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%.

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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.

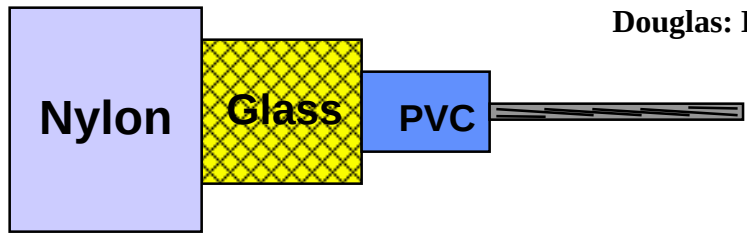
Major Airframe Wire Type Usage

Wire evolution has been driven by weight reductions

PVC/Glass/Nylon

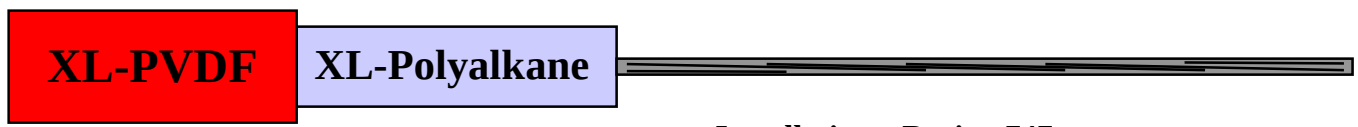
Installations: Boeing: 707, 727, 737
Douglas: DC-8, DC-9

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



44A

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

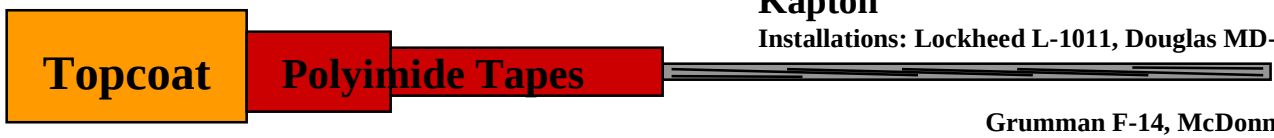


Installations: Boeing 747
GD F-111
Grumman E-2, A-6
Lockheed: C-5, C-130, C-140
Fairchild A-10
Many General Aviation A/C

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,

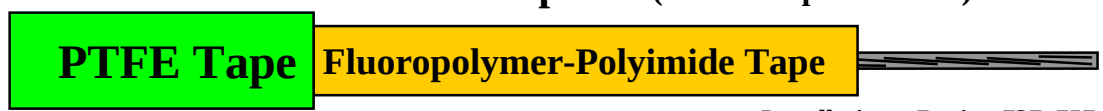
Grumman F-14, McDonnell F-15, GD F-16

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

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

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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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)

RANK	PROPERTY
1	Arc-Track Resistance
2	Flammability
3	Toxicity of Smoke
4	Smoke Density
5	Wire-Frame Abrasion
6	Cut-thru at rated Temp
7	Reduced Weight
8	Hydrolysis Resistance
9	Cut-thru at Room Temp
10	Wire-Wire Abrasion

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AIRCRAFT ELECTRICAL WIRE

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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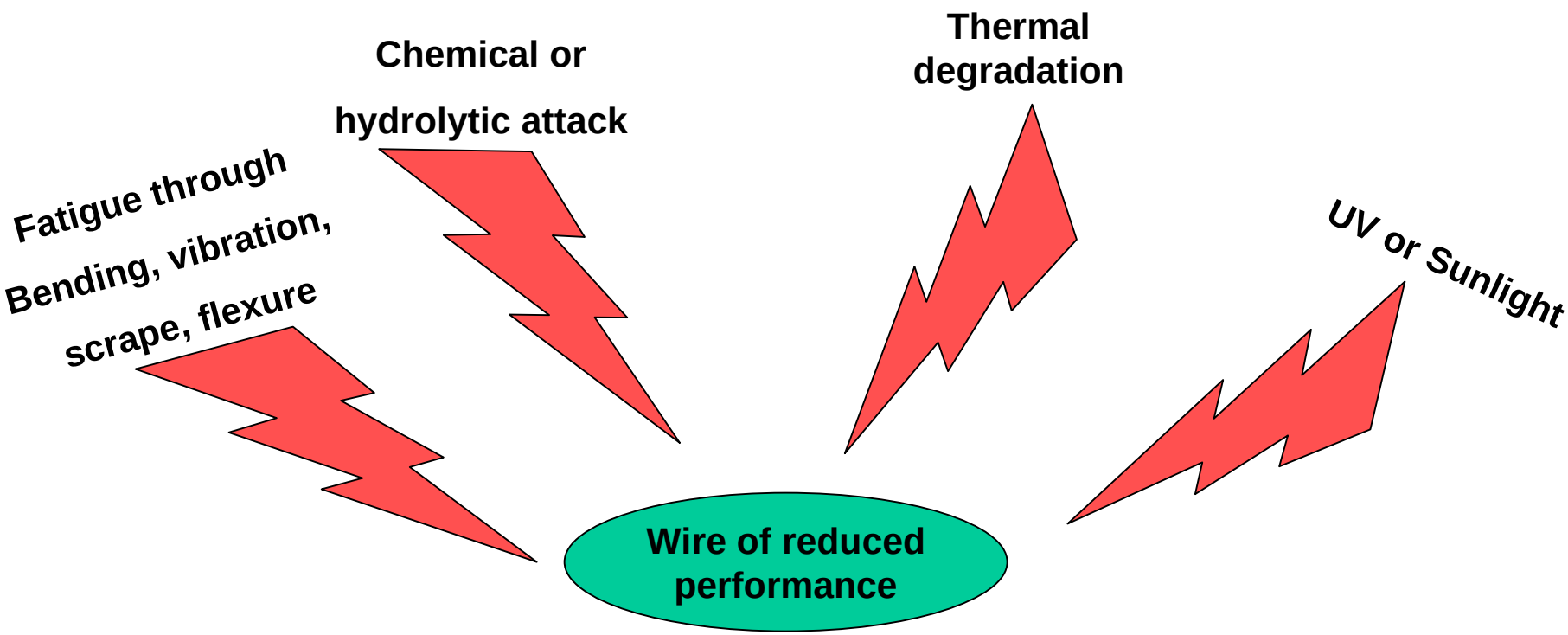
Practical Considerations of Aging



