

**Hugh Hoagland Consulting, Inc.**

**ArcWear.com**

**Electric Arc Exposure Tests**

**For Innovative Textiles**

**Fabric system**

**Outer Layer:**

**5.5 oz/yd<sup>2</sup> IUS Twill, 88% Cotton 12% Nylon,  
Style 341,  
Khaki**

**Laundered wt. 6.6 oz/yd<sup>2</sup>**

**Inner Layer:**

**6.5 oz/yd<sup>2</sup> Knit Interlock, Modacrylic/Cotton Blend ,  
Style 1008,  
Light Grey**

**Laundered wt. 7.4 oz/yd<sup>2</sup>**

January 2010

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

# Electric Arc Exposure Tests

Materials for use in Electric Arc

## Innovative Textiles

### 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 F 1959/F 1959M-06ae1. The test samples were washed and dried by the Hugh Hoagland Consulting, Inc. in accordance with the above standard.

Fabric system specified in the table below received arc rating as **ATPV= 26.3 cal/cm<sup>2</sup>**

Customer	Innovative Textiles
Layer 1	
Fabric design	5.5 oz/yd <sup>2</sup> IUS Twill, 88% Cotton 12% Nylon
Style	Style 341
Color	Khaki
Laundered wt	6.6 oz/yd <sup>2</sup>
Layer 2	
Fabric design	6.5 oz/yd <sup>2</sup> Knit Interlock, Modacrylic/Cotton Blend
Style	Style 1008
Color	Light Grey
Laundered wt	7.4 oz/yd <sup>2</sup>

Requested by: Mr. John Wasylyk

Approved by Hugh Hoagland  
Hugh Hoagland Consulting, Inc.

This report was prepared by Hugh Hoagland Consulting, Inc. as an account of work performed for Innovative Textiles .

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- b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

# **Innovative Textiles**

## **Evaluation of Textile Materials**

### **ASTM F 1959/F 1959M-06ae1**

#### **Full Scale Arc Tests at Kinectrics High Current Laboratory**

At the request of Mr. John Wasylyk, electric arc exposure tests were conducted on textile systems for Innovative Textiles . Mr. John Wasylyk arranged with Hugh Hoagland Consulting, Inc. to conduct tests at the High Current Laboratory of Kinectrics in Toronto and review test data.

The textiles were tested according to the ASTM F 1959/F 1959M-06ae1 Standard Test Method for Determining the Arc Rating 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 materials developed by Innovative Textiles are designed to be resistant to flame and are to be rated for electric arc exposure.

### **Test Samples**

Sample preparation was completed in accordance with ASTM F 1959/F 1959M-06ae1. An adequate amount of material of each layer was washed three times and dried. Following the washing procedure, material was cut into panels and assembled into two-layered test samples.

Sample preparation was completed by Hugh Hoagland Consulting, Inc. .

The samples as tested are described in the Table below:

Customer	Innovative Textiles
Layer 1	
Fabric design	5.5 oz/yd <sup>2</sup> IUS Twill, 88% Cotton 12% Nylon
Style	Style 341
Color	Khaki
Laundered wt	6.6 oz/yd <sup>2</sup>
Layer 2	
Fabric design	6.5 oz/yd <sup>2</sup> Knit Interlock, Modacrylic/Cotton Blend
Style	Style 1008
Color	Light Grey
Laundered wt	7.4 oz/yd <sup>2</sup>

## **Test Method**

### ***Test apparatus***

The ASTM F 1959/F 1959M-06ae1 Standard Test Method for Determining the Arc Rating of Materials for Clothing requires testing conducted in a high current laboratory with a controlled arc source. Test apparatus is required to be equipped with instrumented sensor panels and instrumented monitor sensors as shown on Figure 1.

The Kinectrics High Current Laboratory uses a 100 MVA supply (100 million volt-amperes). This supply feeds the arc current to the arc electrodes through co-axial circuit.

Arc electrodes are enclosed within a modified Faraday “cage” to minimize the effects of magnetic fields on the directionality of the arc. The test apparatus is placed in a test cell to minimize or eliminate the effect of rain, wind and ambient temperature.

A series of trials completes one test. Each trial results in three data point.

