Hugh Hoagland Consulting, Inc.

ArcWear.com

Electric Arc Exposure Tests

For Riverside Manufacturing

Fabric system

Outer Layer:
ITI Twill, 55% Modacrylic 45% Cotton,
Style PFR832,
Blue Chambry
Laundered wt. 5.9 oz/yd²

Inner Layer:
Drifire Silk Weight Tubular Knit Jersey , 75% Modacrylic 15% Cotton 10% Nylon ,
Style 80142-30000014FDS,
Tan
Laundered wt. 6.0 oz/yd²

Note: Style PFR832 is Riverside's designation for ITI's Style 6000.

August 2009

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

Electric Arc Exposure Tests

Materials for use in Electric Arc

Riverside Manufacturing

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
Ebt= 18.8 cal/cm²

Customer	Riverside Manufacturing
Layer 1	
Fabric design	ITI Twill, 55% Modacrylic 45% Cotton
Style	Style PFR832
Color	Blue Chambry
Nominal/Laundered wt	5.9 oz/yd²
Layer 2	
Fabric design	Drifire Silk Weight Tubular Knit Jersey , 75% Modacrylic 15% Cotton 10% Nylon
Style	Style 80142-30000014FDS
Color	Tan
Nominal/Laundered wt	6.0 oz/yd²

Requested by: Mr. Will Vereen

Approved by Hugh Hoagland
Hugh Hoagland Consulting, Inc.

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

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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.

Riverside Manufacturing

Evaluation of Textile Materials

ASTM F 1959/F 1959M-06ae1

Full Scale Arc Tests at Kinectrics High Current Laboratory

At the request of Mr. Will Vereen, electric arc exposure tests were conducted on textile systems for Riverside Manufacturing. Mr. Will Vereen 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 used by Riverside Manufacturing 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	Riverside Manufacturing
Layer 1	
Fabric design	ITI Twill, 55% Modacrylic 45% Cotton
Style	Style PFR832
Color	Blue Chambry
Nominal/Laundered wt	5.9 oz/yd²
Layer 2	
Fabric design	Drifire Silk Weight Tubular Knit Jersey , 75% Modacrylic 15% Cotton 10% Nylon
Style	Style 80142-30000014FDS
Color	Tan
Nominal/Laundered wt	6.0 oz/yd²

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.

