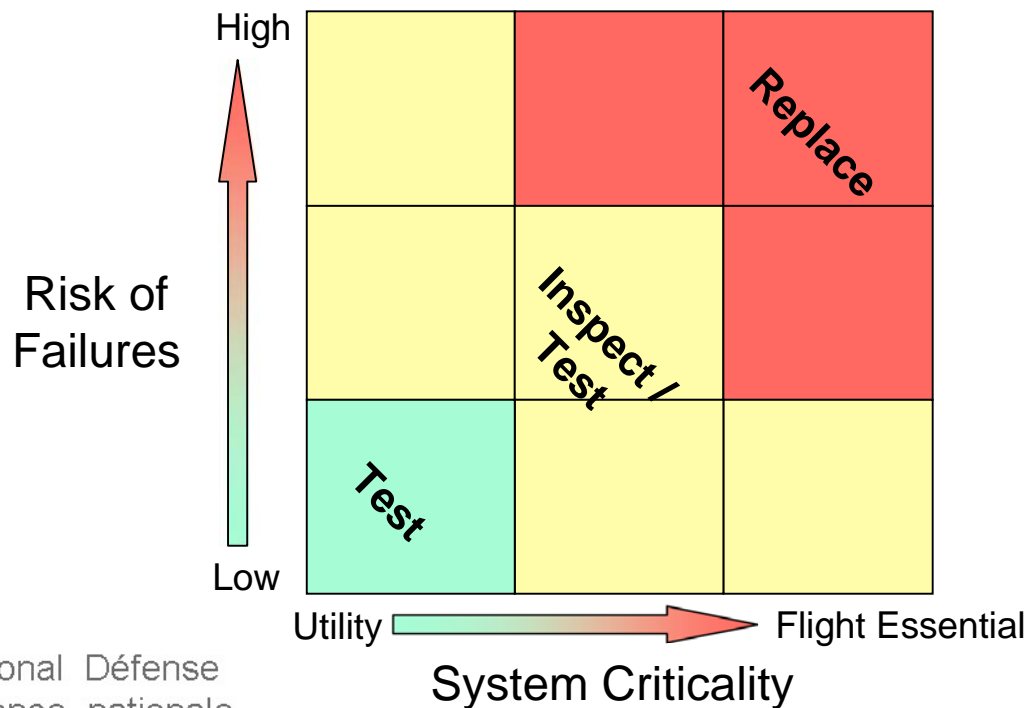
The Center Barrel Replacement modification, should not have a detrimental effect on the wire condition.

Cables assemblies in the CF-18 Center Barrel area are presently in a deteriorated state and will continue to deteriorate, specifically behind Door 42 and in the SWAMP areas (identified as rapid wire aging zone).

Wire harness replacement should be considered.

Risk Assessment

Study sets the base for the risk assessment and a replacement Priority (High, Medium and Low) was assigned to each cable based on system criticality, location and current maintenance data



Study Outcome

Initially: 9 cable harnesses were identified as high priority (red) for replacement. Focus was limited to Center Barrel area.

Today: 5 additional cable harnesses have been added to the high priority list. Focus expended to entire aircraft.

Medium priority (yellow) cables replaced as required (case-by-case)

3 Nose Wheel Well (NWW) harnesses that were not part of the study are also being replaced on each aircraft (due to their SWAMP location)

Wire Harness Integrity Program

Focal point for coordinating the efforts required for the manufacturing and replacement of the cable harnesses:

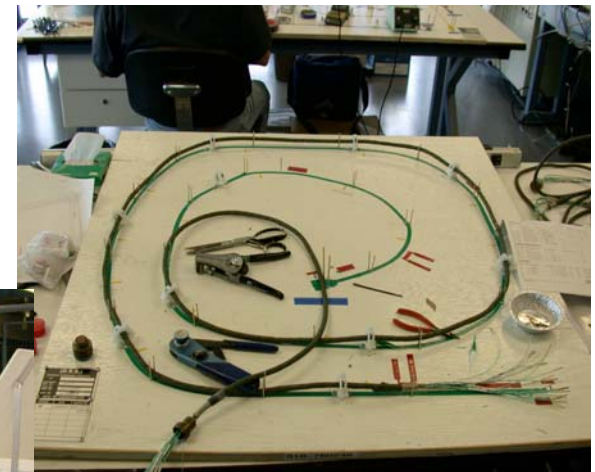
- Manufacturing occurs solely at Third Line (Depot Level Maint)
- Replacement occurs mostly at Third Line, but some harnesses are replaced at First Line (O-Level Maint)

Ongoing monitoring of CF-18 wiring aging conditions through baselining, inspection, testing and trend analysis.