Following parameters are set, checked and recorded for each trial:

- arc current
- arc duration
- arc electrodes spacing
- distance between test specimen(s) and arc electrode

The peak current is controlled by closing phase angle of the 60 Hz supply source with accuracy of 0.01 cycles.

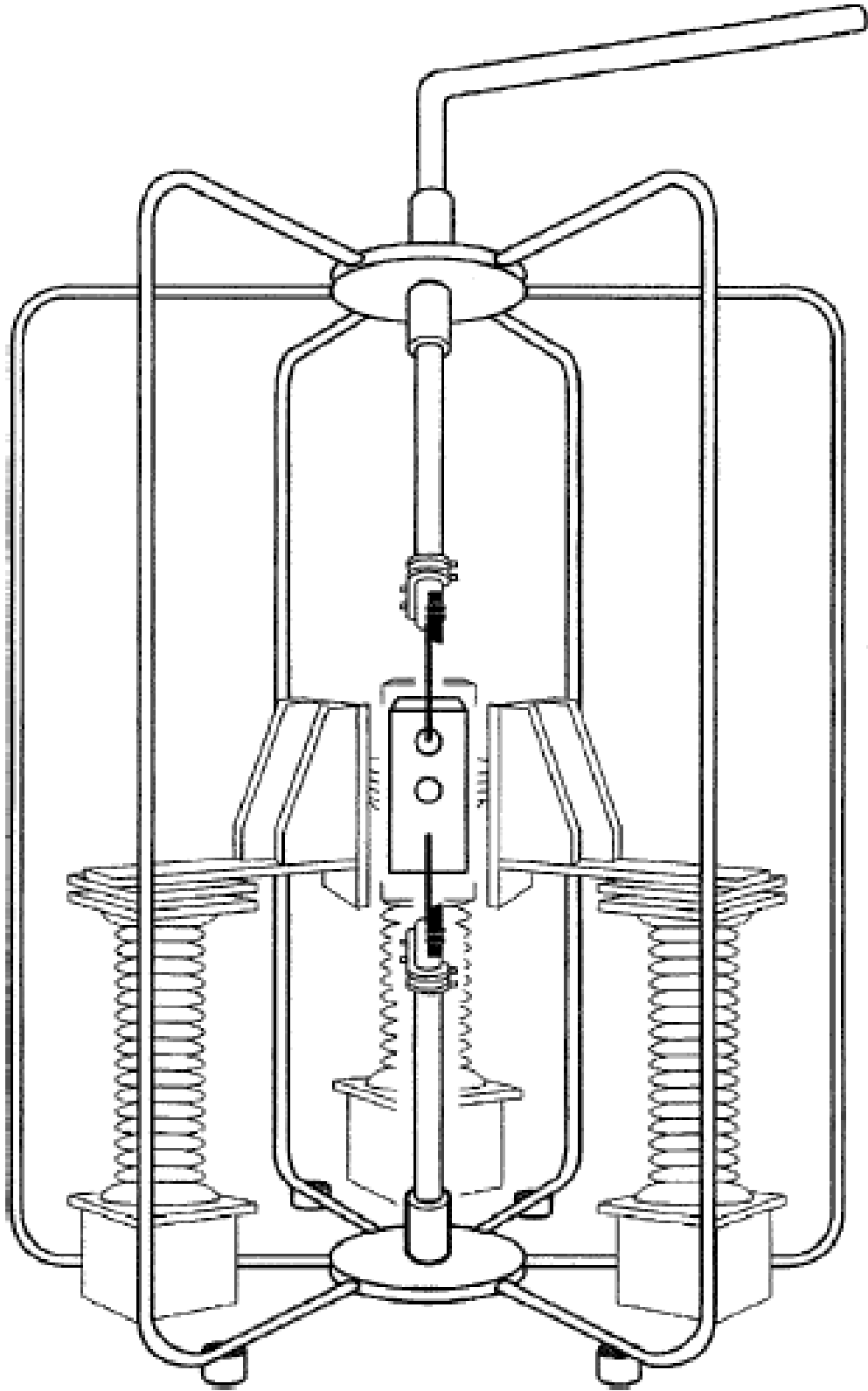
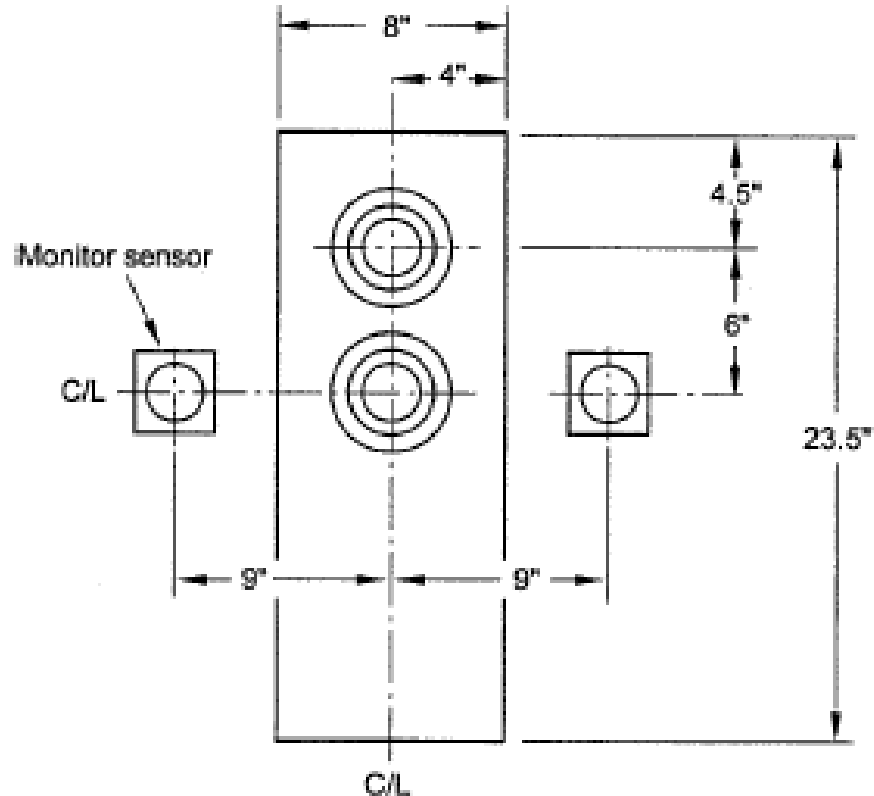


