

**Hugh Hoagland Consulting, Inc.**

**ArcWear.com**

**Electric Arc Exposure Tests**

**For Carhartt Inc.**

**Fabric system**

**Outer Layer:**

**6.0 oz/yd<sup>2</sup> MVM Mohawk Twill, 88% Cotton 12% Nylon ,  
Style Firetw10KHI ,  
Khaki  
Laundered wt. 6.3 oz/yd<sup>2</sup>**

**Inner Layer:**

**6.5oz/yd<sup>2</sup> ITI Interlock Knit, 55% Modacrylic 45% Cotton ,  
Style 1008 ,  
Navy  
Laundered wt. 8.1 oz/yd<sup>2</sup>**

**Note: Style Firetw10KHI  
is Carhartt's designation  
for Mt Vernon style XMOH.**

December 2009

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

# Electric Arc Exposure Tests

Materials for use in Electric Arc

**Carhartt Inc.**

## 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. 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  
**EBT=28.0 cal/cm<sup>2</sup>**

Customer	Carhartt Inc.
Layer 1	
Fabric design	6.0 oz/yd <sup>2</sup> MVM Mohawk Twill, 88% Cotton 12% Nylon
Style	Style Firetw10KHI
Color	Khaki
Laundered wt	6.3 oz/yd <sup>2</sup>
Layer 2	
Fabric design	6.5oz/yd <sup>2</sup> ITI Interlock Knit, 55% Modacrylic 45% Cotton
Style	Style 1008
Color	Navy
Laundered wt	8.1 oz/yd <sup>2</sup>

Requested by: Ms. Cara Gilevich

Approved by Hugh Hoagland  
Hugh Hoagland Consulting, Inc.

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

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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.

## **Carhartt Inc.**

### **Evaluation of Textile Materials**

#### **ASTM F 1959/F 1959M**

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

At the request of Ms. Cara Gilevich, electric arc exposure tests were conducted on textile systems for Carhartt Inc. . Ms. Cara Gilevich 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 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 used by Carhartt Inc. 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. 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	Carhartt Inc.
Layer 1	
Fabric design	6.0 oz/yd <sup>2</sup> MVM Mohawk Twill, 88% Cotton 12% Nylon
Style	Style Firetw10KHI
Color	Khaki
Laundered wt	6.3 oz/yd <sup>2</sup>
Layer 2	
Fabric design	6.5oz/yd <sup>2</sup> ITI Interlock Knit, 55% Modacrylic 45% Cotton
Style	Style 1008
Color	Navy
Laundered wt	8.1 oz/yd <sup>2</sup>

## **Test Method**

### ***Test apparatus***

The ASTM F 1959/F 1959M 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.

