Flammability of Aircraft Insulation Blankets Subjected to Electrical Arc Ignition Sources

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April 2000

DOT/FAA/AR-TN00/20

U.S. Department of Transportation
Federal Aviation Administration

NOTICE

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Technical Report Documentation Page

1. Report No. DOT/FAA/AR-TN00/20	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle FLAMMABILITY OF AIRCRAFT INSULATION BLANKETS SUBJECTED TO ELECTRICAL ARC IGNITION SOURCES		5. Report Date April 2000
		6. Performing Organization Code
7. Author(s) Patricia Cahill		8. Performing Organization Report No.
9. Performing Organization Name and Address Federal Aviation Administration Airport and Aircraft Safety William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Office of Aviation Research Washington, DC 20591		13. Type of Report and Period Covered Technical Note
		14. Sponsoring Agency Code ANM-114
15. Supplementary Notes		

16. Abstract

In the fall of 1998, the Federal Aviation Administration (FAA) initiated a program of intense testing, i.e., full-scale testing, intermediate testing, bench-scale testing, and electrical ignition testing on thermal acoustical insulation. This work was prompted by several factors related to current fire test requirements, including the crash of the Swissair MD-11 off the coast of Canada, and the failure of an industry fire test standard called the cotton swab test to characterize the flammability characteristics of a certain foam and fiberglass cover material. Electrical testing was an important part of this program due to the number of reported incidents involving flame spread on thermal acoustical insulation blankets caused by electrical failures such as short circuits. The thermal acoustical insulation films tested in this program were polyimide, metallized and nonmetallized polyester poly (ethylene terepthalate) (PET) and metallized poly (vinyl fluoride) (PVF). Each of these materials was used to fabricate test blankets with 0.42 pound per cubic foot (pcf) fiberglass batting. The test blankets were subjected to 115- and 208-volt electrical arcing tests. This same testing was performed on these blankets with a corrosion inhibiting compound (CIC) sprayed on them. The data showed that the metallized PET blankets ignited with significant flame spread at both voltages with and without CIC. The polyimide and metallized PVF blankets did not ignite at either voltage when tested plain or with CIC application. The plain PET blankets ignited at both voltages, with minimal flame spread, and the fire self-extinguished within seconds. When tested with CIC at 115 volts, flaming in the seam area occurred but self-extinguished within seconds. No ignition occurred at 208 volts.

17. Key Words Thermal acoustical insulation blankets, Electrical arcing, Corrosion inhibiting compound (CIC)		18. Distribution Statement This document is available to the public through the National Technical Information Service (NTIS), Springfield, Virginia 22161.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 13	22. Price N/A

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INTRODUCTION

PURPOSE.

The purpose of this report is to present the results of electrical arcing tests performed on aircraft thermal acoustical insulation blankets.

BACKGROUND.

In 1996, the Federal Aviation Administration (FAA)-sponsored International Aircraft Materials Fire Test Working Group formed an ad hoc task group for the purpose of conducting vertical flammability round-robin testing on thermal acoustical insulation films and blankets and to evaluate a cotton swab test method. A report was issued in September 1997 (DOT/FAA/AR-97/58, Evaluation of Fire Test Methods for Aircraft Thermal Acoustical Insulation). The report concluded that an industry standard called the cotton swab test was a more reproducible test than the mandated vertical flammability test. This was especially apparent for a particular grade of metallized polyester poly (ethylene terepthalate) (PET) film, which passed the vertical test most of the time but propagated fire consistently when subjected to the cotton swab test. As a result of this work, the cotton swab test was incorporated into the Aircraft Materials Fire Test Handbook, scheduled for release in 2000. While the cotton swab test proved itself to be a better flammability test than the vertical test for thermal acoustical insulation, the Working Group felt that further work was needed.

In early 1998, an in-service foam and fiberglass backing were found to be flammable when subjected to testing other than the vertical and cotton swab test. This, along with the Swissair MD-11 crash on September 3, 1998, prompted the FAA to undertake a program of intense testing, i.e., full-scale testing, intermediate testing, bench-scale testing, and electrical ignition testing in order to develop a comprehensive flammability test method for thermal acoustical insulation.

