

Hugh Hoagland Consulting, Inc.

ArcWear.com

Electric Arc Exposure Tests

For Carhartt Inc.

Fabric system

Outer Layer:

**7.0 oz/yd² MVM Arapaho Twill, 88% Cotton 12% Nylon ,
Style Firetw09KHI ,
Khaki
Laundered wt. 8.3 oz/yd²**

Inner Layer:

**6.5oz/yd² ITI Interlock Knit, 55% Modacrylic 45% Cotton ,
Style 1008 ,
Navy
Laundered wt. 8.1 oz/yd²**

**Note: Style Firetw09KHI
is Carhartt's designation
for Mt Vernon style XARA.**

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
ATPV=34.2 cal/cm²

Customer	Carhartt Inc.
Layer 1	
Fabric design	7.0 oz/yd ² MVM Arapaho Twill, 88% Cotton 12% Nylon
Style	Style Firetw09KHI
Color	Khaki
Laundered wt	8.3 oz/yd ²
Layer 2	
Fabric design	6.5oz/yd ² ITI Interlock Knit, 55% Modacrylic 45% Cotton
Style	Style 1008
Color	Navy
Laundered wt	8.1 oz/yd ²

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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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	7.0 oz/yd ² MVM Arapaho Twill, 88% Cotton 12% Nylon
Style	Style Firetw09KHI
Color	Khaki
Laundered wt	8.3 oz/yd ²
Layer 2	
Fabric design	6.5oz/yd ² ITI Interlock Knit, 55% Modacrylic 45% Cotton
Style	Style 1008
Color	Navy
Laundered wt	8.1 oz/yd ²

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.