FAA - ATSRAC

(Aging Transport Systems Rulemaking Advisory Committee)

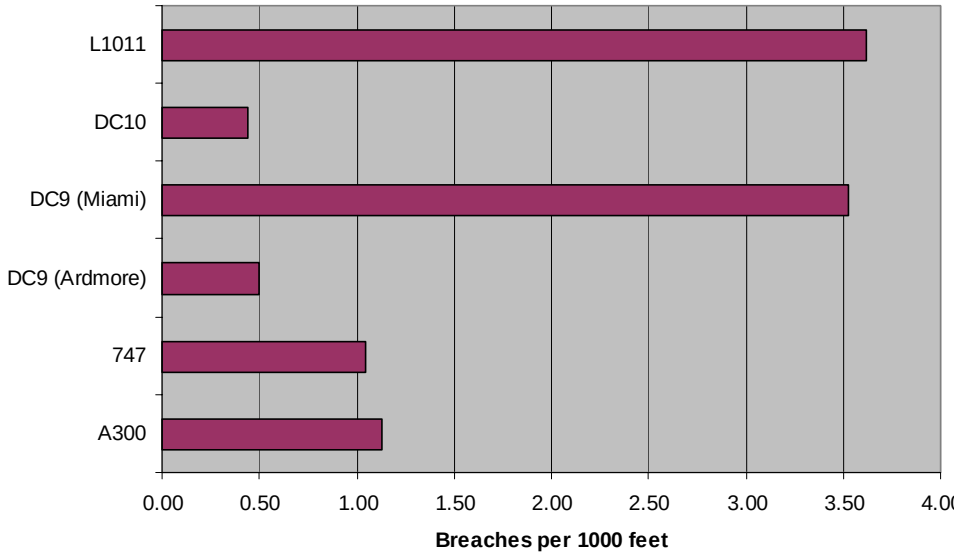
Intrusive Inspection Report

Aircraft	**A300**	**DC-9**	**747**	**DC-9**	**L1011**	**DC-10**
Inspection	9/99	12/99	2/00	5/00	6/00	6/00
Year Mfr	**1978**	**1967**	**1973**	**1971**	**1972**	**1979**
Hours	39,713	74,558	100,241	66,801	63,618	61,334
Cycles	27,078	100,017	20,348	75,446	26,256	18,818
Retired	7/99	9/99	5/99	12/99	6/99	5/00
Wire Type	**Polyimide**	**PVC/G/N**	**Poly-X**	**PVC/G/N**	**Polyimide**	**XL-ETFE**

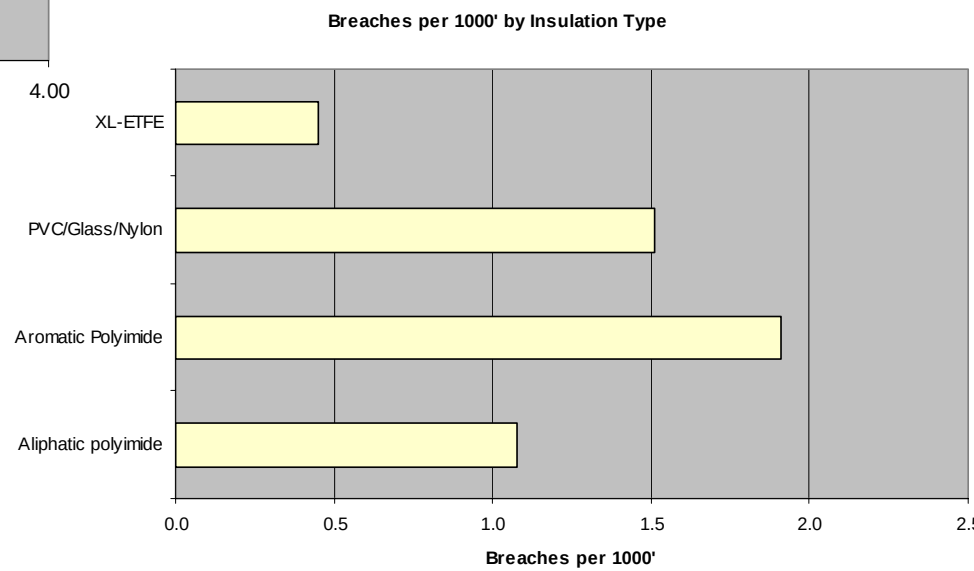
Page 8, Table 1.1: Subject Aircraft Data

FAA - ATSRAC

Intrusive Inspection Report Summary



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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