Electrical ignition testing was an important part of the test program due to the number of confirmed incidents involving electrical arcing and flame spread on the thermal acoustical insulation. Some of these incidents are described in the report mentioned above. This testing was conducted for the purpose of evaluating whether arcing events can ignite thermal acoustical insulation blankets. The circuit breakers and the wire insulation materials were not evaluated in this program.

DISCUSSION

DESCRIPTION OF MATERIALS.

Four film/fiberglass assemblies were tested:

- Polyimide film/0.34 pound per cubic foot (pcf) fiberglass – nylon scrim
- Metallized (PET) film/0.42 pcf fiberglass—nylon scrim
- Plain (PET) film/0.42 pcf fiberglass—polyester scrim
- Metallized poly (vinyl fluoride) (PVF) film/0.34 pcf fiberglass—polyester scrim

Different fabricators supplied the test blankets, which were 16 inches wide and 12 feet long. All samples were sewn around the ends.

TEST FIXTURE AND POWER SUPPLY.

The tests were conducted in a cylindrical section of a DC-10 fuselage. The test fixture was three frames wide (each frame width is about 16 inches) and about 12 feet high and was constructed of an aluminum alloy (see figure 1).

The power supply was a Hobart™ ground power cart rated at 60 KVA. It is a 3-phase, 400-cycle generator. The generator supplies 208 volts phase-to-phase and 115 volts phase-to-ground. Each phase (wire) was connected to a 15-amp aircraft circuit breaker. One wire was connected to the load side of each breaker. The ends of these three wires were stripped and used for arc initiation. The test fixture was grounded to the power supply.

DESCRIPTION OF TESTS.

115 VOLT TESTING. A test blanket was placed in a frame of the test fixture such that it was in contact with the ribs on both sides of the frame. The blanket was then subjected to the effects of electrical arcing at 115 volts. This was accomplished by bringing the exposed (stripped) end of one hot wire into contact with the grounded test fixture (see figure 2). The contact of the wire with the structure was made in such a manner to create ticking faults. Ticking faults are intermittent metal-to-metal events, such as conductor-to-conductor or conductor-to-structure, that result in the discharge of sparks and arcing events. This type of arc initiation was done in order to prevent a dead short circuit (bolted fault) that would have tripped the circuit breaker. While arcing events may be "point" sources of heat, the energy released in the arc may create localized temperatures in excess of 10,000°F.

208 VOLT TESTING. In this series of tests, the blankets were installed in the test fixture in the same manner as above. Arcing events were initiated by bringing the exposed end of one hot wire into intermittent contact with the exposed end of another hot wire that was intertwined in a ten-wire bundle and attached to the blanket (208 volts phase-to-phase) (see figure 3).

TESTING WITH CORROSION INHIBITING COMPOUND. The inadvertent transfer of corrosion inhibiting compound (CIC) from the aircraft skin to the blankets may occur during maintenance operations or replacement of blankets. Dinitrol AV 8™, a newer CIC, which dries hard (not tacky) when compared to older formulations, was sprayed across a 16- by 12-inch area on each type of test blanket. This product contains 50% to 60% naptha (petroleum) as a carrier and has a flash point of > 47°C per the P/M Closed Cup Test Method. The blankets were tested at both 115 and 208 volts approximately 1½ hours after spraying (dry). CICs are considered a conservative representation of other types of contamination (e.g., grease or dust) that may occur in service.