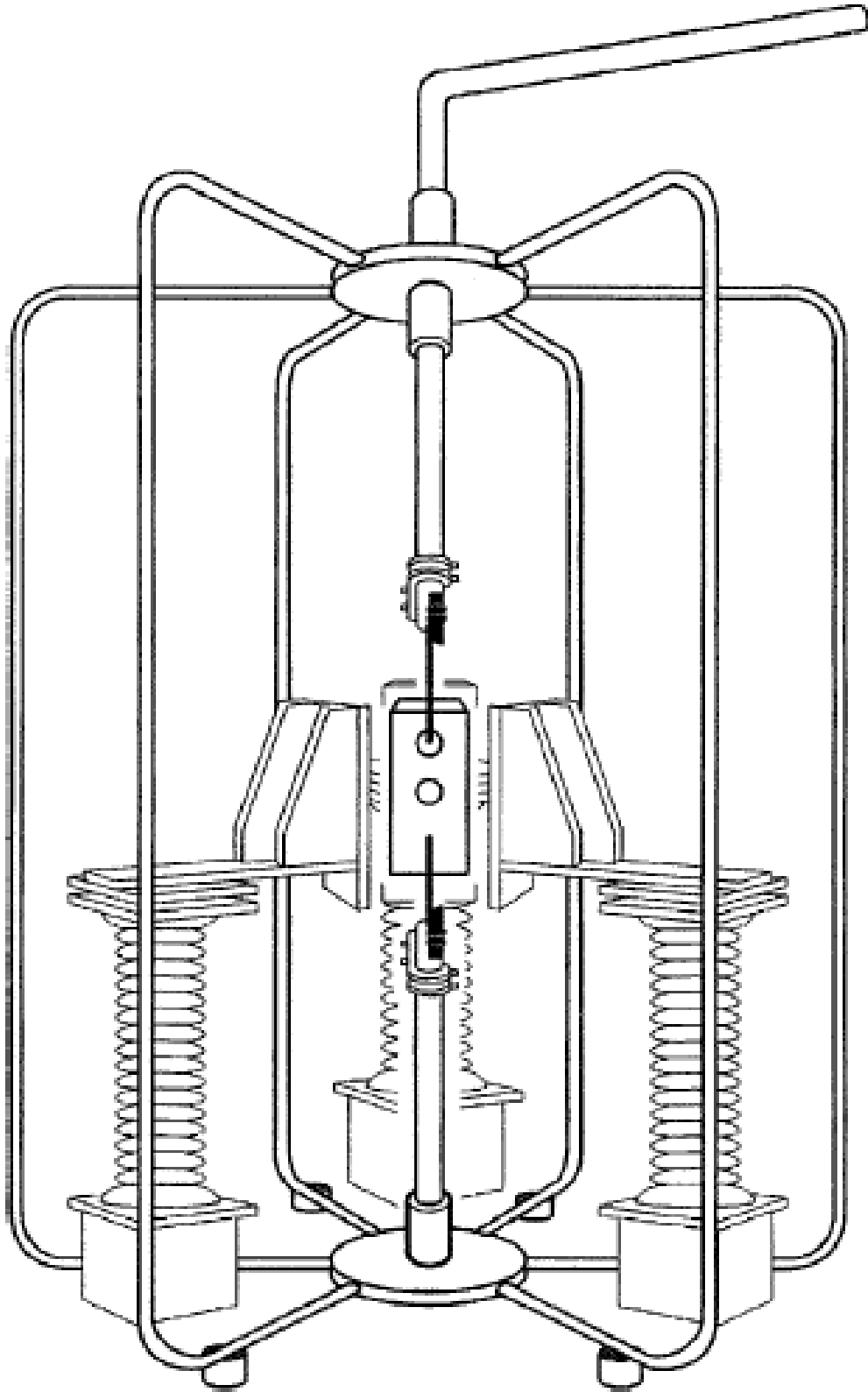


Figure 1. Test Set Up With Cage

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.

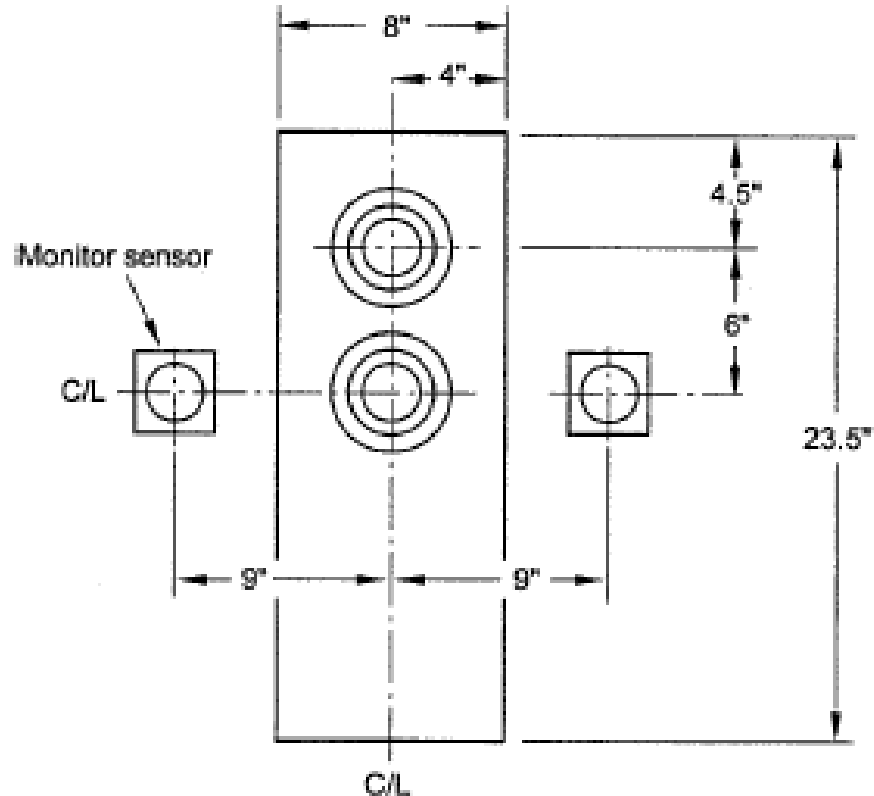


Figure 2. Instrumented Panel and Monitor Sensors

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	7.0 oz/yd ² MVM Arapaho Twill, 88% Cotton 12% Nylon
Style	Style Firetw09KHI
Color	Khaki
Laundered wt	8.3 oz/yd ²
Layer 2	
Fabric design	6.5oz/yd ² ITI Interlock Knit, 55% Modacrylic 45% Cotton
Style	Style 1008
Color	Navy
Laundered wt	8.1 oz/yd ²