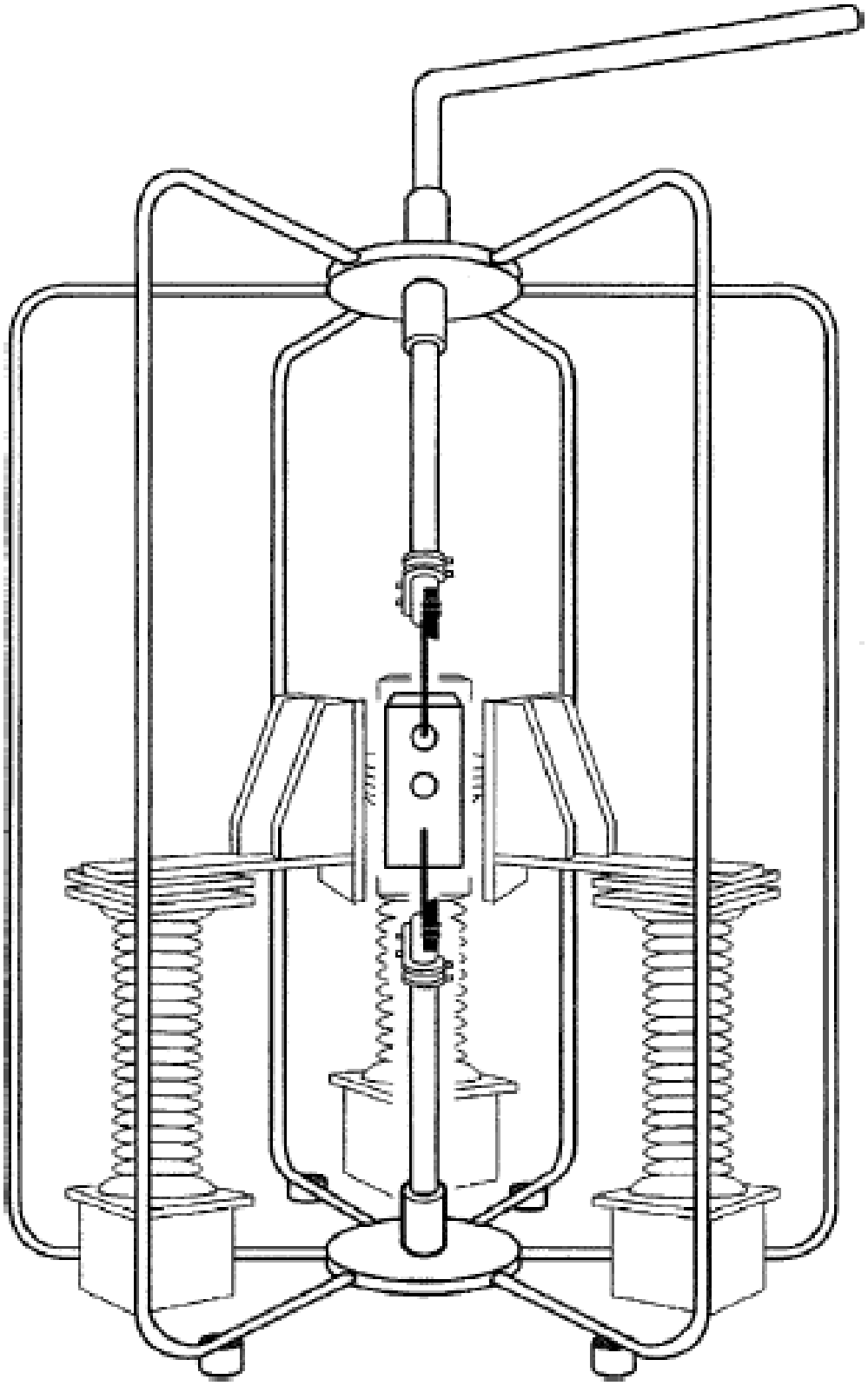


Figure 1. Test Set Up With Cage

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.

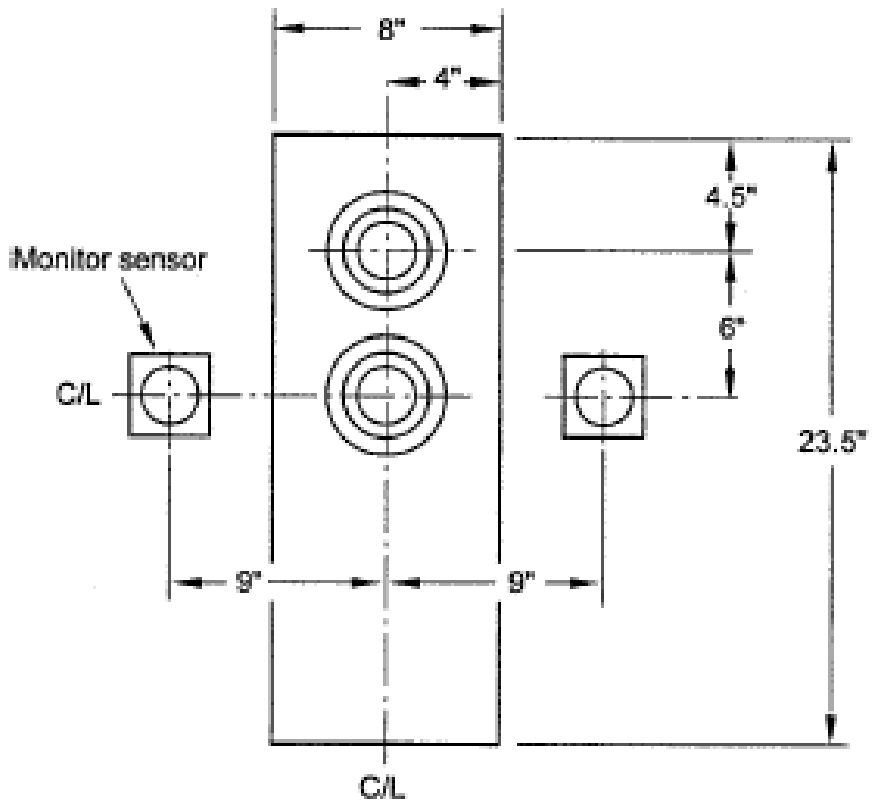


Figure 2. Instrumented Panel and Monitor Sensors

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	Riverside Manufacturing
Layer 1	
Fabric design	ITI Twill, 55% Modacrylic 45% Cotton
Style	Style PFR832
Color	Blue Chambry
Nominal/Laundered wt	5.9 oz/yd²
Layer 2	
Fabric design	Drifire Silk Weight Tubular Knit Jersey , 75% Modacrylic 15% Cotton 10% Nylon
Style	Style 80142-30000014FDS
Color	Tan
Nominal/Laundered wt	6.0 oz/yd²