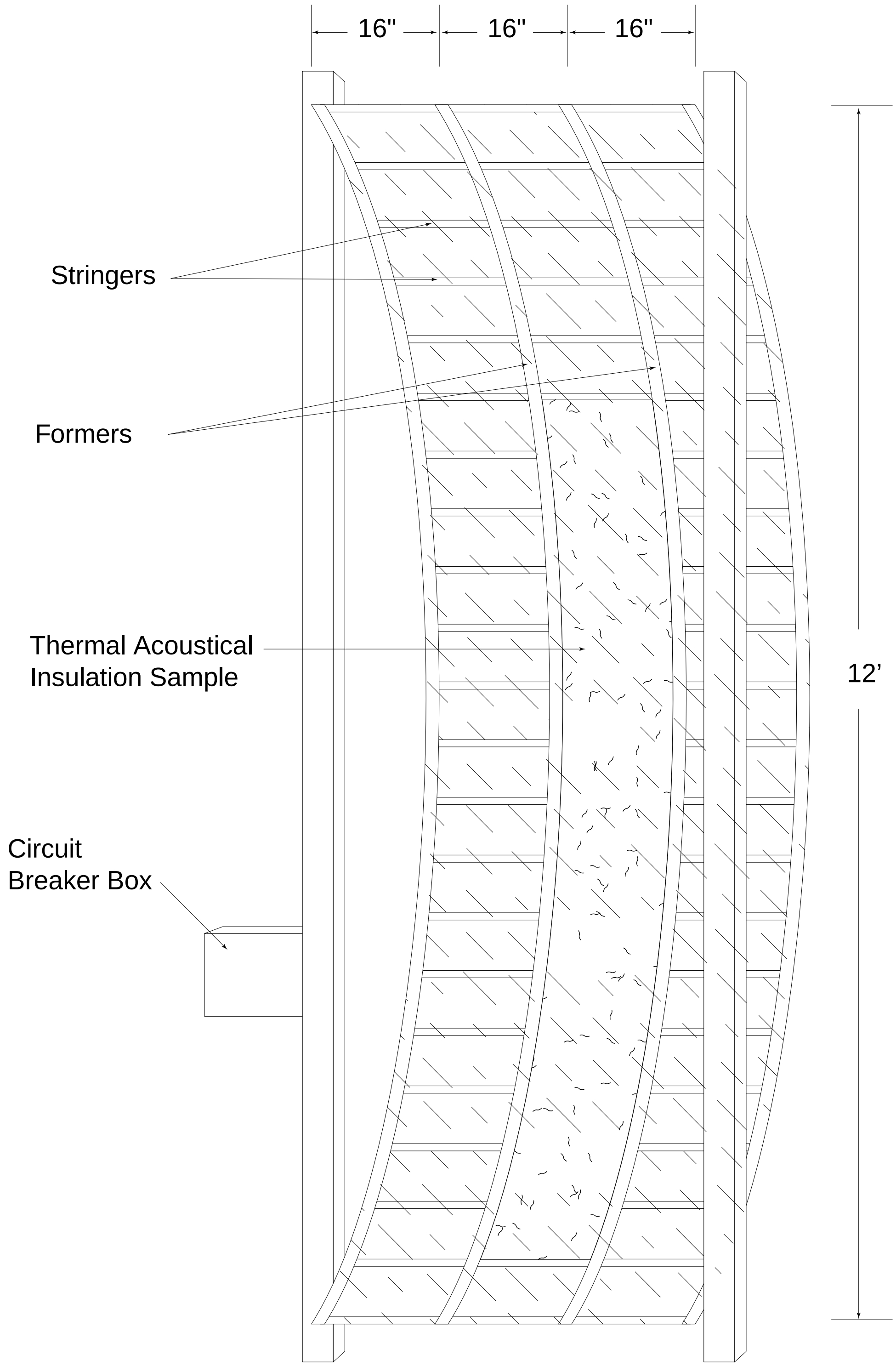

FIGURE 1. TEXT FIXTURE

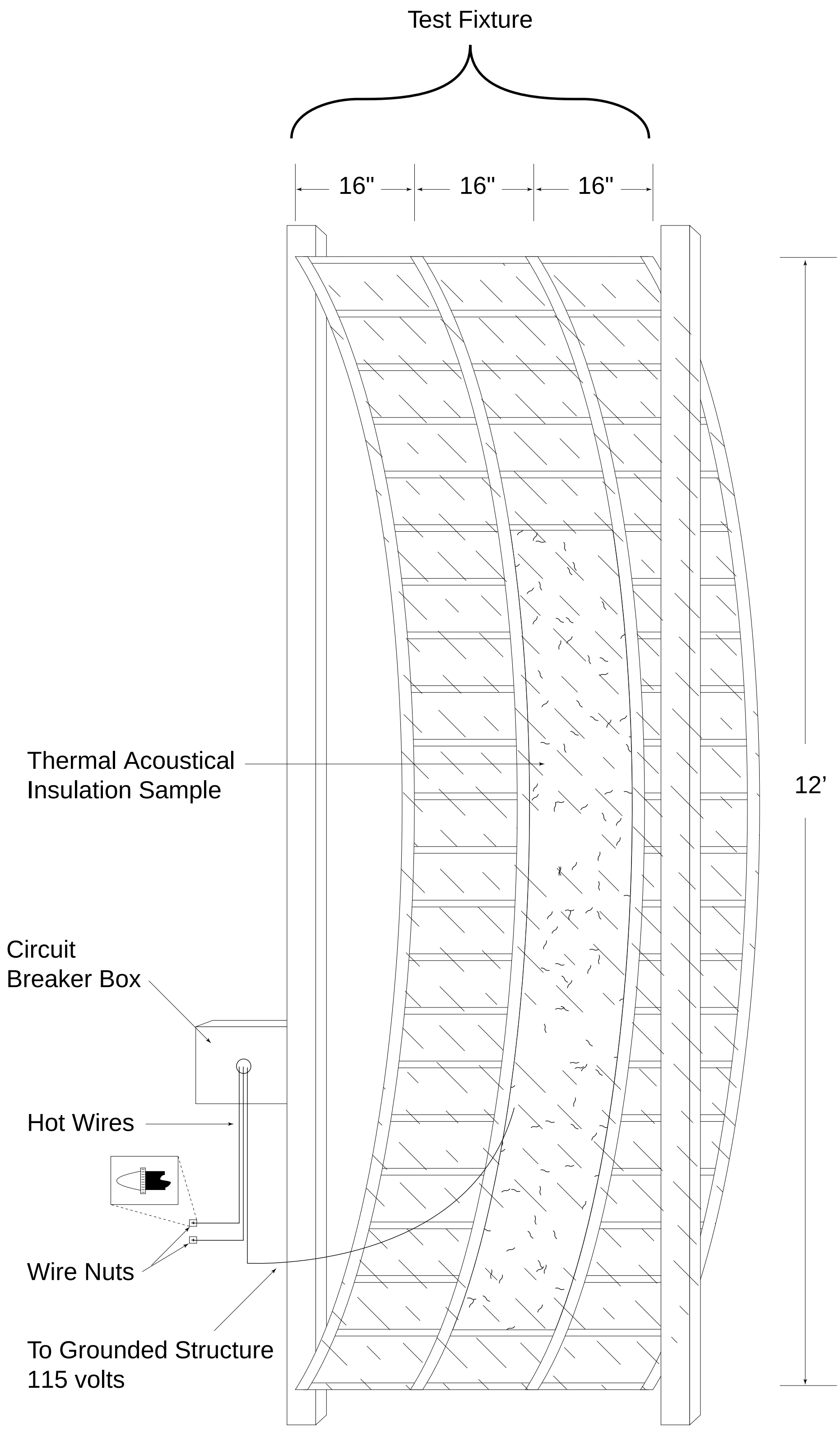