Wire Harness Integrity Program (con't)

Harness Manufacture:

- Kapton® wire, Silver plated wire, and backshells with drain holes are excluded from new wire harness construction;
- Replacement wire: MIL-W-22759 Composite (seamless)



Wire Harness Integrity Program (con't)

Ongoing Monitoring:

- Baselining
 - Test and inspect wiring for each aircraft to determine the immediate need for harness replacement beyond those already planned; and
 - Compile wiring condition data into a database for trend analysis purposes
- Trend analysis
 - Compared wiring condition data with pre-established benchmark test, engineering data and alert level; and
 - Identify the trend to initiate the appropriate corrective action.

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WHIP Validation Testing

To confirm the initial findings and justify the cost of the WHIP, the Canadian Forces Quality Engineering Test Establishment (QETE) was tasked to perform testing on the 9 high priority cable harnesses



WHIP Validation Testing (con't)

Electrical testing and visual inspection of 3 sets of the initial 9 high priority cable harnesses taken from three aircraft with the following usage:

Aircraft A @ 3395 AF Hours

Aircraft B @ 4081 AF Hours

Aircraft C @ 4578 AF Hours

WHIP Validation Testing (con't)

Methodology:

- External Inspection
- Dissection/Internal examination
- Testing (electrical)
 - Immersion testing in water
 - To measure insulation resistance of a portion of wire
 - (DIT-MCO, 500 VDC/1.1 sec)

WHIP Validation Testing (con't)

Results:

- The insulation showed degraded performance when compared to original specifications. However, no imminent failure of the wire under test could be forecasted.
- Correlation found between the number of failures and the number of airframe hours.
- Corrosion products found inside shielding
- Severe corrosion found at the wire mesh tape connecting the machined braid to the backshell.

On-going Research

DND – NRC (IAR - Institute of Aerospace Research) collaboration on ageing wiring and systems research



NRC-CNRC

*Institute for
Aerospace
Research*

CNRC-NRC

*Institut de
recherche
aérospatiale*

On-going Research (con't)

What is a defective wire?

change (increase) in resistance

- leads to heating, incorrect signal

change (decrease) in dielectric breakdown voltage of insulation

- increased risk of arcing

change (increase) in flammability of insulation

- increased risk of fire propagation

When and why replacing wiring?

On-going Research (con't)

Comprehensive visual inspections
of IAR's 727 testbed airframe

Wiring is mostly intact.



On-going Research (con't)

IAR has collected aged wiring samples from CH-124, CC-130, CF-18 under DND direction

IAR and DRDC have agreed to a two year collaborative project for continued efforts to perform sampling tests of the relevant performance parameters of the wiring under test.

AEC - CNRC

*Institute for
Aerospace
Research*

CNRC - AEC

*Institut de
recherche
aérospatiale*



**Defence Research and
Development Canada**

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Conclusion

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Any Questions?



Thank You

On-going Research (con't)

Single wire and installed system

Dielectric breakdown, insulation elasticity, flammability etc...

Electrical Tests (QETE)

Chemical Test (RMC)

Mechanical Tests (NRC)

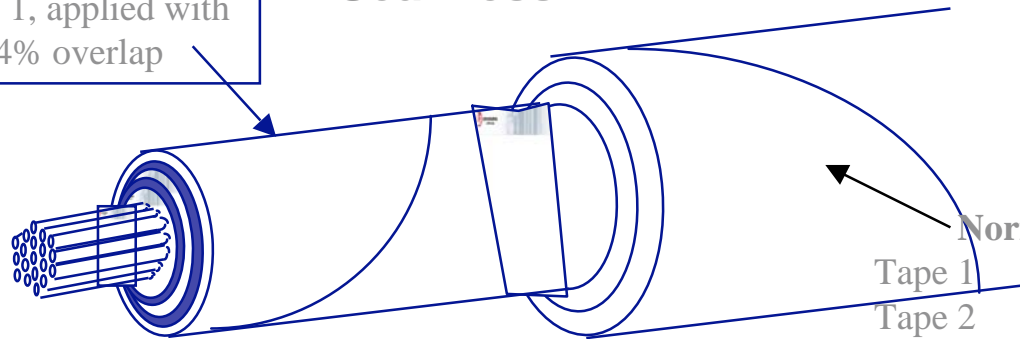
DIT-MCO Tester



Replacement wire

MIL-W-22759 “Composite” Seamless

Tape 1, applied with
51-54% overlap



Normal Wall Insulation (Airframe)

Tape 1 .5 mil FP / 1 mil PI / .5mil FP
Tape 2 2 mil Unsintered PTFE
Total Nominal Thickness 7.6 mil

Thin Wall Insulation (Hook-Up)

Tape 1 .45 mil FP / .65 mil PI / .1mil FP
Tape 2 2 mil Unsintered PTFE
Total Nominal Thickness 5.8 mil

Advantages

- Temperature Performance (260C)
- Mechanical Toughness
- Hydrolytic Stability
- Arc Resistance
- Smoke Generation
- Flexibility
- Low Weight
- Laser Markable



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