Arcing Flammability Factors

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OBJECTIVE

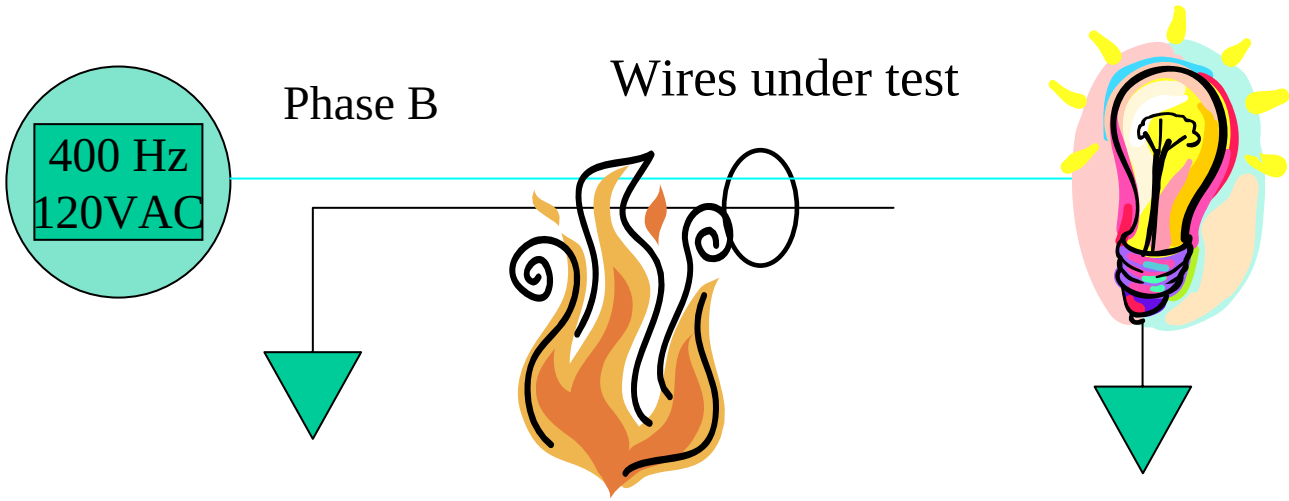
- The goal of this research is an assessment of the damage tolerance of the EWIS under the stress of aircraft fire, including the effect of variables such as contamination, material types, and circuit protection to increase or decrease the hazard potential.

Wire Types

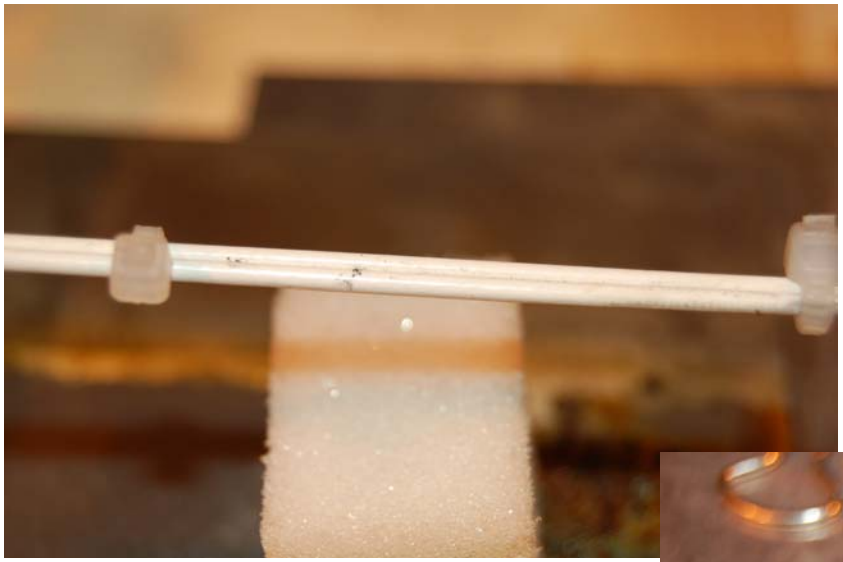
Material
Polyimide Mil-DTL-81381/11-20
PVC Mil-W-5086/1-20
PTFE AS22759/9-20
PTFE AS22759/34-16

The Carbonized Flammability Test

The set up consists of a two wire bundle where one wire is connected to a 400Hz Single phase generator, a circuit breaker and a constant light load. The other wire in the bundle is connected to the aircraft return. The power wire is monitored electrically through out the test cycle. A schematic of the test set up is shown below.



Test 6 Gnd Burn Through Mil 22759/34-16

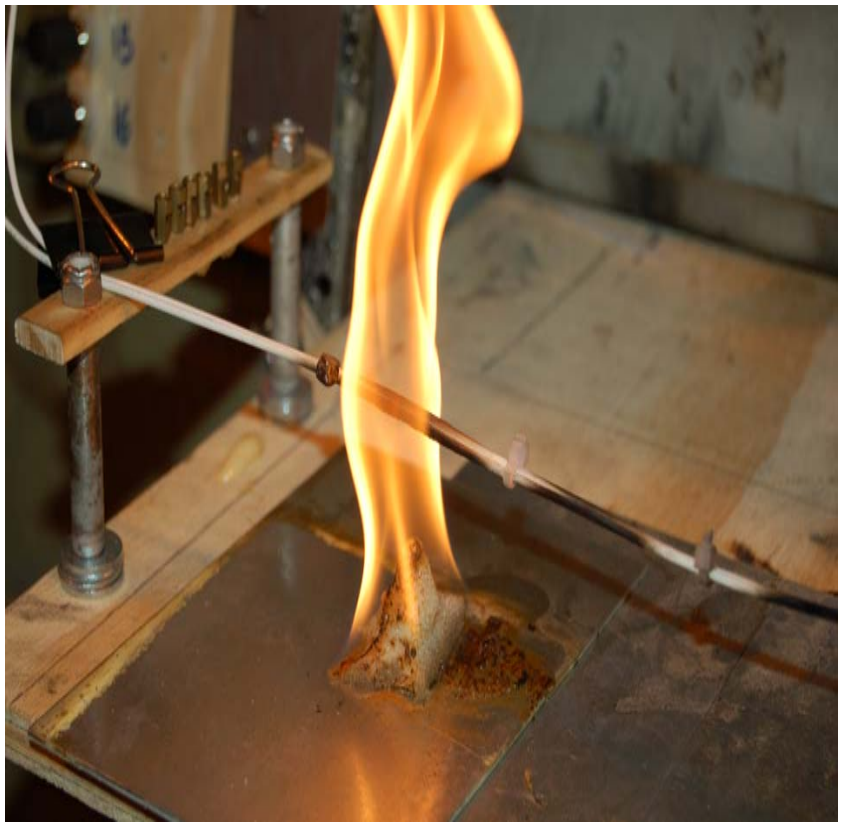


Used foam and heptane to increase the flame

No fault Detected after 10 Minutes, However after Review of Damage The conductor of the ground wire is visible through the char