FIGURE 2. 115 VOLT ARCING TEST

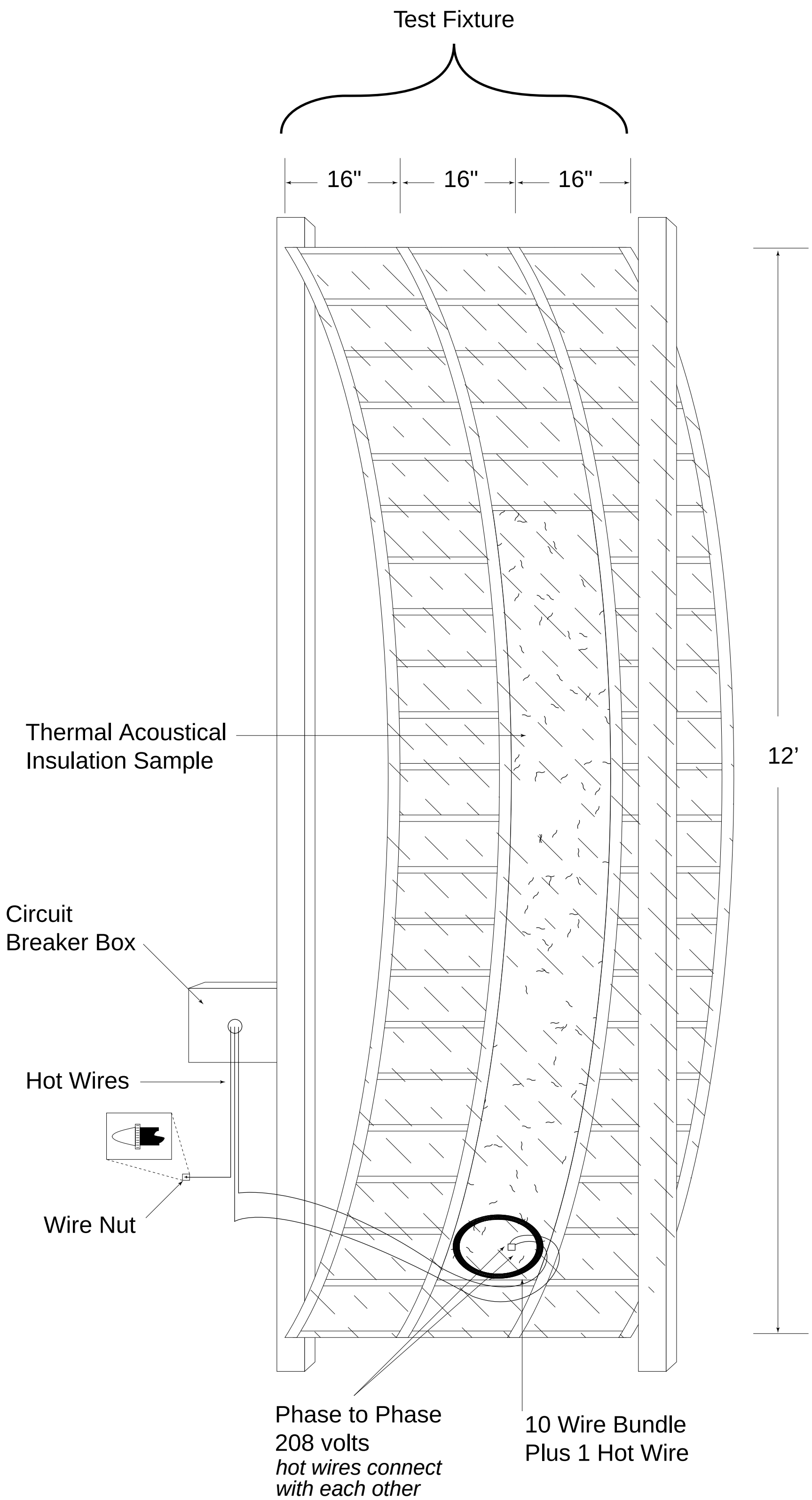

FIGURE 3. 208 VOLT ARCING TEST

TEST RESULTS

Tables 1 and 2 summarize the electric arc test results on insulation blankets without and with CIC spray, respectively.

