

# EVALUATION OF PYROLYSIS AND ARC TRACKING ON CANDIDATE WIRE INSULATION DESIGNS FOR SPACE APPLICATIONS

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- \* NHB 8060.1C Comparison
- \* Apparatus
- \* Sample Description
- \* Procedure
- \* Results
- \* Discussion
- \* Conclusions
- \* Future Plans

NHB 8060.1C (April 1991)

Flammability, Odor, Offgassing, and  
Compatibility Requirements and Test  
Procedures for Materials in  
Environments that Support Combustion.

Office of Safety and Mission Quality

Section 4.18 Arc Tracking (Test 18)

## PURPOSE

- \* Determine ability of wire insulation materials and constructions to resist arc tracking.
- \* Assess damage caused by initial arcing and restrike events.

## TEST CRITERIA:

### NHB 8060.1C:

- Arc propagation on either initial application of power or on reapplication of power is considered a test failure.
- Tests conducted on samples of worst-case use insulation thickness and wire gauge, and in the worst-case environment.

### Wiring for Space Applications Program:

- All candidate space application insulation constructions arc track.
- Worst case insulation: prepyrolized polyimide wire insulation.

## Results of Arc Tracking Initiation.

- \* Self Extinguish (Best scenario).
  - No loss in wire bundle performance.
  - Charred insulation.
- \* Conductors Lose Insulation (exposed conductors)
  - Safety hazard.
  - Short-circuit risks
  - No loss in wire bundle performance.
- \* Severed Conductor.
  - Lost use of a wire pair within the bundle.
  - No loss in remainder of wire bundle performance.
  - No loss in wire bundle performance.
- \* Flashover Severs All Wires. (Worst scenario)

## Best and Worst Case Differences

- \* Voltage difference between two conductors.
  - High enough to break down the dielectric strength of the charred material.
  - Not high enough to break down the dielectric strength of the charred material (self ext.)
- \* Current Flow:
  - High enough, such that Joule heating will continue to pyrolyze neighboring insulation.
  - Not high enough, such that Joule heating will continue to pyrolyze neighboring insulation.
    - Self Extinguish
    - Glow like a carbon filament light bulb (Vacuum case)

## Properly Insulated Wire.

(Rated for task requirements)

- Will not Arc Track due to voltage difference between conductors.
- Will not Arc Track due to typical Joule heating from current in conductors.