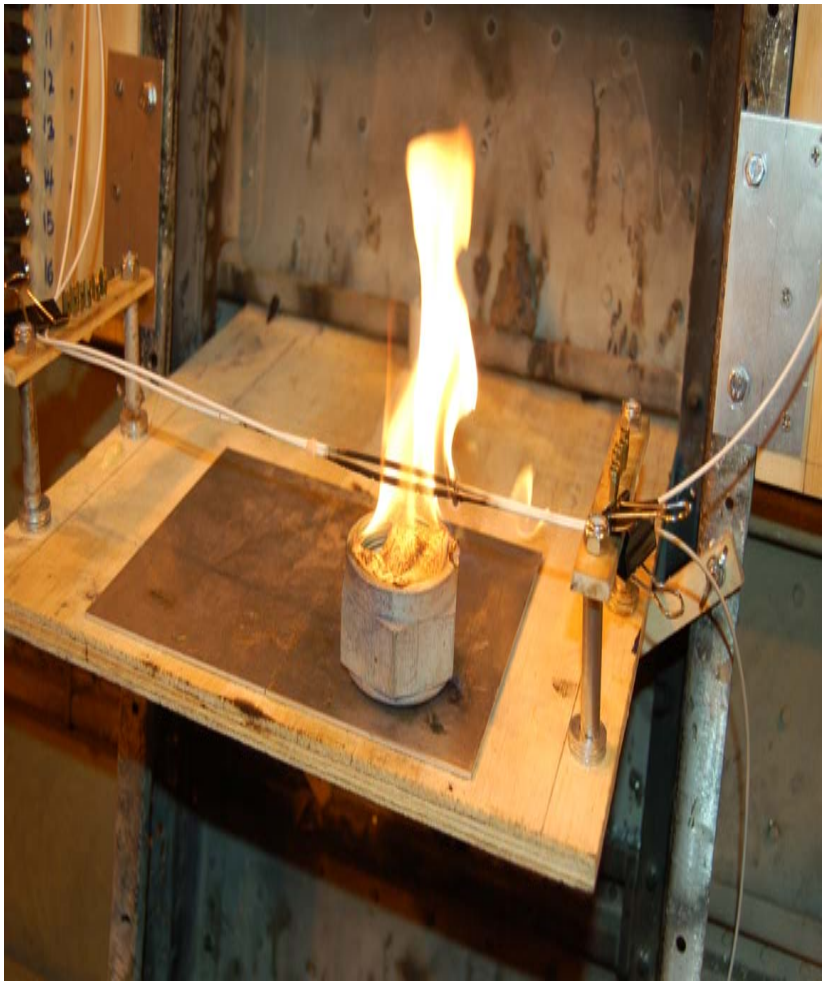
The power wire did not burn through all the way.

Test 7 Wire type Mil 22759/34-16

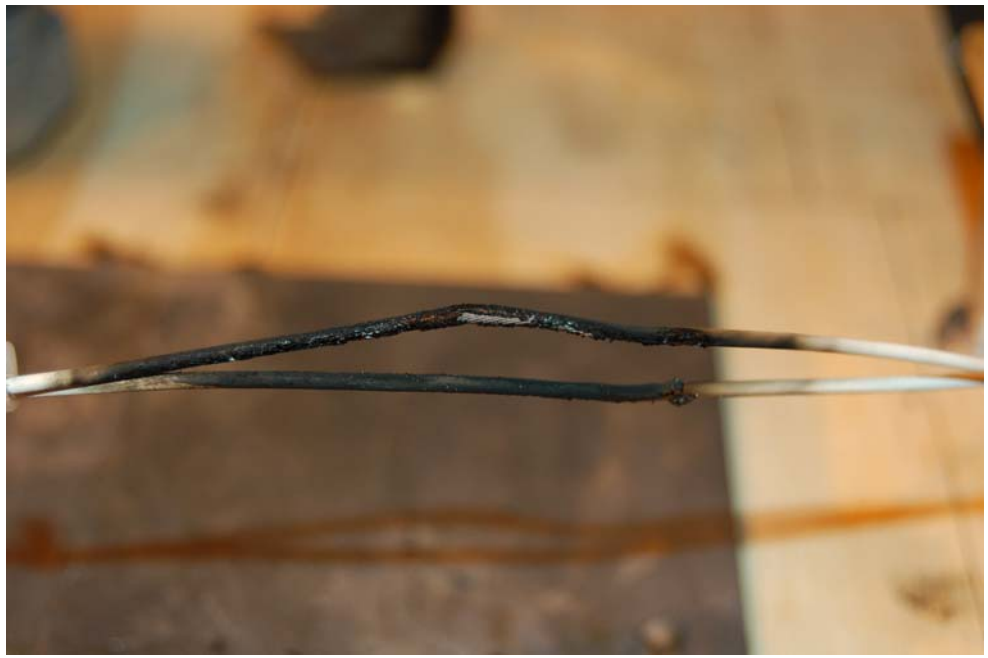


- **Wire Mil 22759/34-16**
- **Wire arced open**
- **2 minutes 50 seconds till breech**

