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Electric Arc Exposure Tests

for Stern & Stern

October 2002

Tests Conducted at Kinectrics High Current Laboratory
Toronto, Ontario, Canada

Electric Arc Exposure Tests

Materials for use in Electric Arc

October 2002

Certificate of Performance

This is to certify that the tests documented in this report were conducted at Kinectrics High Current Laboratory in accordance with ASTM International Standard Test Method F1959-1999. The samples were washed and dried by the client in accordance with the above standard according to client testimony.

4.1 oz/yd² HT-487 Filament Nomex® Lint-free material with anti-stat
Arc Rating (ATPV) = 5.0 cal/cm²
95% Confidence Rate 4.8, 5.2 cal/cm²

Requested by: Stanley Cone
Stern & Stern

Approved by Hugh Hoagland
Hugh Hoagland Consulting, Inc.

This report was prepared by Hugh Hoagland Consulting, Inc. as an account of work performed for **STERN & STERN**

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STERN & STERN
Evaluation of Textile Materials
ASTM F1959-1999

Full Scale Arc Tests at Kinectrics High Current Laboratory
October 2002

At the request of Mr. Stanley Cone, Stern & Stern, electric arc exposure tests were conducted on textile systems to be sold by Stern & Stern. Mr. Cone arranged with Hugh Hoagland Consulting, Inc. to conduct tests at the High Current Laboratory of Kinectrics in Toronto and review the data.

The textiles were tested with the ASTM F1959-1999 Standard Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing

Introduction: The electrical industry has experienced severe injuries to workers when they have inadvertently been exposed to the energies of the electric arc. Burns resulting in death or requiring lengthy rehabilitation have occurred when workers have been exposed to the thermal effects of an electric arc. Many of these burns have been further complicated by ignition, melting and continued burning of non-flame resistant materials or non-arc resistant materials. The flame resistant materials developed by Stern & Stern are designed to be resistant to flame and are to be rated for electric arc exposure.

Test Samples: Stern & Stern brought to Hugh Hoagland Consulting, Inc. 28 panels of the materials listed below for determining ASTM F1959-1999 arc rating. Hugh Hoagland Consulting washed the materials 3X using Tide Detergent in a home laundry and dried them once. The sample as tested are below:

- 1) 4.1 oz/yd² HT-487 Filament Nomex® Lint-free material with anti-stat

Test Method: The ASTM F1959-1999 Standard Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing uses a high current laboratory, a controlled arc source, instrumented sensor panels and instrumented monitor sensors. The Kinectrics High Current Laboratory uses a 100 MVA supply (100 million volt-amperes). This supply feeds, through co-axial circuit, the current to the arc electrodes which are enclosed by a modified Faraday “cage” to minimize the effects of magnetic fields on the directionality of the arc. The test apparatus is enclosed in a test cell to minimize or eliminate the effect of rain, wind and temperature. The test setup is shown in the Figures. The fault current, the duration of the arc, the arc length, and the test specimen distance from the arc set for each test. The

current offset is controlled by point on wave switching of the 60 Hz supply controlled within 0.01 cycles. Monitor sensors on each side of the panels measure the incident energy (E_i) for the panel. Two other sensors are on each panel to measure the pass through energy which is used to model with the Stoll burn criteria predicting second degree burn from the standard.