Figure 1. Test Set Up With Cage

## ***Instrumented Panel and Monitor Sensors***

Each panel equipped with two copper calorimeters mounted as shown in Figure 2. Two monitor sensors attached with mounting hardware on both sides of each panel. Each monitor sensor is equipped with one copper calorimeter.

Monitor sensors measure the incident energy ( $E_i$ ) for the panel. Panel sensors measure the pass through energy that is compared with to the Stoll second-degree burn criteria.



**Figure 2. Instrumented Panel 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 high currents in the test circuit.

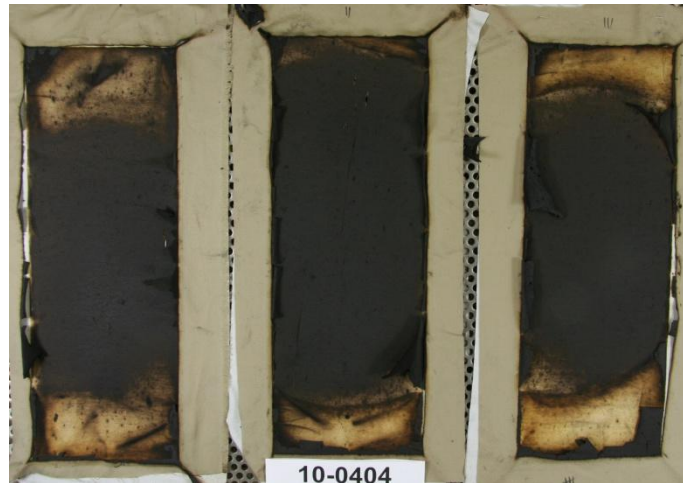
The monitor sensors on each side of the panels measure the heat across materials. The temperature rises of the sensors are evaluated to determine the results of each test.

However, in addition to recorded data each trial must be evaluated using visual observations.

## Test Results

The test program includes minimum of seven three-panel arc trials. The test data set is evaluated using logistic regression method. A comparison of logistic regression to linear regression is also available on request.

Detailed test data, test observations, statistical analysis, and graphs are shown on attached three pages and photograph.