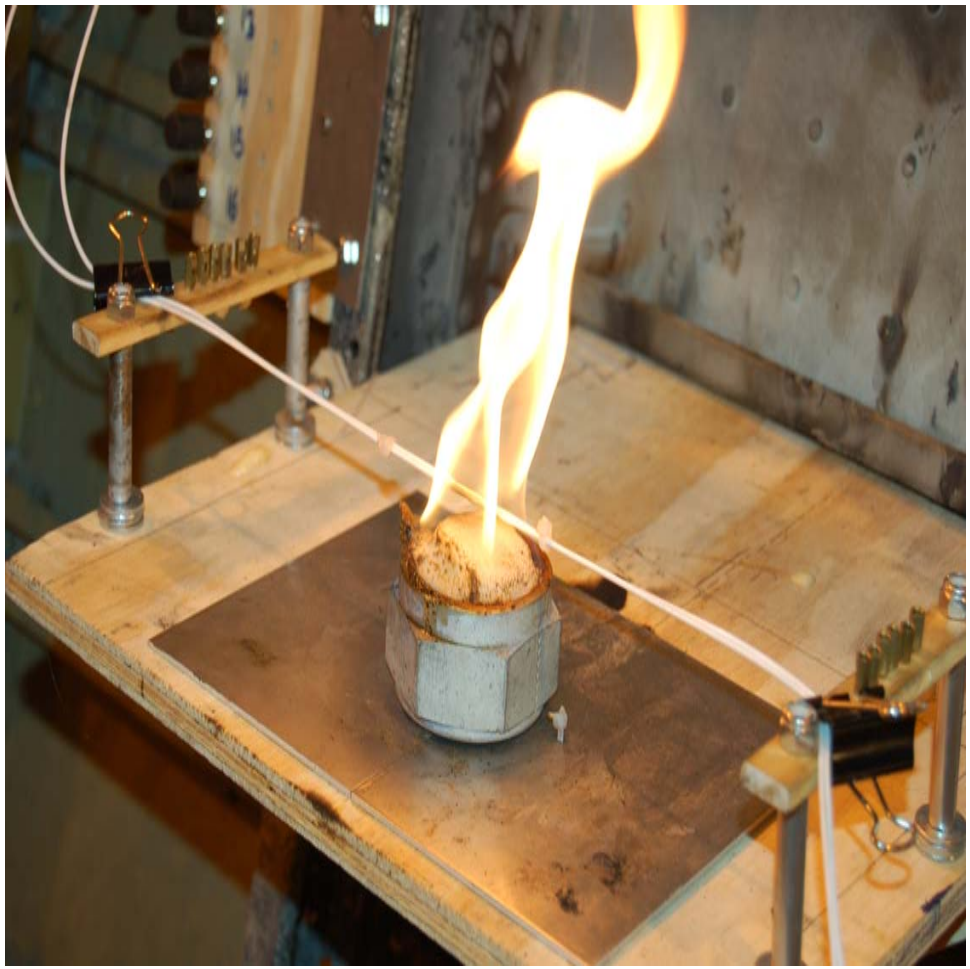
Test 8 Wire type 22759/34-16



- **Wire Mil 22759/34-16**
- **Saw presence of arcing visually, audio, and through the scope. Thermal Breaker Trip**
- **2 minutes 10 seconds first breech**



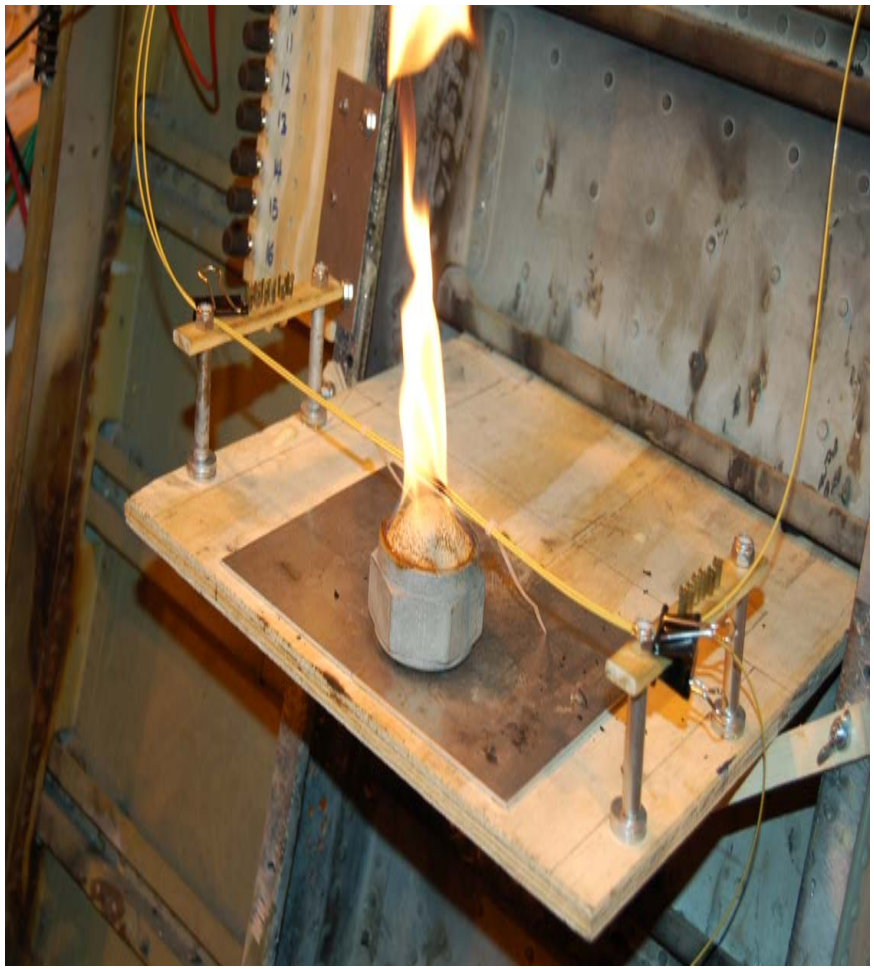
Test 9 Wire type 22759/34-16



Wire type 22759/34 –16

6 minutes 20 seconds to breech

Test 10-12,15



Mil 88381 to see what point it breaches and arc tracks

30 minutes did not go through insulation.