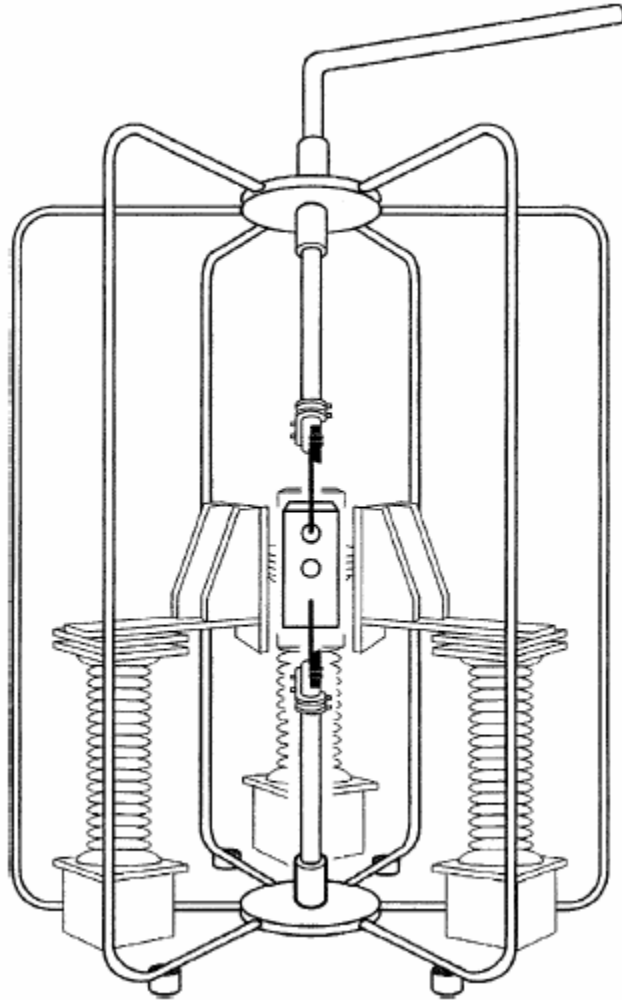


Figure 1 Test Set Up With Cage

Instrumented Monitor Sensors: The panels have two copper calorimeters mounted as shown in Figure 2. The monitor sensors each consist of one copper calorimeter and mounting hardware.

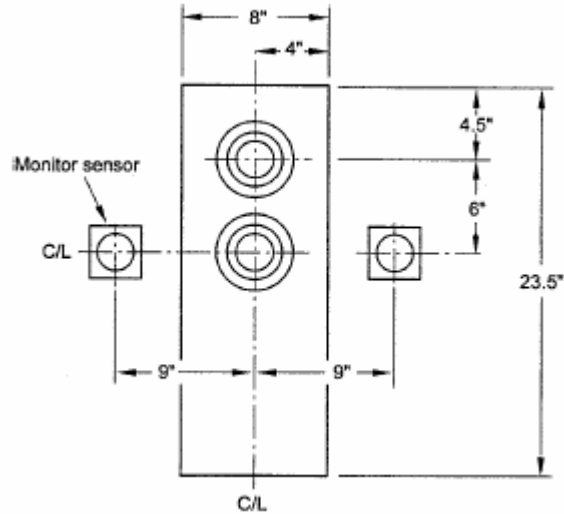


Figure 2 Sensed Panels and Monitor Sensors

Arc Thermal Energy Measurement: The arc is not a straight vertical column. It may move horizontally or vertically or both. The co-axial supply and the arc “cage” (Fig. 1) reduce this arc movement caused by the magnetic field by the large currents in the test circuit. The monitor sensors on each side of the panels measure the heat across materials. The temperature rise of the sensors are evaluated to determine the results of each test, however, each test must be evaluated using the recorded data and the visual observations. The arc voltage, current, duration and energy and the temperature rise for each sensor are shown on the attached graphs in the Appendix.

Test Results: The test program consisted of a minimum of 7 arc tests of three panels each. The sets were evaluated using the current method and a logistic regression method. The test results are presented in tabular and graphical form. Each test was video taped. The video tape is included on the CD. Comparisons of the heat across the shields with the heat measured behind the shields at the various sensors are shown in the reports following.

Test Observations: All the observations are recorded in the report sheets.