TABLE 1. ELECTRICAL ARCING TESTS ON UNSPRAYED BLANKETS

Blanket	115 Volts	208 Volts	Notes
Polyimide	No ignition	No ignition	• Charring of film and crater formation in fiberglass (both voltages)
Metallized PET	Ignition: blanket consumed	Ignition: blanket consumed	• Flame propagated and consumed the blanket (both voltages)
Plain PET	Ignition: seam area, self-extinguished	Ignition: self-extinguished	• Slightly longer sustained burning in seam area (115 volts) than in middle of blanket (208 volts) • Primarily shrinkage of film cover • Crater formation in fiberglass (both voltages)
Metallized PVF	No ignition	No ignition	• Shrinkage of film cover • Crater formation in fiberglass (both voltages)

TABLE 2. ELECTRICAL ARCING TESTS ON BLANKETS SPRAYED WITH CIC

Blanket	115 Volts	208 Volts
Polyimide	No ignition	No ignition
Metallized PET	Flame spread, blanket ~50% consumed	Flame spread, blanket ~75% consumed
Plain PET	Small flaming area at the seam, self-extinguished	No ignition
Metallized PVF	No ignition	No ignition

DISCUSSION OF TEST RESULTS

Referring to table 1, it can be seen that the polyimide and metallized poly (vinyl fluoride) (PVF) blankets did not ignite when subjected to multiple arcing events at either 115 or 208 volts. The polyimide film charred in those areas struck by the arcs but no flaming was observed. Crater-like holes were formed in the fiberglass due to the energy of the arc. The PVF film shrunk away from the intense heat of the arcing, leaving small circular voids in the film cover. The same crater-like holes were formed in the fiberglass.

The metallized PET film ignited from arcing at both 115 and 208 volts, resulting in uncontrolled flame propagation. The flames spread upward, downward, and horizontally. This nonuniform flame-spread behavior has been observed before, i.e., in the cotton swab test. The burning rate was unsteady at both voltages. In contrast to the metallized PET film that readily ignited, the plain PET film ignited only after prolonged multiple arcing at both voltages. However, at 115 volts, the flaming confined itself to the seam area. At 208 volts, the fire was small and self-extinguished in seconds with minimal flame spread. There was a slightly longer burn length at the seam area than in the middle area of the blanket. Shrinkage is the prevalent characteristic of polyester film when exposed to heat. At both voltages, this effect was observed. Crater-like holes were formed in the fiberglass.

From table 2, it can be seen that no ignition of the polyimide or metallized PVF blankets occurred when tested with an AV 8™ coating at either voltage. Both types of blankets performed in the same manner as they did when tested without AV 8™ (refer to table 1).

When subjected to an electrical arc, the metallized PET film cover sprayed with AV 8™ ignited with flame propagation. At 115 volts, approximately 50% of the blanket was consumed and at 208 volts, approximately 75% of the blanket was consumed. Comparing the data between tables 1 and 2, it can be seen that the blankets were totally consumed when tested with no AV 8™. The amount of blanket consumed is more likely due to the existence of test variables such as flatness of the film cover, melting and dripping, air currents, and not the presence of this particular CIC. The plain PET blanket ignited at the seam when tested at 115 volts and self-extinguished with minimal flame spread. When tested at 208 volts, no ignition occurred.

SUMMARY OF TEST RESULTS

1. Neither the polyimide or metallized PVF blankets ignited when subjected to arcing at 115 and 208 volts nor did they ignite when tested after being sprayed with a coating of AV 8™ corrosion-inhibiting compound at either voltage.

2. The metallized PET blankets ignited from arcing and were totally consumed when subjected to both 115 and 208 volts. When tested with a coating of AV 8™ at 115 volts, approximately 50% of the blanket was consumed. At 208 volts, approximately 75% of the blanket was consumed.

3. The plain PET blankets ignited when subjected to arcing at both 115 and 208 volts; however, there was minimal flame spread and the fire self-extinguished within seconds. When tested with a coating of AV 8™ at 115 volts, flaming in the seam area was observed; however, it self-extinguished within seconds. No ignition occurred at 208 volts.