The arc voltage record, arc current record, arc duration, arc energy and the temperature rise record for each sensor are included on CD.

Each test was video taped. Video is included on CD.

CD is a part of this report.

## Conclusions

The material under test received the arc rating below:

Customer	Innovative Textiles
Layer 1	
Fabric design	5.5 oz/yd <sup>2</sup> IUS Twill, 88% Cotton 12% Nylon
Style	Style 341
Color	Khaki
Laundered wt	6.6 oz/yd <sup>2</sup>
Layer 2	
Fabric design	6.5 oz/yd <sup>2</sup> Knit Interlock, Modacrylic/Cotton Blend
Style	Style 1008
Color	Light Grey
Laundered wt	7.4 oz/yd <sup>2</sup>

**Arc Rating: ATPV= 26.3 cal/cm<sup>2</sup>**



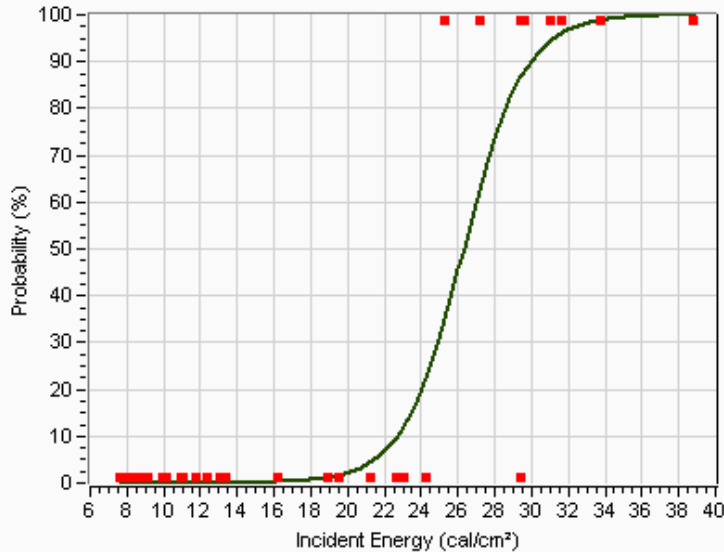


ASTM F1959/F1959M-06ae1  
Standard Test Method for Determining the Arc Rating of Materials for Clothing

**Client:** Innovative Textiles

**Fabric Description:** ITI, IUS Style 341, 5.5 oz/yd<sup>2</sup> Twill, 88% Cotton 12% Nylon, Khaki, Laundered wt 6.6 oz/yd<sup>2</sup> over ITI Style 1008, 6.5 oz/yd<sup>2</sup> Interlock Knit, Light Grey, Laundered wt 7.4 oz/yd<sup>2</sup>

Determination of ATPV, 50% Probability of 2nd Degree Burn

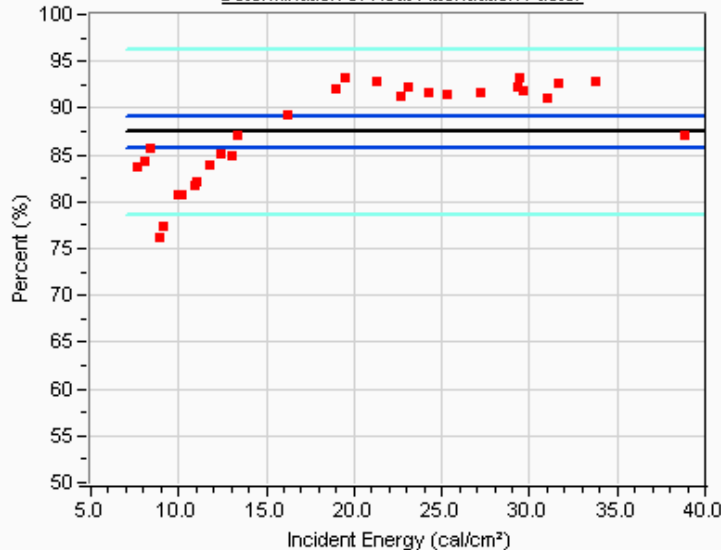


**ATPV = 26.3 cal/cm<sup>2</sup>**

Probability of Burn	Ei
5%	21.4
10%	22.7
20%	24.0
30%	24.9
40%	25.7
50%	26.3
60%	27.0
70%	27.7
80%	28.6
90%	30.0