Conclusions: The materials received the arc rating below:

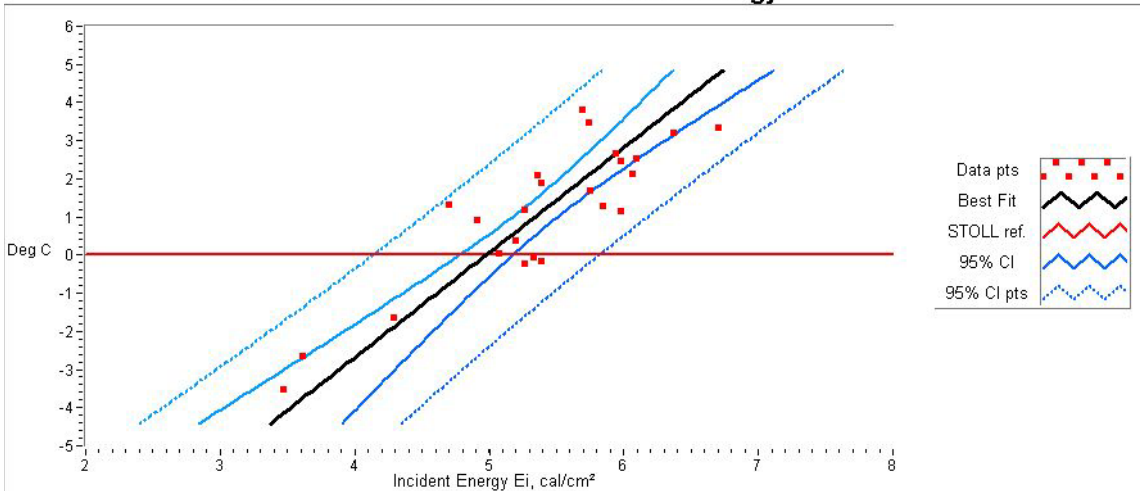
4.1 oz/yd² HT-487 Filament Nomex® Lint-free material with anti-stat
Arc Rating (ATPV) = 5.0 cal/cm²

Stern & Stern Industries, Inc.

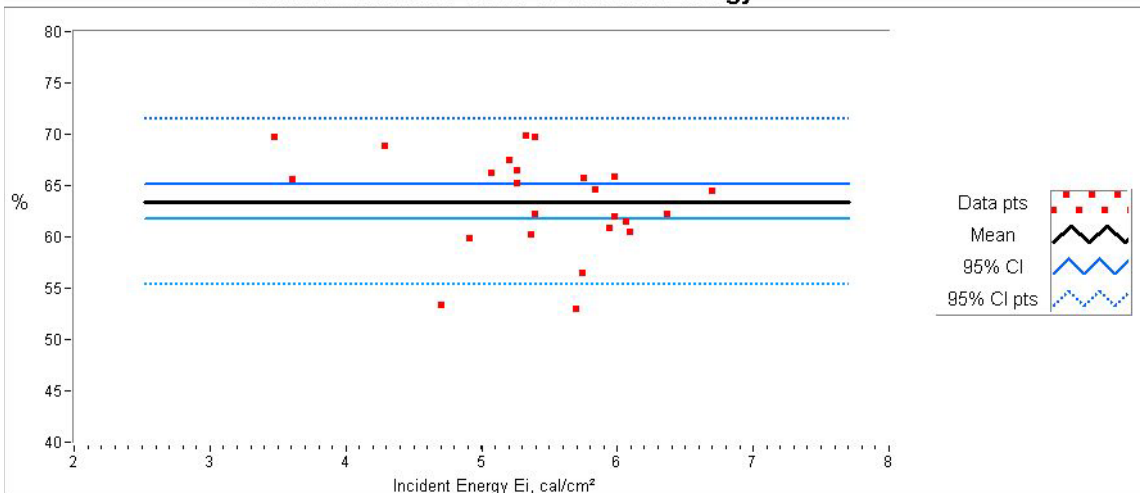
4.1 oz HT 487-60 Filament Nomex®

The following tests were performed on flat panels spaced 12 inches from the arc and an electrode spacing of 12 inches with a current of 8.02 kA rms. The tests were performed at Kinectrics Inc., High Current Lab in Toronto, Canada on Friday, October 25, 2002. The tests were performed and analyzed in accordance with ASTM F1959-99.