## Defectively Insulated Wire.

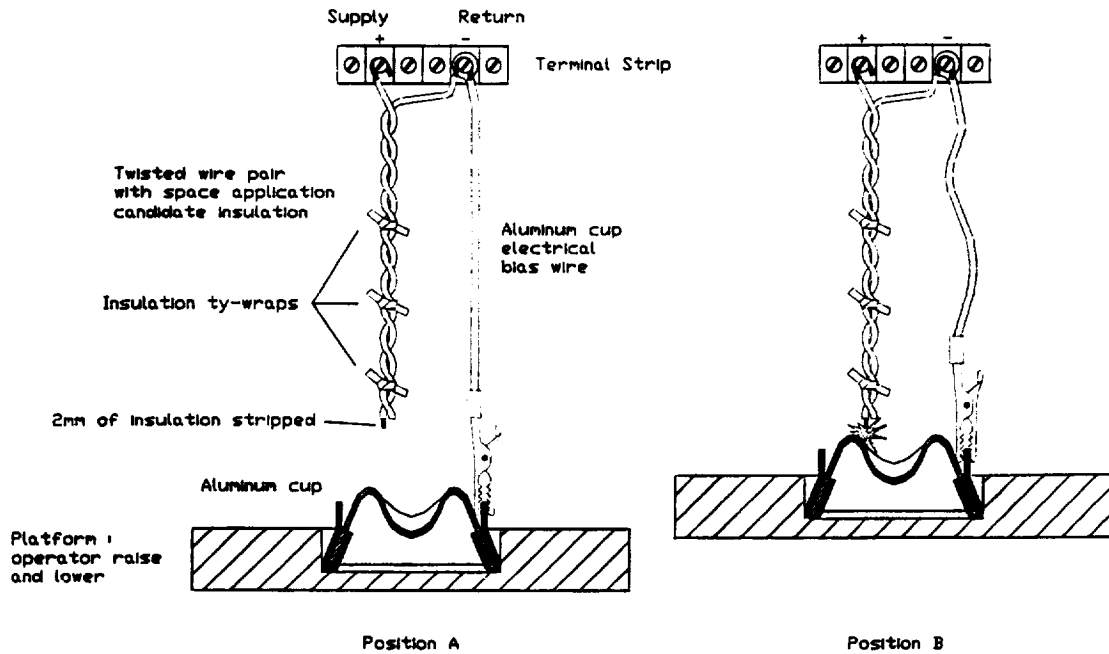
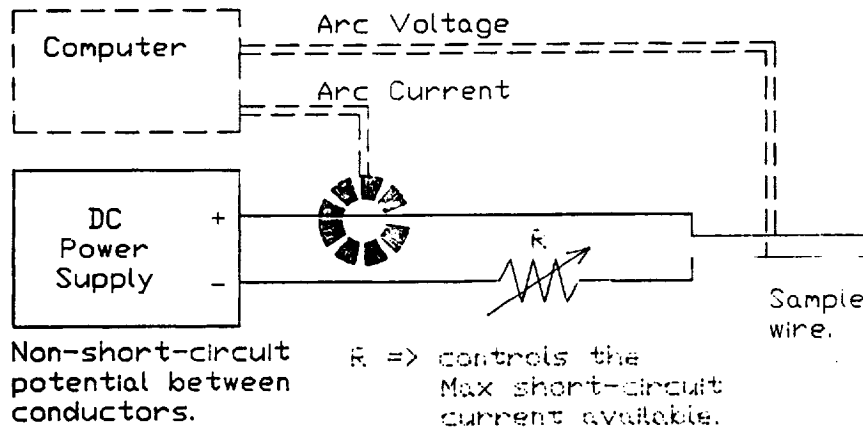
- May momentarily short-circuit
  - Arc generated heat may char the insulation.
  - Charred insulation lowers the dielectric strength.
- n # of momentary short-circuits before sustaining an arc.
- Worst state of insulation.
  - Pyrolyzed to the point of sustained arc tracking.
  - Restrike possible.  
dielectric strength.

Necessary Restrike  
Min. Voltage and Min Current

= EQUALS =

Min. Voltage and Min. Current  
Necessary to Pyrolyze the Insulation  
To The Point of Sustained Arc Tracking

Arc Tracking Circuit.



Insulation Construction	Description
Champlain #1	2919 Kapton (50%DL)/Extruded XL ETFE
Filotex	PTFE Extrusion/616 Kapton (50% Min DL) /PTFE Dispersion.
Thermatics #3	Modified PTFE Tape (50% min DL)/TPT Tape (50% min DL)/Mod PTFE Tape (50% min DL)/PTFE Dispersion.
Abbreviations:	<p>2919 Kapton =&gt; 0.5 mil Fluorocarbon (PTFE), 1 mil Polyimide, 0.5 mil Fluorocarbon (PTFE).</p> <p>616 Kapton =&gt; 0.1 mil Fluorocarbon (FEP), 1 mil Polyimide, 0.1 mil Fluorocarbon (FEP).</p> <p>XL =&gt; Crosslinked.</p> <p>ETFE =&gt; Ethylene Tetrafluoroethylene.</p> <p>DL =&gt; Overlap.</p> <p>PTFE =&gt; Poly Tetrafluoroethylene.</p> <p>1 mil =&gt; 25 micrometers.</p>

#### PROCEDURE:

- 1) Sample Assembly and Installation.
- 2) Vacuum or Atmospheric Air Pressure.
- 3) Arc Tracking Initiation.
- 4) Arc Tracking Restrike.