Summarized Carbonized Flammability Results

Material	The Carbonized Flammability Test
Mil-DTL-81381/11-20 Polyimide	NO breach after 30 minutes
PVC Mil-W-5086/1-20	45 seconds, 50 seconds
PTFE AS22759/9-20	20minutes
PTFE AS22759/34-16	2:50, 2:10, 6:20, Ground Conductor Exposed

Sources of Error

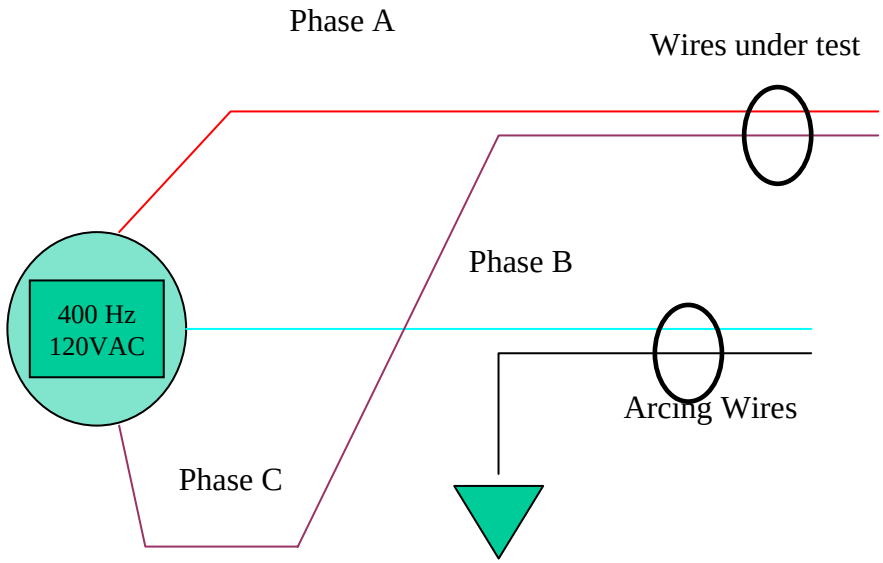
- Drafty conditions in the test cell,
- Height of the flame,
- Point of application of flame on the wire insulation
- Flame temperature
- Separation of the wires because of tie wraps failures.
- However the results do reflect the variation of conditions experienced in an actual aircraft fire and still support the overall objective of the tests, to assess the overall hazards of powered wires exposed to fire.

Observations

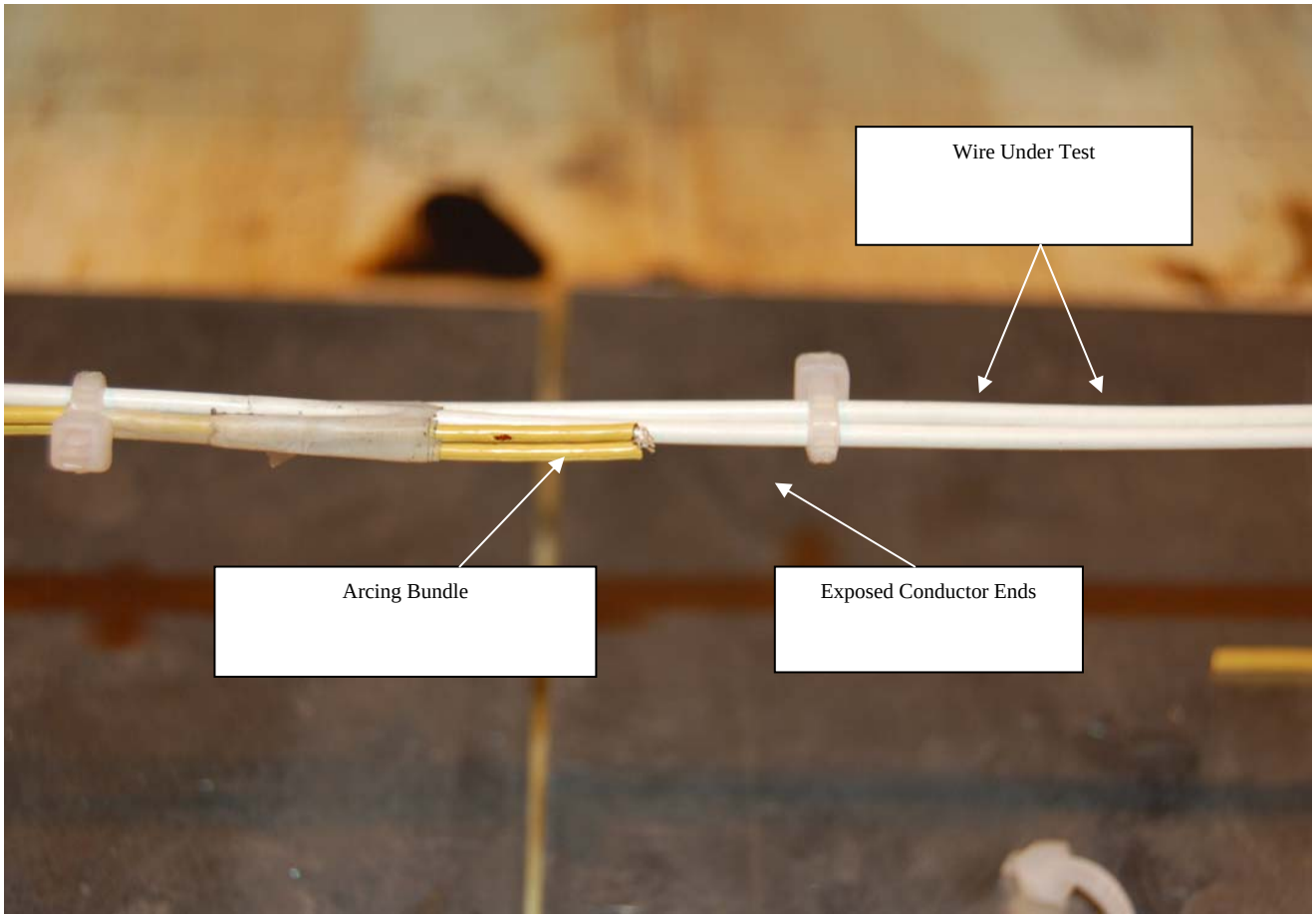
- The damage after failure on all different wire insulations except polyimide followed the same trend for all.
- The insulation on some of the wires that were not breached became stiff and discolored which can lead to cracking of the insulation.
- Conductors were exposed which can be susceptible to additional arcing from contact to other conductors, structure, and fluids.
- The polyimide was covered in carbon after removal of the flame; there was no evidence of breach of insulation to the conductor. and the insulation was discolored and stiff.