Differential from Stoll Curve vs Incident Energy



Heat Attenuation Factor vs Incident Energy



ATP Value(cal/cm²) = 5.0	HAF (%) = 63.4
ATPV 95% Confidence Interval = 4.8 , 5.2	HAF 95% Confidence Interval = 61.8 , 65.1
Pts 95% Confidence Interval = 4.1 , 5.8	Pts 95% Confidence Interval = 55.4 , 71.5
% Above STOLL = 75.0	
# Points = 24	
r² = 0.76	

Summary of Subjective Data

Stern & Stern Industries, Inc.

4.1 oz HT 487-60 Filament Nomex®

Test #	Panel	Ei(cal/cm²)	SCD(°C)	HAF(%)	In analysis	A.F.	Ign.	B.O.	Brittle	Charred	Melting	Dripping	Weak	Comment
1	02-2594	A	5.36	2.10	60.20	Y	1	-	-	-	-	-	-	-
2	02-2594	B	5.07	0.03	66.20	Y	1	-	-	-	-	-	-	-
3	02-2594	C	4.70	1.32	53.41	Y	1	-	-	-	-	-	-	-
4	02-2595	A	7.73	17.03	39.04	N	30	-	Y	Y	Y	-	-	-
5	02-2595	B	6.39	6.24	59.65	N	25	-	Y	Y	Y	-	-	-
6	02-2595	C	6.09	2.53	60.46	Y	1	-	-	-	-	-	-	-
7	02-2596	A	5.94	2.66	60.85	Y	1	-	-	-	-	-	-	-
8	02-2596	B	5.75	1.70	65.75	Y	1	-	-	-	-	-	-	-
9	02-2596	C	5.84	1.28	64.59	Y	1	-	-	-	-	-	-	-
10	02-2597	A	5.98	1.14	65.86	Y	1	-	-	-	-	-	-	-
11	02-2597	B	6.09	7.30	50.63	N	1	-	Y	Y	Y	-	-	-
12	02-2597	C	5.74	3.47	56.48	Y	1	-	-	-	-	-	-	-
13	02-2598	A	5.33	-0.06	69.83	Y	1	-	-	-	-	-	-	-
14	02-2598	B	5.26	-0.24	66.52	Y	1	-	-	-	-	-	-	-
15	02-2598	C	6.06	2.13	61.52	Y	1	-	-	-	-	-	-	-
16	02-2599	A	6.70	3.33	64.54	Y	1	-	-	-	-	-	-	-
17	02-2599	B	5.20	0.98	67.54	Y	1	-	-	-	-	-	-	-
18	02-2599	C	5.39	1.90	62.21	Y	1	-	-	-	-	-	-	-
19	02-2600	A	5.98	2.46	62.01	Y	1	-	-	-	-	-	-	-
20	02-2600	B	5.39	-0.17	69.77	Y	1	-	-	-	-	-	-	-
21	02-2600	C	4.91	0.92	59.86	Y	1	-	-	-	-	-	-	-
22	02-2601	A	6.37	3.21	62.29	Y	1	-	-	-	-	-	-	-
23	02-2601	B	5.26	1.20	65.22	Y	1	-	-	-	-	-	-	-
24	02-2601	C	5.69	3.83	53.05	Y	1	-	-	-	-	-	-	-
25	02-2602	A	4.29	-1.64	68.90	Y	1	-	-	-	-	-	-	-
26	02-2602	B	3.61	-2.63	65.61	Y	1	-	-	-	-	-	-	-
27	02-2602	C	3.47	-3.51	69.73	Y	1	-	-	-	-	-	-	-
28														
29														
30														
31														
32														
33														
34														
35														
36														
Min Ei (cal/cm²)=		3.5	Number of Break-open:		3	Ignition:		No		Melting:		No		On multi-layer system, subjective information applies to last FR layer unless noted otherwise
Max Ei (cal/cm²)=		7.7	Lowest Ei - break-open:		6.1 Cal/cm²	Embrittlement:		Onset at 6.1 Cal/cm²		Dripping:		No		
			Highest Ei - non break-open:		6.7 Cal/cm²	Charring:		Onset at 6.1 Cal/cm²		Weak:		No		
			After-flame (sec):		30.0 sec									

Thursday, October 24, 2002

4.1 oz HT487 filament Nomex11