#### ARC TRACKING INITIATION:

Objective: Manually initiate arc tracking on the wire sample.

Procedure: Raise and lower platform until arc tracking started.

Next Step: Terminate power.  
Reset power supplies to 0V.  
Test samples ready for restrike tests.

## ARC TRACKING RESTRIKE

- Objective: Ascertain minimum voltage to sustain an arc.
- Procedure: Increment voltage from 0.
- Results: Upon restrike, terminate arc by removing power.
- Log Data: Open-Circuit-Voltage, and employed current limiter.
- Calculations: Potential Short-Circuit-Current and, Volt \* Amp product.

## FUTURE INITIATION PLANS

Arc tracking did not initiate at onset of first momentary short-circuit.

Number of momentary arcs necessary to initiate arc tracking may be dependant on the intensity of the arc.

Quantify the energy necessary to initiate arc tracking by summing the energy in each arc during initiation exercises.

Use computer to log the data.

This information may determine which insulation type is least likely to start arc tracking.

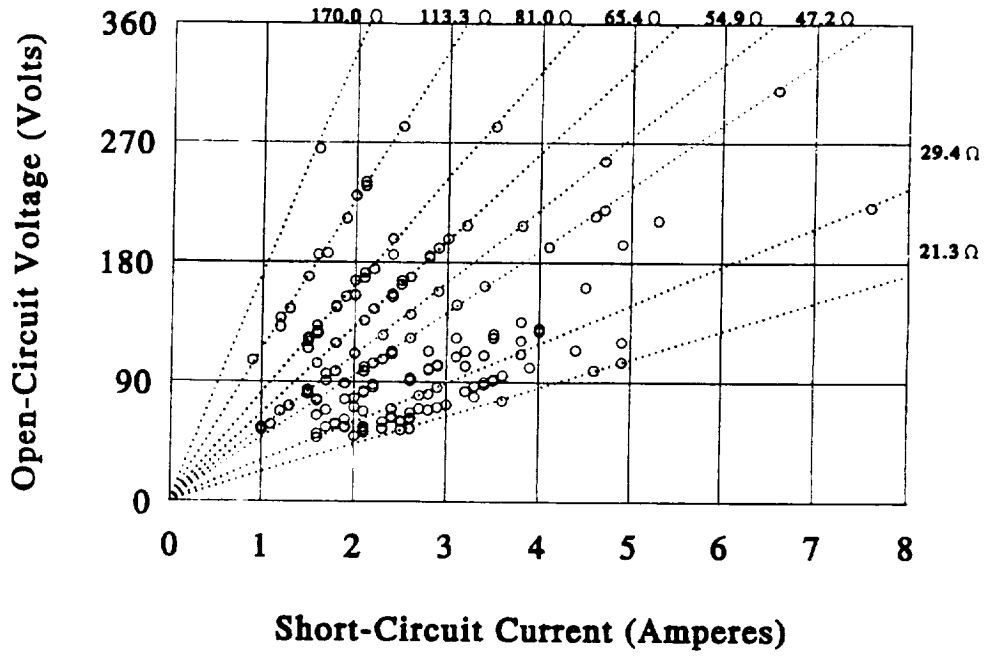
## FUTURE RESTRIKE PLANS

Monitor voltage and current characteristics of an arc.