Arcing Burn- through Test

The set up consists of a two wire polyimide bundle where each wire is connected to two independent phases of the 400Hz generator with separate circuit breaker protection. The end of the wire has exposed conductors which will produce a phase to phase arcing event. The wire under test (another two wire bundle) is connected to final independent phase and aircraft power return (identical to the *Carbonized Flammability Test*) the bundle is positioned on top or adja1cent to the polyimide arcing bundle. The initiation of the arcing is done by momentarily shorting out the stripped ends of the polyimide arcing wire by an external conductor and dragging out an arc to start the event. The schematic of the test set up is shown below.



Arcing Burn- through Test



Test 21 Wire type 5086

•Wire 50861-20 (PVC)

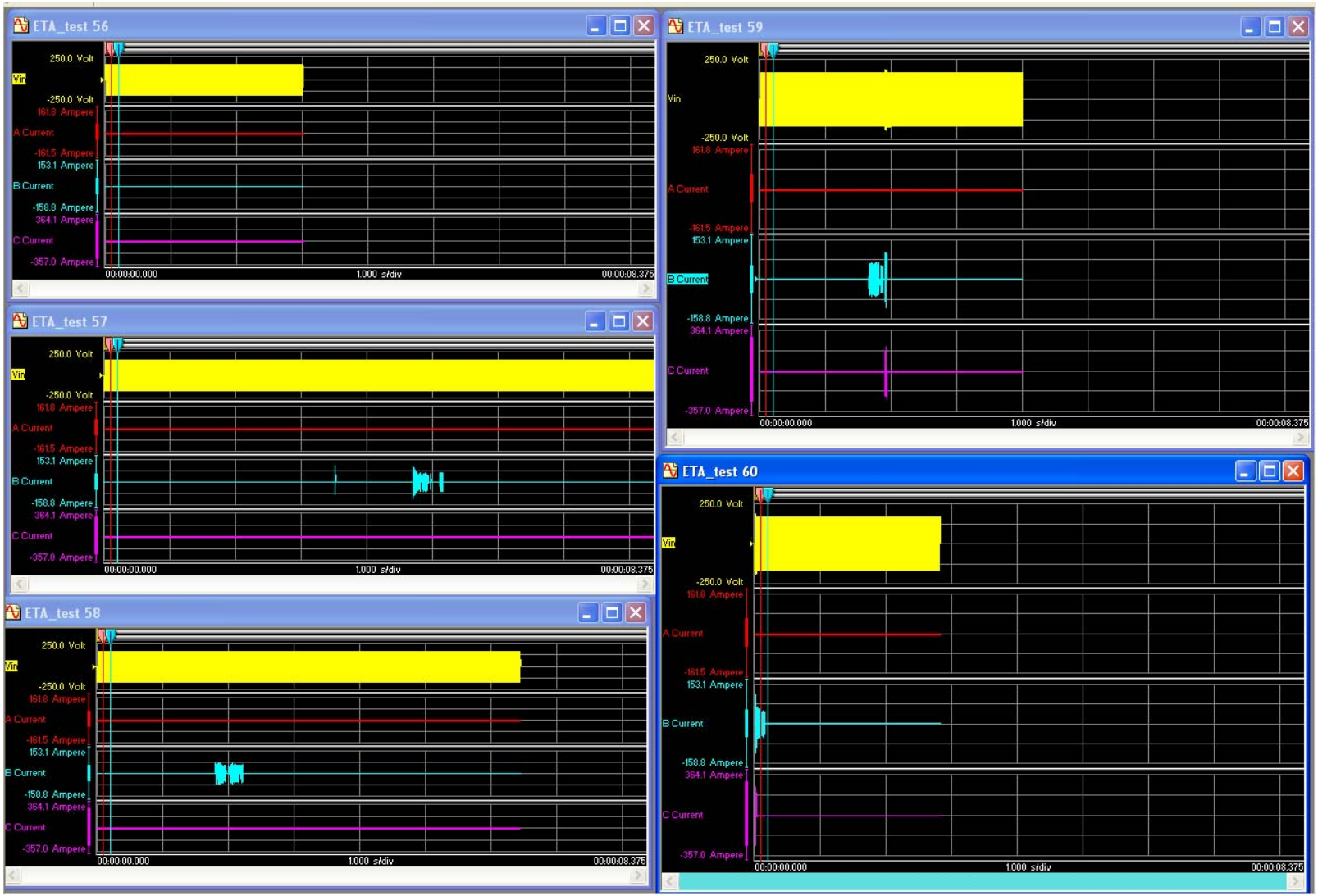
•**Phase A and GND on the 5086 wire**.

• Phase B to Ground on the Arcing Wire. Thermal Breaker B Trip. Did it Multiple times,