# Pts = 30  
 # Pts above Stoll = 8  
 # Pts Break-Open = 5  
 # Pts always >STOLL = 5  
 # Pts always <STOLL = 21  
 # Pts within 20% = 10  
 # Pts in mix zone = 4

Determination of Heat Attenuation Factor



**HAF = 87.4 %**

Confidence Intervals  
 95% CI = 85.8 , 89.0

Data pts   
 Best Fit   
 95% CI   
 95% CI pts 

Ref#: K-418230

January 20, 2010

ASTM F1959/F1959M-06ae1  
Standard Test Method for Determining the Arc Rating of Materials for Clothing

Client: Innovative Textiles

Fabric: ITI, IUS Style 341, 5.5 oz/yd<sup>2</sup> Twill, 88% Cotton 12% Nylon, Khaki, Laundered wt 6.6 oz/yd<sup>2</sup> over ITI  
Description: Style 1008, 6.5 oz/yd<sup>2</sup> Interlock Knit, Light Grey, Laundered wt 7.4 oz/yd<sup>2</sup>

Test #	Panel	Cycles # (60Hz)	Ei cal/cm <sup>2</sup>	SCD cal/cm <sup>2</sup>	HAF %	Burn yes/no	Break Open Y/N	After Flame sec.	Omit Y/N	Comment	Ignition T-shirt
1	10-397	A	12.0	9.12	-0.23	77.4	No	-	-	No	
2	10-397	B	12.0	10.97	-0.35	81.8	No	-	-	No	
3	10-397	C	12.0	8.95	-0.22	76.1	No	-	-	No	
4	10-398	A	10.0	7.66	-0.94	83.8	No	-	-	No	
5	10-398	B	10.0	8.43	-0.89	85.8	No	-	-	No	
6	10-398	C	10.0	8.09	-0.92	84.3	No	-	-	No	
7	10-399	A	14.1	9.97	-0.33	80.8	No	-	-	No	
8	10-399	B	14.1	11.03	-0.36	82.2	No	-	-	No	
9	10-399	C	14.1	12.37	-0.44	85.1	No	-	-	No	Ablation
10	10-400	A	16.1	13.32	-0.51	87.2	No	-	-	No	Ablation
11	10-400	B	16.1	16.23	-0.52	89.3	No	-	-	No	Ablation
12	10-400	C	16.1	10.95	-0.31	81.7	No	-	-	No	
13	10-401	A	15.1	11.74	-0.42	83.9	No	-	-	No	Ablation
14	10-401	B	15.1	13.04	-0.36	85.0	No	-	-	No	Ablation
15	10-401	C	15.1	10.14	-0.39	80.7	No	-	-	No	
16	10-402	A	26.0	19.49	-0.61	93.2	No	-	-	No	Ablation
17	10-402	B	26.0	21.25	-0.48	92.9	No	-	-	No	Ablation
18	10-402	C	26.0	18.92	-0.46	92.0	No	-	-	No	Ablation
19	10-403	A	32.1	23.09	-0.30	92.3	No	-	-	No	Ablation
20	10-403	B	32.1	25.32	0.06	91.5	Yes	-	-	No	Ablation
21	10-403	C	32.1	22.62	-0.15	91.3	No	-	-	No	Ablation
22	10-404	A	36.2	29.45	-0.13	93.2	No	-	-	No	Ablation
23	10-404	B	36.2	29.36	0.17	92.3	Yes	-	-	No	Ablation
24	10-404	C	36.2	24.28	-0.20	91.6	No	-	-	No	Ablation
25	10-405	A	39.2	29.59	0.23	91.9	Yes	-	-	No	Ablation
26	10-405	B	39.2	31.62	0.17	92.6	Yes	Y	-	No	Ablation
27	10-405	C	39.2	27.16	0.13	91.6	Yes	Y	-	No	Ablation
28	10-406	A	44.1	33.75	0.01	92.9	Yes	Y	-	No	Ablation
29	10-406	B	44.1	38.79	3.17	87.1	Yes	Y	-	No	Ablation
30	10-406	C	44.1	31.03	0.89	91.0	Yes	Y	-	No	Ablation
31											
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January 20, 2010