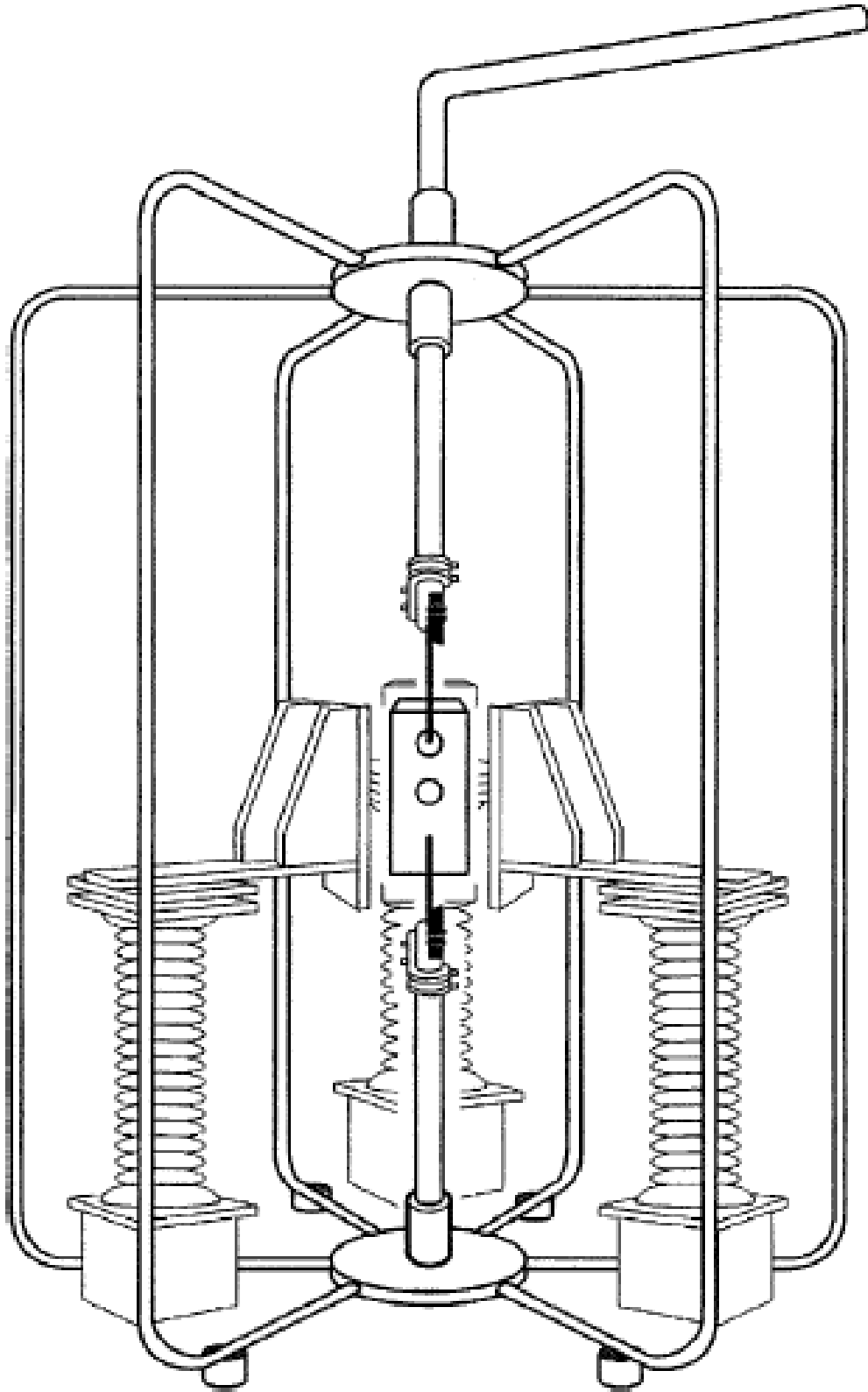
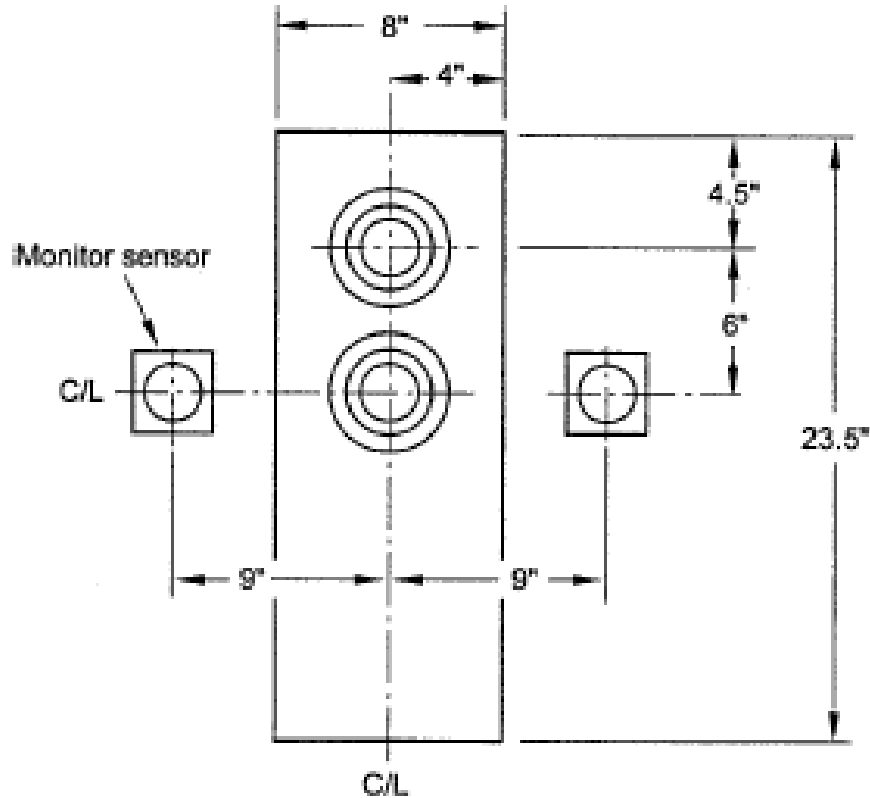