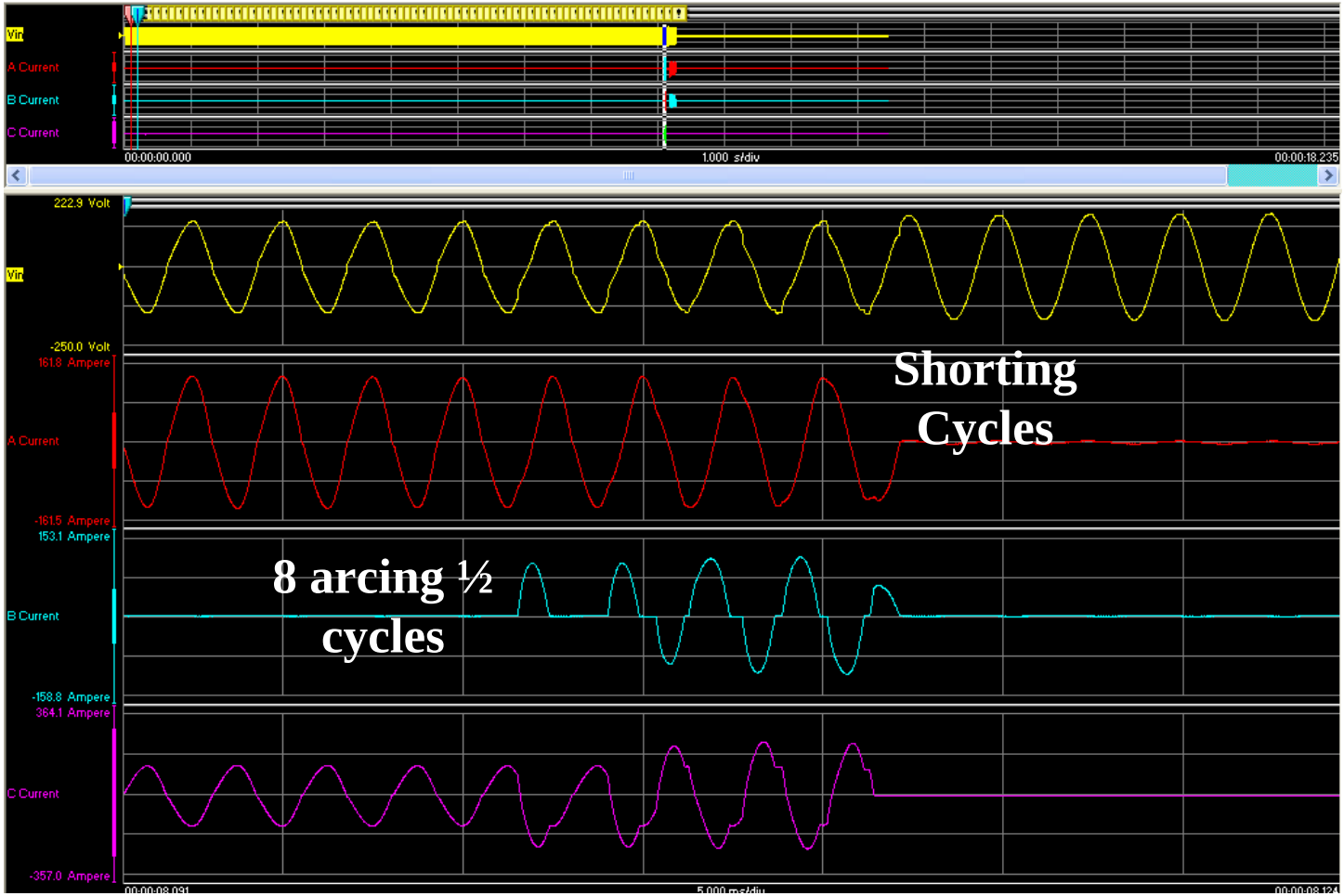
Wire Damage on Test 21 Wire type 5086

Test 22 Wire type 81381

229 Arcing ½ cycles to first breech



Counting Arcing ½ cycles

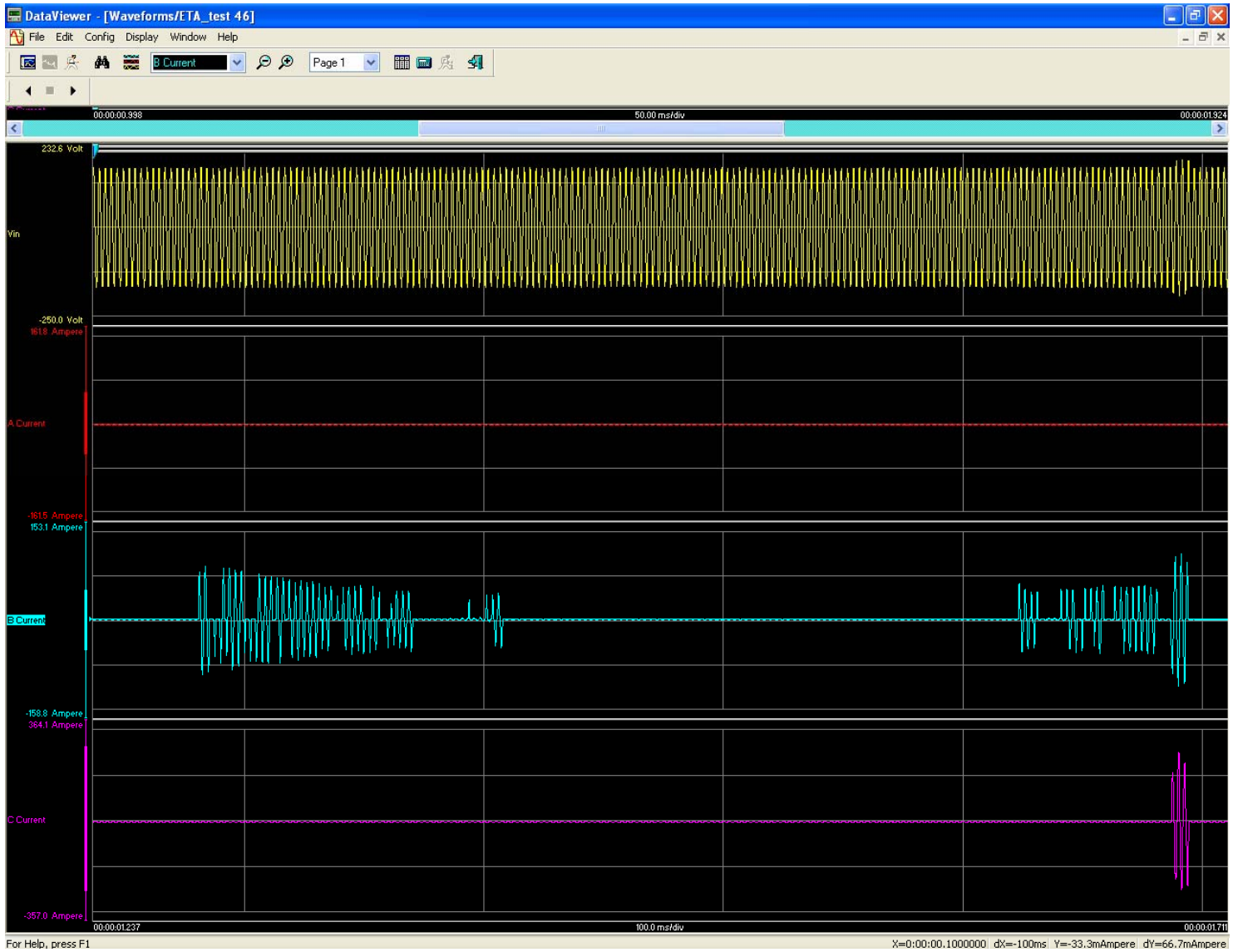


Test 19 Wire type 5086

5086 wire. Phase B to Ground on the Arcing Wire.