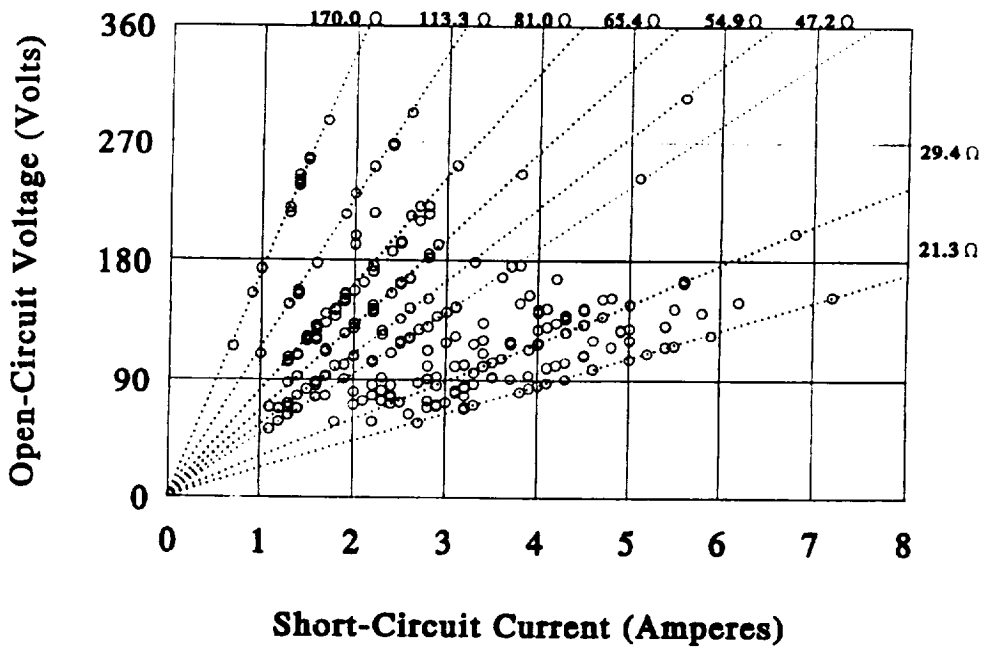
Obtain necessary pyrolysis energy.

To determine which insulation type is least likely to restrike.

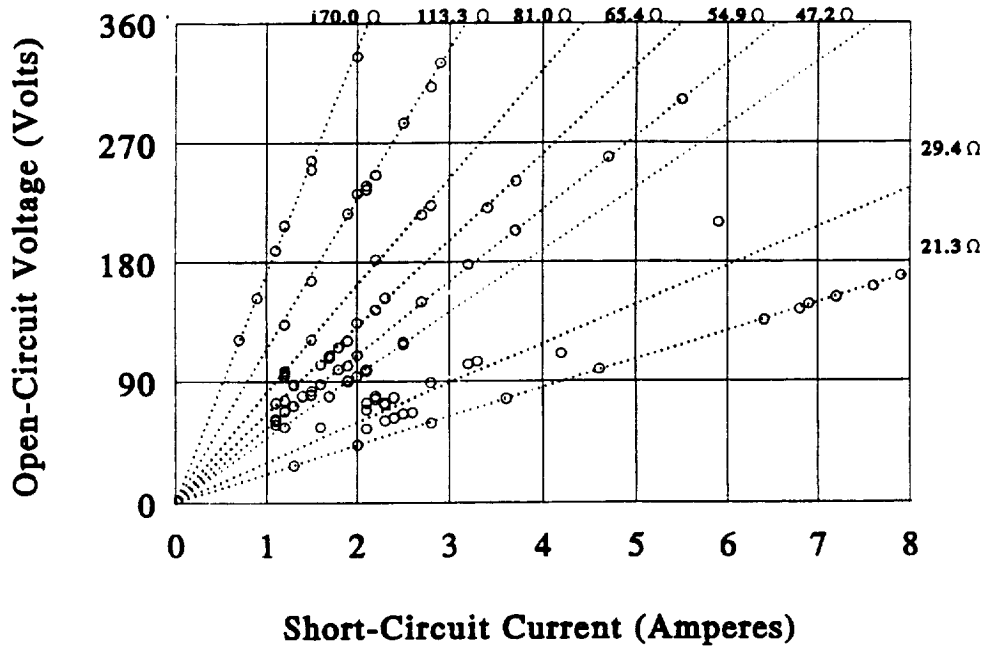
### Champlain Arc Tracking Restrike AWG 20, Vacuum