Arc Rating: Ebt= 18.8 cal/cm²

Date: August 12, 2009 Report # K-418210	High Current Test Laboratory Kinectrics Inc., Canada Test Summary	KINECTRICS ISO 9001-2000

Client

Riverside Uniforms

Fabric description

Riverside, ITI Style PFR832, Twill, 55% Modacrylic 45% Cotton, Chambray Blue, Laundered weight 5.9 oz/yd² over DRIFIRE Style 80142-30000014FDS, Silk Weight Tubular Knit Jersey, 75% Modacrylic 15% Cotton 10% Nylon, Tan, Laundered weight 6.0 oz/yd²

Reference Standard

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

Test Parameters: Test current: 8kA

Distance to Fabric: 12 inches

Arc Gap: 12 inches

Number of samples analysed: 24

Incident Energy Range: 8 to 22 cal/cm²

Summary

The arc rating of this material is intended for use as flame resistant clothing for workers exposed to electric arcs. The material used in this test method are in the form of flat specimens, actual performance of the complete garment may vary depending on the final design and assembly of the garment. This test method does not apply to the electrical contact or electrical shock hazard.

Based on the data obtained and analysed in accordance with the latest version of the applicable standards, the following Arc Rating was calculated.

Material Break-Open Threshold Energy, Ebt = 18.8 Cal/cm²
Heat Attenuation Factor, HAF = 89.2%

The measured data and observations of the test samples after the arc exposure were collected and summarized in the attached table. The graphs and statistics on the attached sheets provide more detailed information to better understand the Arc Rating assigned to this item. The client shall review this full report, the video recordings of the arc exposure and the photographs of the samples after the test to determine if the material meets the intended specification.

Test performed by:

Hugh Hoagland
ArcWear.com
502-314-7158
hugh@arcwear.com

Contact information

Will Vereen
Riverside Uniforms
229-985-5210
WVereen@riversideuniforms.com

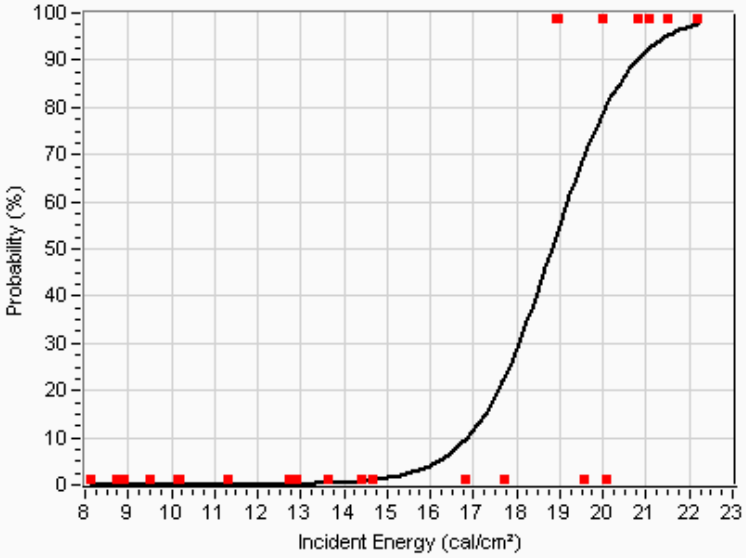
ASTM F1959/F1959M-06ae1
Standard Test Method for Determining the Arc Rating of Materials for Clothing

KINECTRICS
ISO 9001-2000

Client: Riverside Uniforms

Fabric Description: Riverside, ITI Style PFR832, Twill, 55% Modacrylic 45% Cotton, Chambray Blue, Laundered weight 5.9 oz/yd² over DRIFIRE Style 80142-30000014FDS, Silk Weight Tubular Knit Jersey, 75% Modacrylic 15% Cotton 10% Nylon, Tan, Laundered weight 6.0 oz/yd²