Figure 1. Test Set Up With Cage

## ***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	Carhartt Inc.
Layer 1	
Fabric design	6.0 oz/yd <sup>2</sup> MVM Mohawk Twill, 88% Cotton 12% Nylon
Style	Style Firetw10KHI
Color	Khaki
Laundered wt	6.3 oz/yd <sup>2</sup>
Layer 2	
Fabric design	6.5oz/yd <sup>2</sup> ITI Interlock Knit, 55% Modacrylic 45% Cotton
Style	Style 1008
Color	Navy
Laundered wt	8.1 oz/yd <sup>2</sup>

**Arc Rating: EBT=28.0 cal/cm<sup>2</sup>**





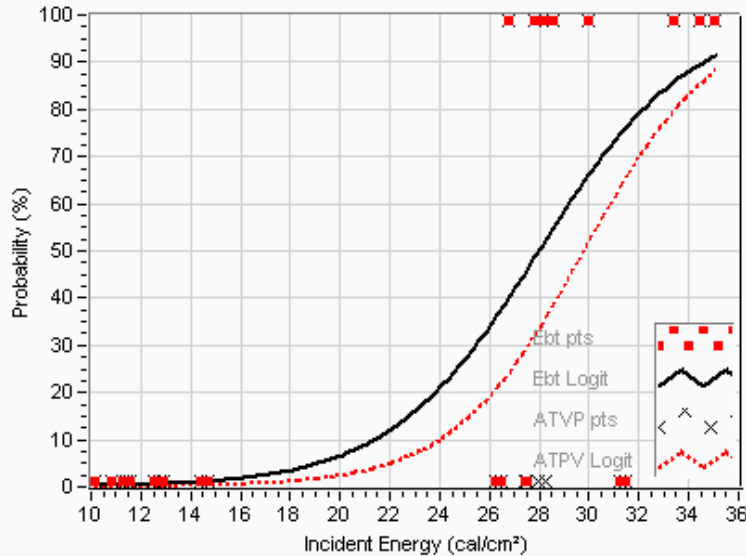


ASTM F1959/F1959M-06ae1  
Standard Test Method for Determining the Arc Rating of Materials for Clothing

**Client:** Carhartt

**Fabric Description:** Carhartt, MVM Style Firetw10KHI Mohawk Twill, Nominal Weight 6.0 oz/yd<sup>2</sup>, 88% Cotton 12% Nylon, Khaki, Laundered Weight 6.3 oz/yd<sup>2</sup> OVER ITI Style 1008 Interlock Knit, Nominal Weight 6.5 oz/yd<sup>2</sup>, 55% Modacrylic 45% Cotton, Navy; Laundered Weight 8.1 oz/yd<sup>2</sup>

Determination of Ebt, 50% of Probability of Breakopen with overlay of ATPV Logit curve

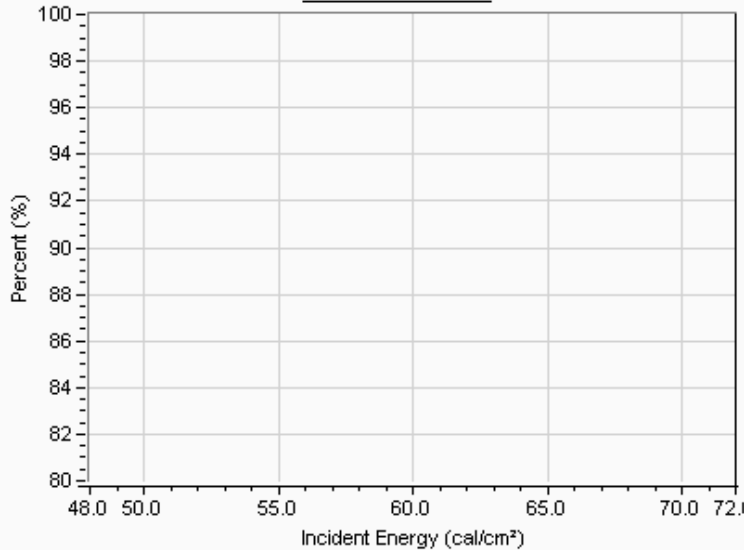


**Ebt = 28.0 cal/cm<sup>2</sup>**

Probability of Break-Open	Ei
5%	19.1
10%	21.4
20%	23.8
30%	25.4
40%	26.8
50%	28.0
60%	29.2
70%	30.5
80%	32.2
90%	34.6