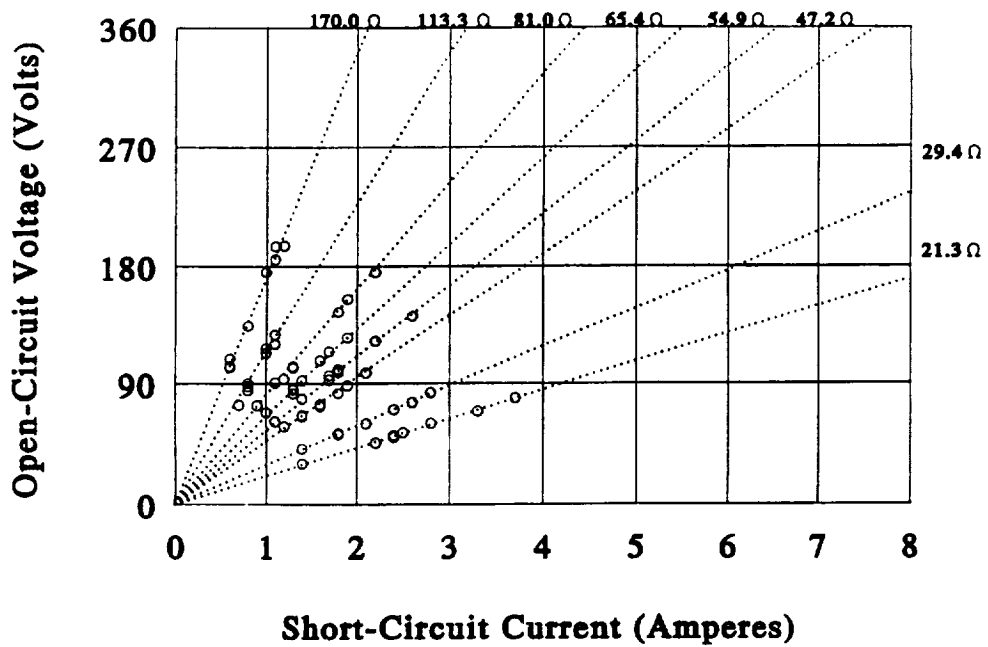
### Filotex Arc Tracking Restrike AWG 20, Vacuum