Arc Rating: ATPV=34.2 cal/cm²

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

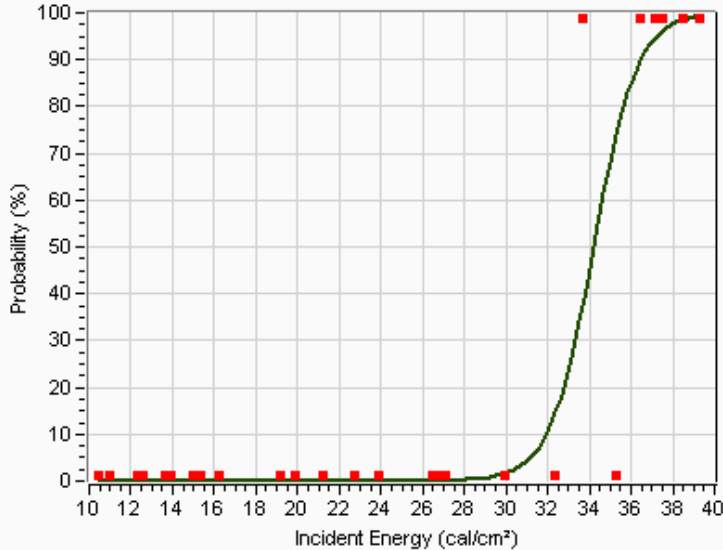


Client: Carhartt

Fabric description

Carhartt, MVM Style Firetw09KHI Arapaho Twill, Nominal Weight 7.0 oz/yd², 88% Cotton 12% Nylon, Khaki; Laundered Weight 8.3oz/yd² OVER ITI Style 1008 Interlock Knit, Nominal Weight 6.5 oz/yd², 55% Modacrylic 45% Cotton, Navy; Laundered Weight 8.1 oz/yd²

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

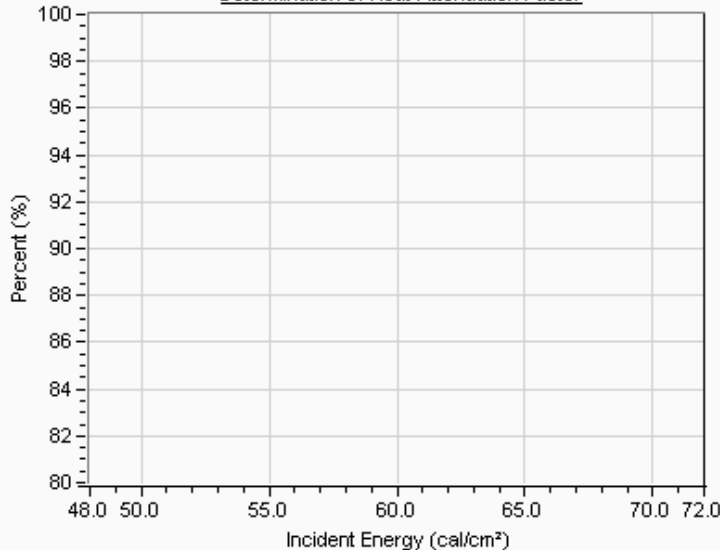


ATPV = 34.2 cal/cm²

Probability of Burn	Ei
5%	31.2
10%	31.9
20%	32.8
30%	33.3
40%	33.8
50%	34.2
60%	34.6
70%	35.1
80%	35.7
90%	36.5

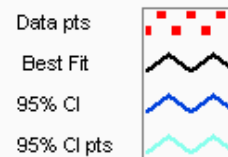
- # Pts = 30
- # Pts above Stoll = 7
- # Pts Break-Open = 5
- # Pts always >STOLL = 6
- # Pts always <STOLL = 22
- # Pts within 20% = 10
- # Pts in mix zone = 2

