AIRCRAFT
ELECTRICAL WIRE
Wire Manufacturers Perspective

Tyco Electronics (Raychem)
Walter Cinibulk
AIRCRAFT ELECTRICAL WIRE

• Important Wire Performance Characteristics
• Major Airframe Wire Type Usage
• Priority of Performance Requirements
• Wire Aging Considerations
• FAA - ATSRAC Inspection Data
• Wire Manufacturer Product Tests

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Some Reference Points

• A large commercial transport aircraft such as the 747 uses approximately 750,000 feet (about 140 miles) of wire, weighing about 3,500 pounds.

• All aircraft designs are weight critical.

• Since wire contributes significantly to the total weight of the aircraft it has received a great deal of attention for weight reduction.

• The two available approaches to reduce weight of wiring are:
  – reduce the weight by developing wires with higher temperature rating, which allows less copper content
  – reduce the weight of the insulation by developing better materials that can safely be used in smaller thickness

• Since 1950 the total wire weight reduction through improved insulation materials alone has been of the order of 25%.
Important Wire Performance Characteristics

• **Aircraft Design**
  – Weight
  – Size
  – Compatibility with anticipated aircraft operating environment

• **Aircraft Manufacture**
  – Ease of preparation: Easy to cut, strip, mark, terminate, etc.
  – Ease of installation: Flexibility, for ease of routing and handling
  – Compatibility with manufacturing environment: Compatible with chemicals/cleaners used during wire harness manufacture

• **Operation**
  – Withstand abrasion and other mechanical abuse
  – Maintain circuit integrity in case of current overload
  – Not propagate flame/fire
  – No hazard due to arc tracking susceptibility
  – Not generate large amounts of smoke if overheated or involved in a fire
  – Withstand influence of moisture, UV, fluids, cleaning compounds, etc.

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Major Airframe Wire Type Usage

Wire evolution has been driven by weight reductions

**PVC/Glass/Nylon**
- Installations: Boeing: 707, 727, 737
- Douglas: DC-8, DC-9

1950
- Weight: 6.8 lbs.
  - 1000 ft; 20 AWG
- Max Temp: 105°C
- Insulation: 25 mils

1964
- Weight: 5.5 lbs.
  - 1000 ft; 20 AWG
- Max Temp: 150°C
- Insulation: 15 mils

**XL-PVDF**
**XL-Polyalkane**

44A
- Installations: Boeing 747
  - GD F-111
  - Grumman E-2, A-6
  - Lockheed: C-5, C-130, C-140
  - Fairchild A-10
  - Many General Aviation A/C
Major Airframe Wire Type Usage

Wire evolution has been driven by weight reductions

1966
Weight: 4.6 lbs.
1000 ft; 20 AWG
Max Temp: 200 C
Insulation: 8.4 mils

Kapton
Installations: Lockheed L-1011, Douglas MD-80, Boeing 727, 737, 757,
Grumman F-14, McDonnell F-15, GD F-16

1977
Weight: 4.9 lbs.
1000 ft; 20 AWG
Max Temp: 200 C
Insulation: 10 mils

XL-ETFEXL-ETFEXL-ETFEXL-ETFEXL-ETFEXL-ETFEXL-ETFE

55A
Installations: Boeing 747, 767, 777
US Navy A/C, some US AF & Army A/C
Several satellite & other space programs

1991
Weight: 4.5 lbs.
1000 ft; 20 AWG
Max Temp: 260 C
Insulation: 8 mils

TKT Composite (Teflon/Kapton/Teflon)
Installations: Boeing 737, 757
Partially on some defense A/C

PTFETape

1992
Weight: 4.5 lbs.
1000 ft; 20 AWG
Max Temp: 200 C
Insulation: 8 mils

55PC
Installations: Boeing 747, 767, 777 & several General Aviation A/C

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Kapton, Teflon, and Tefzel are trade marks of the DuPont Corporation
Tyco Electronics 260 C Aircraft Electrical Wire

March 2002
Weight: 5.4 lbs.
1000 ft; 20 AWG
Max Temp: 260 C
Insulation: 12 mils

Mica Tape with Perfluoropolymer Jacket
-Circuit Separation Wire - Thick Wall

October 2002
Weight: 4.5 lbs.
1000 ft; 20 AWG
Max Temp: 260 C
Insulation: 6 mils

Mica Tape with Perfluoropolymer Jacket
-Airframe Wire-
**AIRCRAFT ELECTRICAL WIRE**

Performance Requirements Priority as Dictated by our customers (QFD)

<table>
<thead>
<tr>
<th>RANK</th>
<th>PROPERTY</th>
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<tbody>
<tr>
<td>1</td>
<td>Arc-Track Resistance</td>
</tr>
<tr>
<td>2</td>
<td>Flammability</td>
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<tr>
<td>3</td>
<td>Toxicity of Smoke</td>
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<tr>
<td>4</td>
<td>Smoke Density</td>
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<tr>
<td>5</td>
<td>Wire-Frame Abrasion</td>
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<tr>
<td>6</td>
<td>Cut-thru at rated Temp</td>
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<tr>
<td>7</td>
<td>Reduced Weight</td>
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<tr>
<td>8</td>
<td>Hydrolysis Resistance</td>
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<tr>
<td>9</td>
<td>Cut-thru at Room Temp</td>
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<tr>
<td>10</td>
<td>Wire-Wire Abrasion</td>
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</tbody>
</table>

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Fire Hazard Performance

Importance Ranking

• Arc Tracking
• Flammability
• Toxicity
• Smoke

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Customer Manufacturing Requirements

• Dual Layer
• Stripping
• Toughness / Flexibility
• Surface properties:
  – marking contrast
  – smooth exterior
  – adhesion to labels
  – friction for grip/handling
  – bond or seal to potting material

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Practical Considerations of Aging

Fatigue through
Bending, vibration,
scrape, flexure

Chemical or hydrolytic attack

Thermal degradation

UV or Sunlight

Wire of reduced performance
### FAA - ATSRAC  
(Aging Transport Systems Rulemaking Advisory Committee)  
Intrusive Inspection Report

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>A300</th>
<th>DC-9</th>
<th>747</th>
<th>DC-9</th>
<th>L1011</th>
<th>DC-10</th>
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<td>12/99</td>
<td>2/00</td>
<td>5/00</td>
<td>6/00</td>
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<td>Wire Type</td>
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<td>Poly-X</td>
<td>PVC/G/N</td>
<td>Polyimide</td>
<td>XL-ETFE</td>
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Page 8, Table 1.1: Subject Aircraft Data  
Tyco Electronics, Walter Cinibulk
FAA - ATSRAC

Intrusive Inspection Report Summary

Breaches per 1000' by Insulation Type

Page 24, Figure 3.2: Aircraft Specific Findings per 1000 feet of wire

Page 25, Figure 3.4: Wire-Type Specific Findings per 1000 feet of wire

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Typical Wire Test Requirements
(Customer performance/test requirements)

• **Dimensional** - Size & Weight

• **Electrical** - Resistance, Voltage Rating, IR

• **Thermal** - Thermal Aging, Low Temperature Flexibility

• **Mechanical** - Cross-Wire Rub, Scrape Abrasion, Cut-Thru

• **Flammability** - Arc Track Resistance, Flame Resistance, Smoke, Toxicity

• **Chemical** - Diameter Swell, Chemical Attack

• **Handling** - Laser Markability, Stripping
We are committing to continue:

• Manufacturing to the highest performance and quality standards

• To globally support all of our electrical interconnect products

• To invest in new technologies

• The production of Spec55 XL-ETFE

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