### Teledyne Therm. Arc Tracking Restrike AWG 20, Vacuum

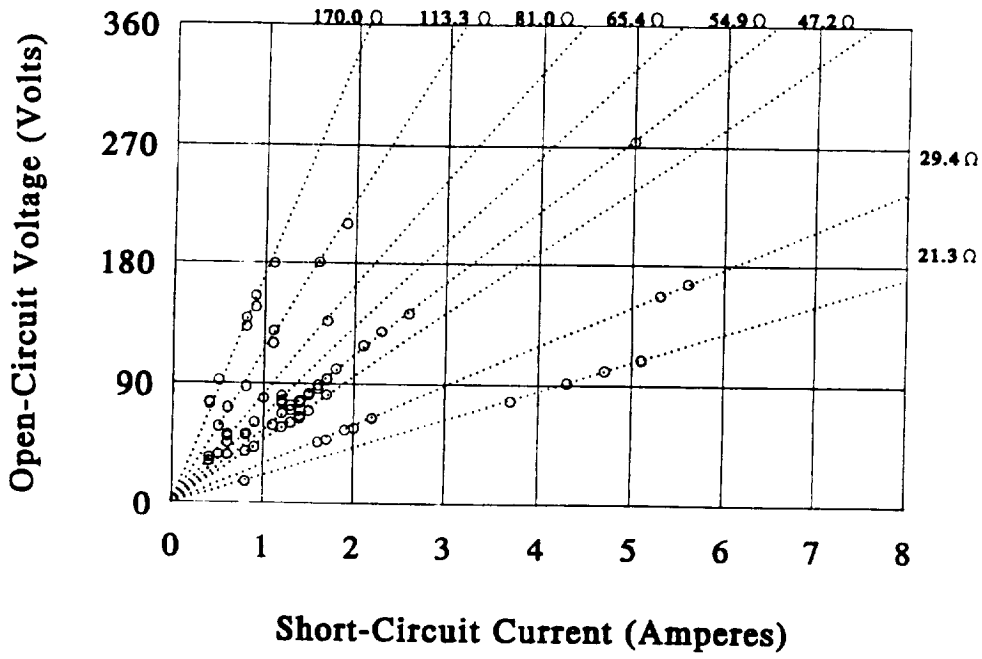


### Champlain Arc Tracking Restrike AWG 20, Air

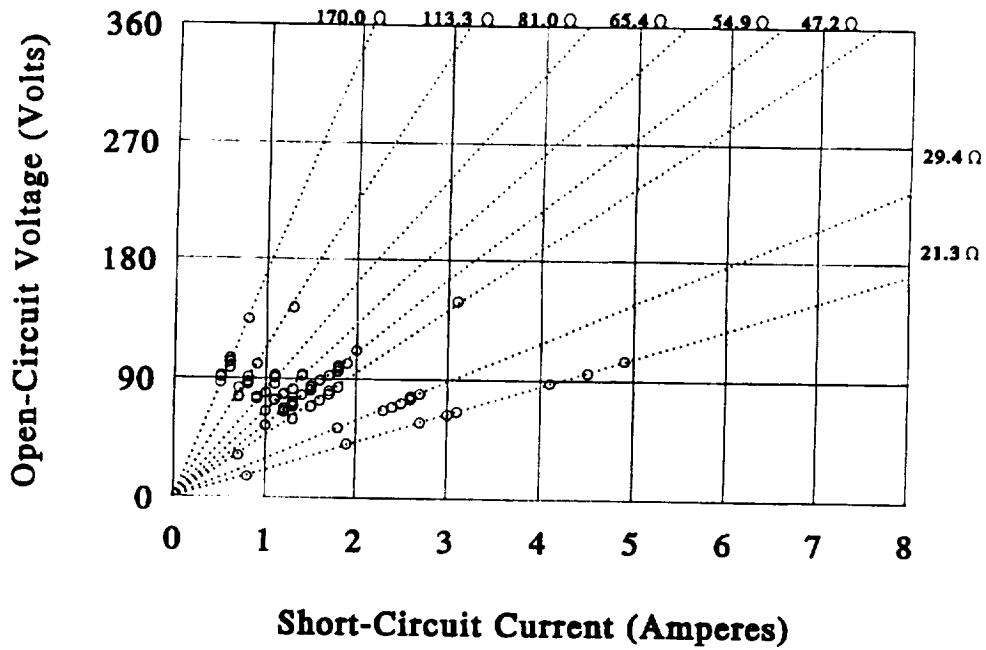




### Filotex Arc Tracking Restrike AWG 20, Air

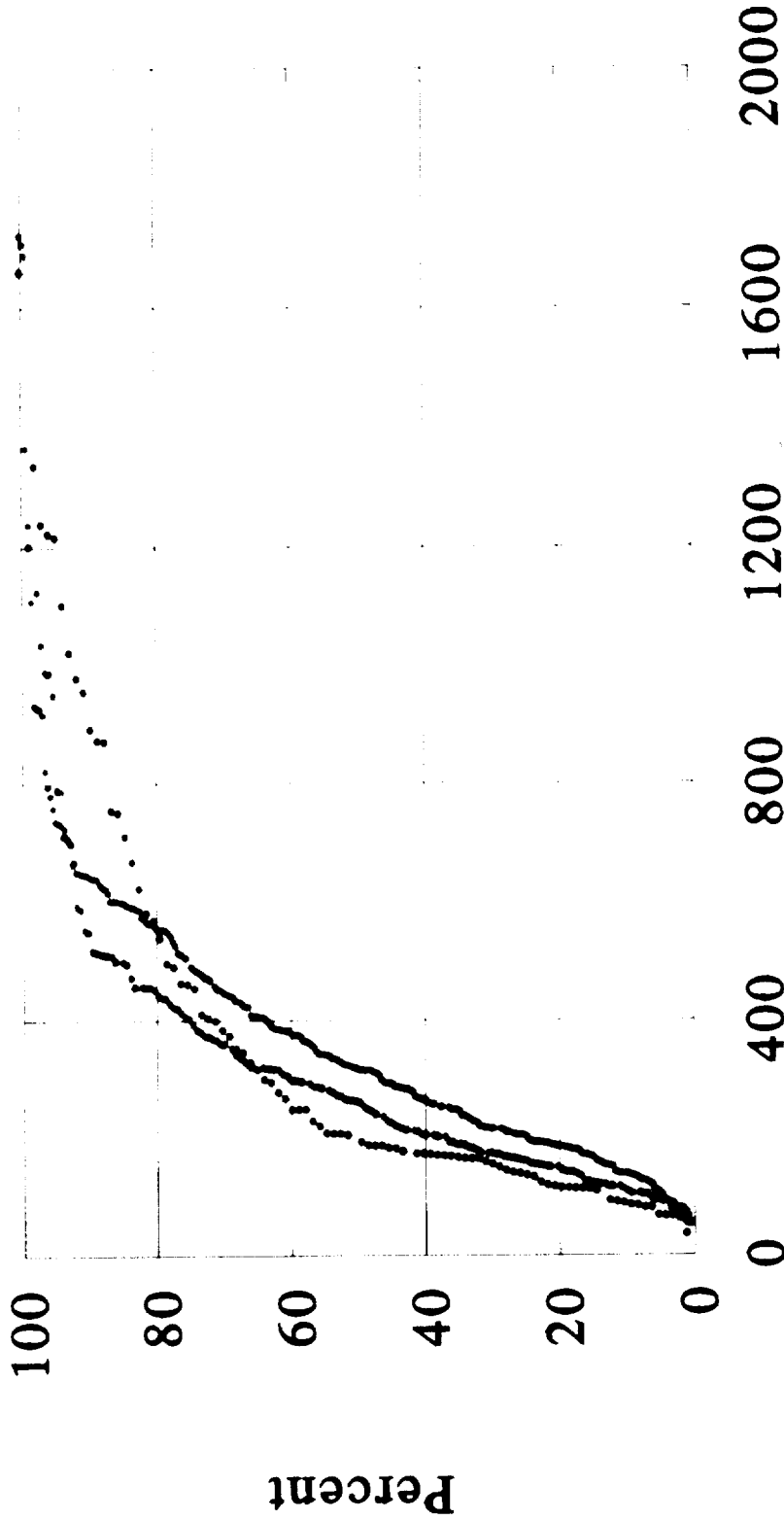


### Teledyne Therm. Arc Tracking Restrike AWG 20, Air





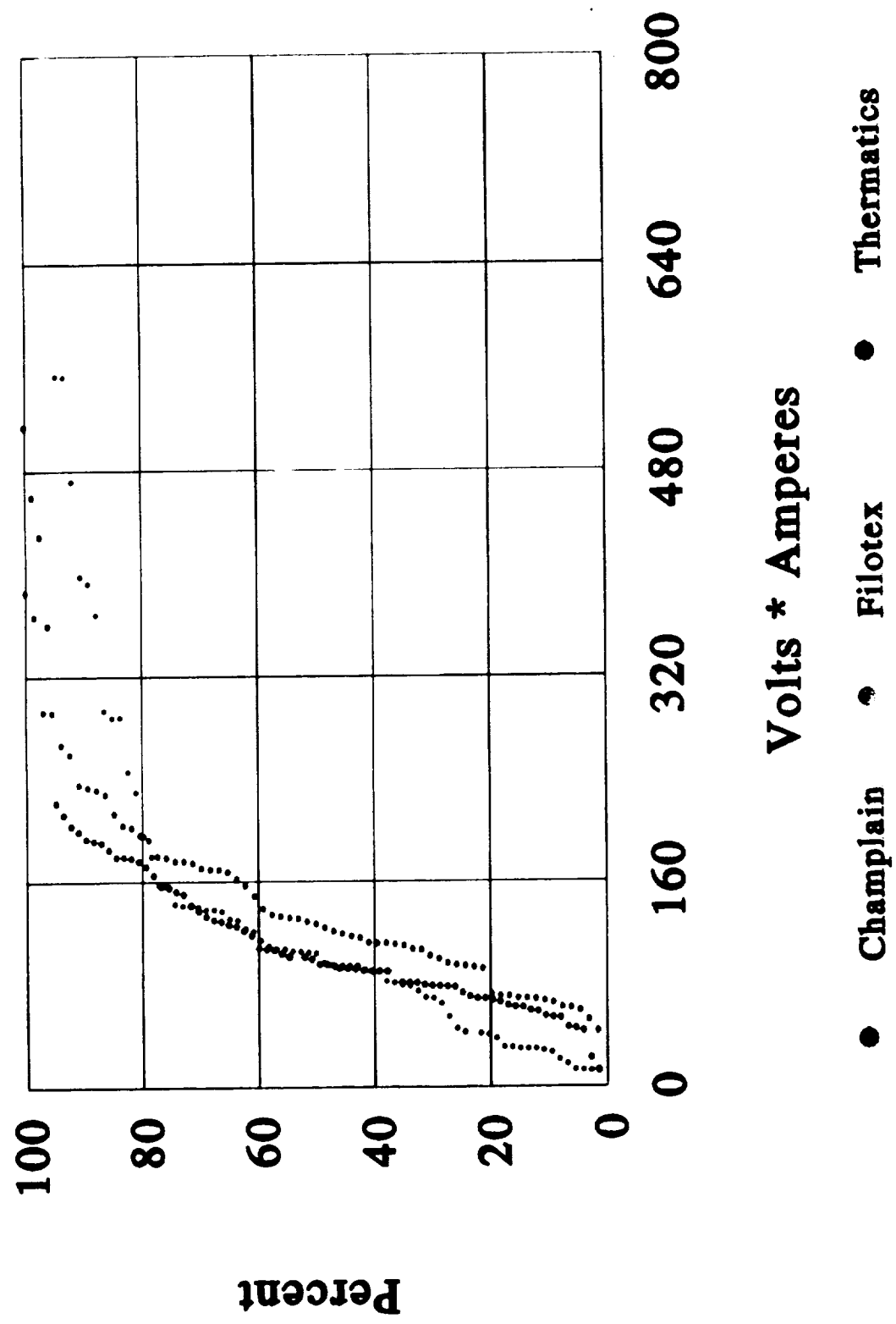
# Restrike Percentage vs. Volt\* Amp Product Vacuum Tests



● Champlain    \* Filotex    ● Thermatics



# Restrike Percentage vs. Volt\* Amp Product Air Tests



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## DISCUSSION

- \* Remnants of hexagonal, graphitic carbon residue remained.
- \* Carbon residue, not necessarily a perfect conductor (gaps).
- \* Gaps prevent current flow, for low voltage.
- \* Higher electric field strengths may exceed carbon/gap median dielectric strength.
- \* Necessary breakdown voltage may be dependant on carbon trace positioning.
- \* Joule heating results from an arc breakdown.
- \* Restrike data describes breakdown voltage and necessary available current for Joule heating.

## CONCLUSIONS

- Arc tracking tests conducted on Champlain, Filotex, and Teledyne Thermatics indicate the Filotex is least likely to arc track.
- Arc tracking occurs more readily in air than it does in vacuum.

## PLANNED ACTIVITIES

- Further testing will be conducted to consider other space application candidate wire insulation constructions.
- Future testing will be done to determine ambient temperature influence on arc tracking
- Future testing will be conducted to determine the level of Joule heating necessary for arc tracking initiation and propagation.