Determination of Ebt, 50% of Probability of Breakopen

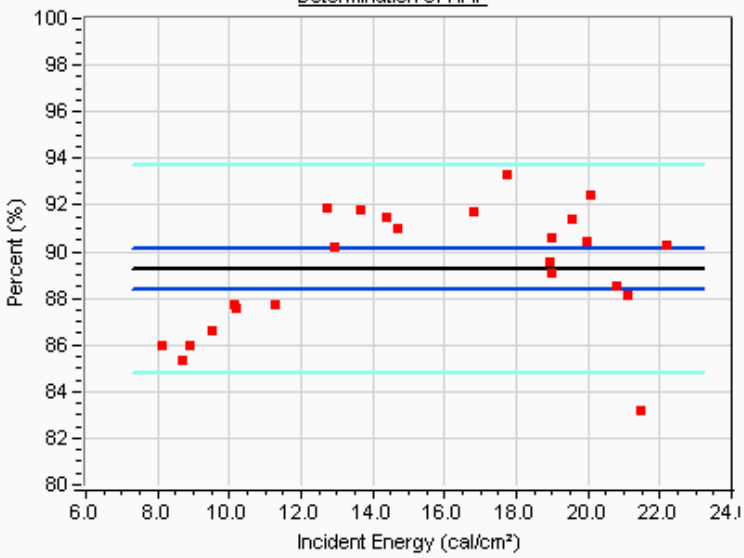


Ebt = 18.8 cal/cm²

Probability of Break-Open	Ei
5%	16.2
10%	16.9
20%	17.6
30%	18.1
40%	18.5
50%	18.8
60%	19.2
70%	19.6
80%	20.1
90%	20.8

Pts = 24
Pts above Stoll = 5
Pts Break-Open = 8
Pts above mix zone = 4
Pts below mix zone = 14
Pts within 20% = 12
Pts in mix zone = 6

Determination of HAF



HAF = 89.2 %

Confidence Intervals
95% CI = 88.3 , 90.2

Data pts
Best Fit
95% CI
95% CI pts

Kinectrics WO: K-418210

August 12, 2009

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

KINECTRICS
ISO 9001-2000

Client: Riverside Uniforms

Fabric Description: Riverside, ITI Style PFR832, Twill, 55% Modacrylic 45% Cotton, Chambray Blue, Laundered weight 5.9 oz/yd² over DRIFIRE Style 80142-30000014FDS, Silk Weight Tubular Knit Jersey, 75% Modacrylic 15% Cotton 10% Nylon, Tan, Laundered weight 6.0 oz/yd²

	Test #	Panel	Cycles # (60Hz)	Ei cal/cm²	SCD cal/cm²	HAF %	Burn yes/no	Break Open Y/N	After Flame sec.	Omit Y/N	Comment	Ignition T-shirt
1	09-3472	A	12.0	10.13	-0.73	87.7	No	-	-	No		
2	09-3472	B	12.0	10.20	-0.71	87.6	No	-	-	No		
3	09-3472	C	12.0	9.52	-0.65	86.6	No	-	-	No		
4	09-3473	A	17.0	12.92	-0.67	90.2	No	-	-	No	Ablation	
5	09-3473	B	17.0	14.40	-0.67	91.5	No	-	-	No	Ablation	
6	09-3473	C	17.0	14.67	-0.55	91.0	No	-	-	No	Ablation	
7	09-3474	A	15.0	11.29	-0.65	87.7	No	-	-	No	Ablation	
8	09-3474	B	15.0	12.74	-0.59	91.9	No	-	-	No	Ablation	
9	09-3474	C	15.0	13.63	-0.61	91.8	No	-	-	No	Ablation	
10	09-3475	A	10.0	8.12	-0.82	86.0	No	-	-	No		
11	09-3475	B	10.0	8.90	-0.70	86.0	No	-	-	No		
12	09-3475	C	10.0	8.71	-0.73	85.3	No	-	-	No		
13	09-3476	A	24.0	17.73	-0.58	93.3	No	-	-	No	Ablation	
14	09-3476	B	24.0	18.98	-0.16	89.1	No	Y	-	No	Ablation	
15	09-3476	C	24.0	20.81	0.93	88.5	Yes	Y	-	No	Ablation	
16	09-3477	A	27.1	19.57	-0.34	91.4	No	-	-	No	Ablation	
17	09-3477	B	27.1	21.49	2.09	83.2	Yes	Y	-	No	Ablation	
18	09-3477	C	27.1	22.19	0.37	90.3	Yes	Y	-	No	Ablation	
19	09-3478	A	26.0	19.97	-0.13	90.4	No	Y	-	No	Ablation	
20	09-3478	B	26.0	21.08	0.80	88.1	Yes	Y	-	No	Ablation	
21	09-3478	C	26.0	18.91	0.25	89.6	Yes	Y	-	No	Ablation	
22	09-3479	A	23.0	16.79	-0.52	91.7	No	-	-	No	Ablation	
23	09-3479	B	23.0	20.09	-0.32	92.4	No	-	-	No	Ablation	
24	09-3479	C	23.0	18.97	-0.04	90.6	No	Y	-	No	Ablation	
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