Burn thru and Arc over to Phase C. Thermal Breakers on A and C did not Trip.

85 Arcing ½ cycles



Test 23 Video

Test 23

Mil 81381 (Polyimide) wire. Phase B to Ground on the Arcing Wire.

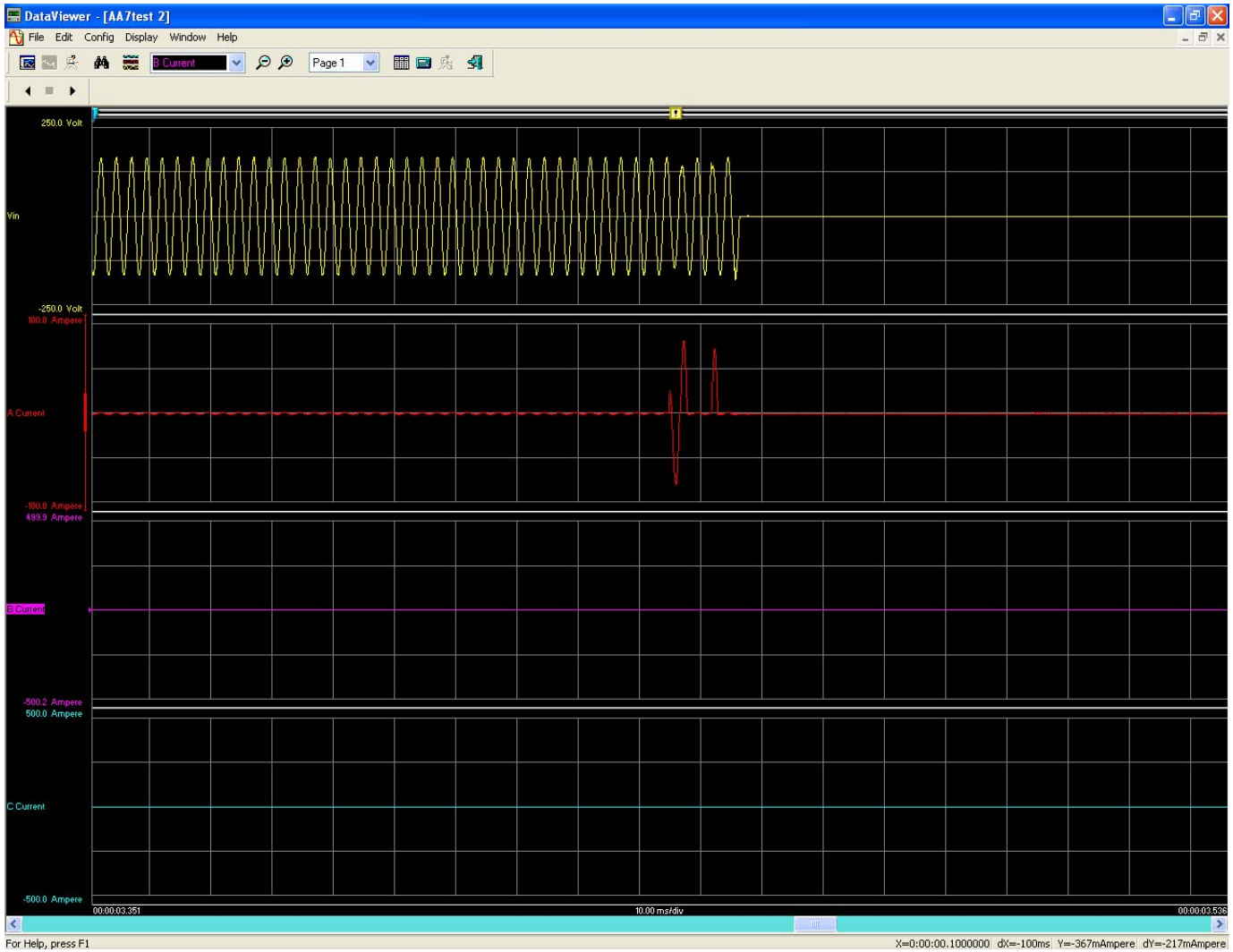
294 Arcing ½ cycles to first trip

Thermal Breaker B Trip.

Test Results Summary

Material	Test Number	Arcing Half Cycles To First Breach
Polyimide Mil-DTL-81381/11-20	Test 22	229
	Test 23	294
PVC Mil-W-5086/1-20	Test 18	Breached to Ground
	Test 19	85
PTFE AS22759/9-20	Test 24	150
PTFE AS22759/34-16	Test 25	66

Arc Fault Waveform



Sources of Error

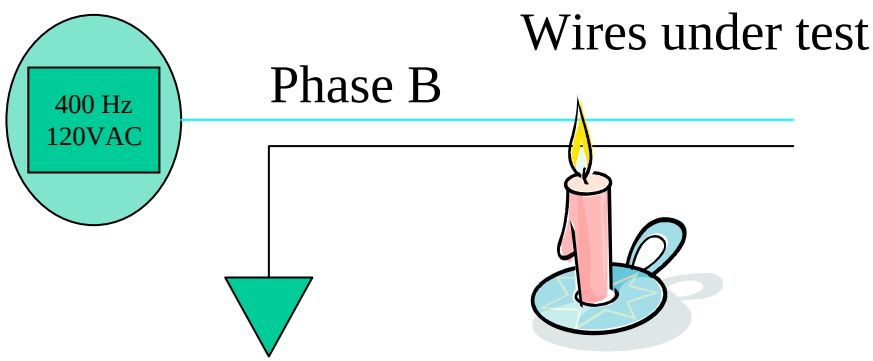
- Results varied with the placement of the Arcing wire
  - Tested bundle the time to breach was greater and the damage effect was less than when the arcing wire on the side of the test bundle
- The adhesive tape used to hold the two bundles together became flammable during some tests creating additional damage to the insulation.
- The arc tracking characteristics of polyimide cause the arc event not to be in a constant position to the wire tested.