Determination of Heat Attenuation Factor



HAF = 89.5 %

Confidence Intervals
95% CI = 88.0 , 91.0





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

Client: Carhartt

Fabric Description: Carhartt, MVM Style Firetw09KHI Arapaho Twill, Nominal Weight 7.0 oz/yd², 88% Cotton 12% Nylon, Khaki; Laundered Weight 8.3oz/yd² OVER ITI Style 1008 Interlock Knit, Nominal Weight 6.5 oz/yd², 55% Modacrylic 45% Cotton, Navy; Laundered Weight 8.1 oz/yd²

Test #	Panel	Cycles # (60Hz)	Ei cal/cm ²	SCD cal/cm ²	HAF %	Burn yes/no	Break Open Y/N	After Flame sec.	Omit Y/N	Comment	Ignition T-shirt
1	09-5809	A	16.0	12.60	-0.12	80.5	No	-	-	No	
2	09-5809	B	16.0	13.68	-0.44	84.1	No	-	-	No	
3	09-5809	C	16.0	13.94	-0.31	83.5	No	-	-	No	
4	09-5810	A	19.0	14.95	-0.32	85.6	No	x	-	No	Ablation
5	09-5810	B	19.0	15.07	-0.28	85.3	No	x	-	No	Ablation
6	09-5810	C	19.0	15.33	-0.27	85.6	No	x	-	No	Ablation
7	09-5811	A	25.1	19.86	-0.56	90.5	No	x	-	No	Ablation
8	09-5811	B	25.1	21.26	-0.40	90.4	No	x	-	No	Ablation
9	09-5811	C	25.1	19.15	-0.45	89.8	No	x	-	No	Ablation
10	09-5812	A	14.0	10.43	-0.92	84.1	No	-	-	No	
11	09-5812	B	14.0	11.00	-0.71	83.6	No	-	-	No	
12	09-5812	C	14.0	12.33	-0.28	82.1	No	-	-	No	
13	09-5813	A	31.0	23.90	-0.69	93.8	No	x	-	No	Ablation
14	09-5813	B	31.0	26.65	-0.67	95.3	No	x	-	No	Ablation
15	09-5813	C	31.0	22.72	-0.72	94.4	No	x	-	No	Ablation
16	09-5814	A	37.1	26.51	-0.57	93.4	No	x	-	No	Ablation
17	09-5814	B	37.1	27.07	-0.58	94.5	No	x	-	No	Ablation
18	09-5814	C	37.1	29.92	-0.32	93.5	No	x	-	No	Ablation
19	09-5815	A	50.0	37.12	0.45	92.7	Yes	Y	-	No	Ablation & Breakopen
20	09-5815	B	50.0	37.53	0.49	92.8	Yes	Y	-	No	Ablation & Breakopen
21	09-5815	C	50.0	39.32	1.56	90.9	Yes	Y	-	No	Ablation & Breakopen
22	09-5816	A	43.0	33.68	-0.44	94.5	y	x	-	No	Ablation
23	09-5816	B	43.0	32.32	-0.42	94.2	No	x	-	No	Ablation
24	09-5816	C	43.0	35.27	-0.35	94.4	No	x	-	No	Ablation
25	09-5817	A	47.0	38.51	0.39	93.2	Yes	Y	-	No	Ablation & Breakopen
26	09-5817	B	47.0	36.46	0.32	93.3	Yes	Y	-	No	Ablation & Breakopen
27	09-5817	C	47.0	37.39	0.01	93.8	Yes	x	-	No	Ablation & Breakopen
28	09-5818	A	18.0	16.26	-0.51	88.4	No	x	-	No	Ablation
29	09-5818	B	18.0	12.48	-0.21	80.7	No	-	-	No	
30	09-5818	C	18.0	15.04	-0.49	87.1	No	x	-	No	Ablation
31											
32											
33											
34											
35											
36											