# Pts = 27  
 # Pts above Stoll = 7  
 # Pts Break-Open = 9  
 # Pts above mix zone = 3  
 # Pts below mix zone = 14  
 # Pts within 20% = 13  
 # Pts in mix zone = 10

Determination of HAF



**HAF = 88.5 %**

Confidence Intervals  
 95% CI = 86.7 , 90.2

Data pts   
 Best Fit   
 95% CI   
 95% CI pts



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

Client: Carhartt

Fabric Description: Carhartt, MVM Style Firetw10KHI Mohawk Twill, Nominal Weight 6.0 oz/yd<sup>2</sup>, 88% Cotton 12% Nylon, Khaki, Laundered Weight 6.3 oz/yd<sup>2</sup> OVER ITI Style 1008 Interlock Knit, Nominal Weight 6.5 oz/yd<sup>2</sup>, 55% Modacrylic 45% Cotton, Navy; Laundered Weight 8.1 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	09-5820	A	16.0	14.42	-0.61	88.1	No	x	-	No	Ablation	
2	09-5820	B	16.0	14.42	-0.41	86.5	No	x	-	No	Ablation	
3	09-5820	C	16.0	11.59	-0.39	82.3	No	-	-	No		
4	09-5821	A	14.1	10.14	-0.17	76.0	No	-	-	No		
5	09-5821	B	14.1	11.28	-0.40	81.8	No	-	-	No		
6	09-5821	C	14.1	12.87	-0.61	85.8	No	-	-	No		
7	09-5822	A	15.0	12.54	-0.01	79.6	No	-	-	No		
8	09-5822	B	15.0	10.85	-0.26	79.1	No	-	-	No		
9	09-5822	C	15.0	12.72	-0.49	84.9	No	x	-	No	Ablation	
10	09-5823	A	15.5	11.44	-0.33	81.3	No	-	-	No		
11	09-5823	B	15.5	12.88	-0.43	85.0	No	-	-	No		
12	09-5823	C	15.5	14.69	-0.58	87.5	No	x	-	No	Ablation	
13	09-5824	A	35.1	26.49	-0.28	93.0	No	x	-	No	Ablation	
14	09-5824	B	35.1	26.23	-0.49	93.6	No	x	-	No	Ablation	
15	09-5824	C	35.1	27.40	-0.43	93.6	No	x	-	No	Ablation	
16	09-5825	A	45.0	34.40	0.50	93.1	Yes	Y	-	No	Ablation & Breakopen	
17	09-5825	B	45.0	33.37	0.71	92.1	Yes	Y	-	No	Ablation & Breakopen	
18	09-5825	C	45.0	35.06	1.14	92.0	Yes	Y	-	No	Ablation & Breakopen	
19	09-5826	A	40.1	29.97	-0.00	92.6	Yes	Y	-	No	Ablation & Breakopen	
20	09-5826	B	40.1	28.52	0.30	91.9	Yes	Y	-	No	Ablation & Breakopen	
21	09-5826	C	40.1	31.25	-0.30	93.8	No	-	-	No		
22	09-5827	A	38.1	27.79	0.09	92.0	Yes	Y	-	No	Ablation & Breakopen	
23	09-5827	B	38.1	28.26	-0.13	92.6	No	Y	-	No	Ablation & Breakopen	
24	09-5827	C	38.1	27.93	-0.11	92.2	No	Y	-	No	Ablation & Breakopen	
25	09-5828	A	37.1	26.78	0.07	91.5	Yes	Y	-	No	Ablation & Breakopen	
26	09-5828	B	37.1	31.45	-0.36	93.9	No	x	-	No	Ablation	
27	09-5828	C	37.1	27.50	-0.21	92.6	No	x	-	No	Ablation	
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