Observations

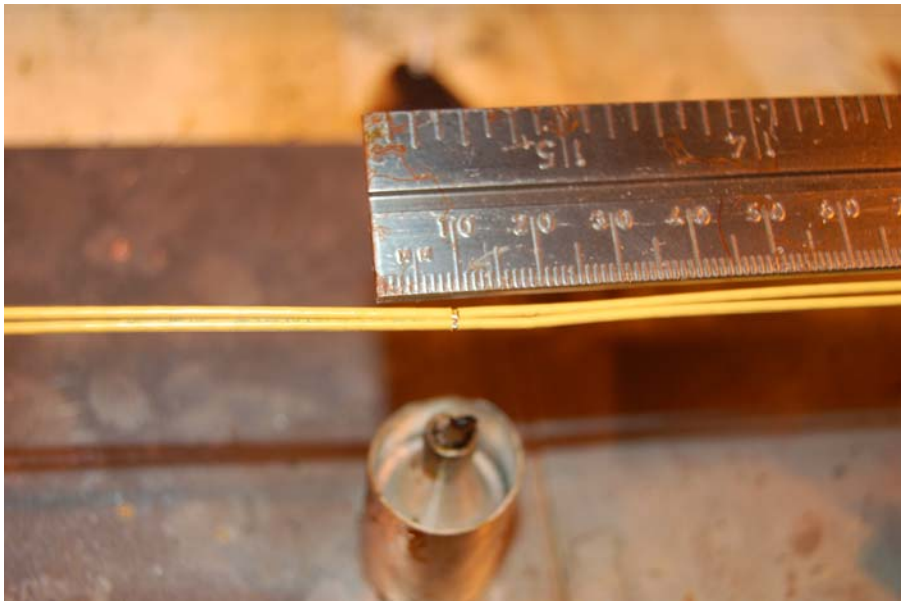
- Arc Fault Circuit Breaker
  - AS5692 requires an AFCB to trip with a maximum of 8 arcing ½ cycles in a 100 msec rolling window
- Resetting the circuit breakers increased damage
  - Resetting circuit breaker caused a breech to additional wires
- Thermal circuit breakers tripped during phase to phase breech

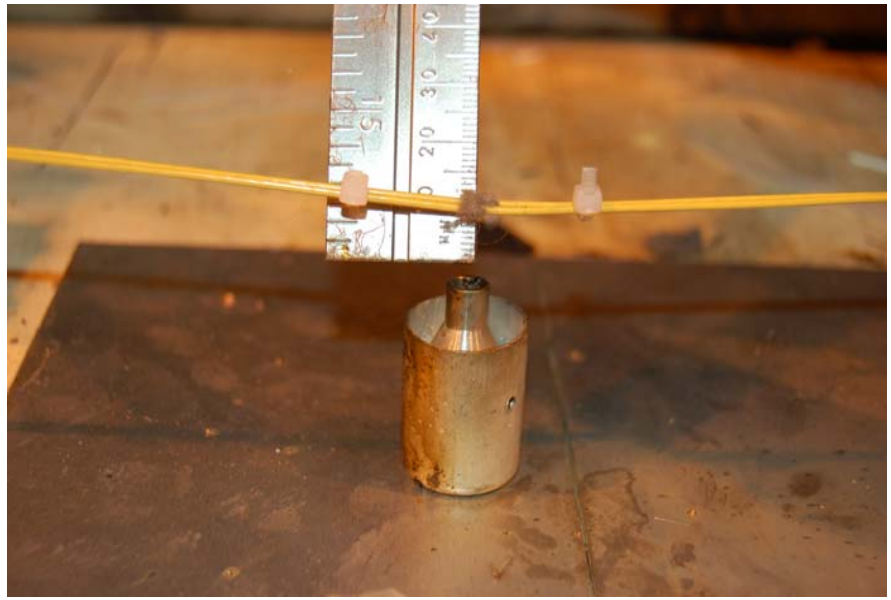
The Contamination Arcing Test

The objective of this test is to determine if the dust and lint contamination assists the creation of a carbonized path to start an arcing event in the presence of fire. A two wire bundle is prepared by creating a 1mm gap in the insulation exposing the conductor on each of the wires. A small amount of dust and lint (1 to 2mm) is placed at the exposed conductor area of the bundle. The bundle under test is powered by two independent phases of the generator or a single phase and aircraft return.



Sample Preparation





For the pristine samples the flame was applied for over 10 minutes with no arc over flash recorded. The time was dependant on the fuel extinguishing from the candle.

Lint Video

Results

- For the dryer lint the time to Carbonization was 51 seconds
- For the aircraft lint the time was 1:36 seconds.

Sources of Error

- The lint and debris used can vary greatly in content and flammability.
- The consistency or how densely lint was packed varied
- The flame position varied during the experiments

Observations

- The bundle without the lint and debris did not arc over
- The flame by it self did not provide sufficient ionization to cause arcing along
- The debris cut the arcing over time to under a minute

Summary Conclusions

- The Heptane flame did not generate a sufficiently high flame temperature for the carbonization of the polyimide insulation to create an arc over event.
- The Heptane flame does not provide sufficient ionization of the air between exposed conductors to facilitate arcing.
- A wire breech during a fire as well as the time to breach is dependent on the flame temperature and the type insulation material.
- The time to breach was significantly faster with arcing than open flame. The temperature during an arcing event, while much higher than the n-Heptane flame, still required repeated arcs and reset of the circuit breakers to breach the wires.
- If an electrical fault does occur and the circuit breakers are reset, it can lead to greater hazard potential of the EWIS.
- Arcing events are capable of compromising a greater range of material types due to the range of higher temperatures these materials can experience during the event..

General Recommendations

- Study the effects of lint and dust on the EWIS.
- Study the flammability properties of contaminants on the EWIS.
- Study the chemical properties of lint and dust from aircraft.

Thank You

Questions