

Hugh Hoagland Consulting, Inc.

ArcWear.com

Electric Arc Exposure Tests

**For
Flamesafe**

Fabric

**6.8 oz/yd², 230 g/m² Interlock Knit, 100% Cotton ,
Style ILUCO 38160,
Navy
Laundered weight (LW) 8.1 oz/yd², 274 g/m²**

October 2010

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

Electric Arc Exposure Tests

Materials for use in Electric Arc

Flamesafe

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 Hugh Hoagland Consulting, Inc. in accordance with the above standard.

Fabric system specified in the table below received arc rating as
ATPV = 13.9 cal/cm²

Customer	Flamesafe
Layer 1	
Fabric design	6.8 oz/yd ² , 230 g/m ² Interlock Knit, 100% Cotton
Style	ILUCO 38160
Color	Navy
Laundered weight (LW)	8.1 oz/yd ² , 274 g/m ²

Requested by: Mr. Peter Bloom



Approved by Hugh Hoagland
Hugh Hoagland Consulting, Inc.

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

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Flamesafe

Evaluation of Textile Materials

ASTM F 1959/F 1959M-06ae1

Full Scale Arc Tests at Kinectrics High Current Laboratory

At the request of Mr. Peter Bloom, electric arc exposure tests were conducted on textile systems for

Flamesafe. Mr. Peter Bloom 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
Flamesafe 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 was washed three times and dried. Following the washing procedure, material was cut into panel test samples.

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

The samples as tested are described in the Table below:

Customer	Flamesafe
Layer 1	
Fabric design	6.8 oz/yd ² , 230 g/m ² Interlock Knit, 100% Cotton
Style	ILUCO 38160
Color	Navy
Laundered weight (LW)	8.1 oz/yd ² , 274 g/m ²

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.

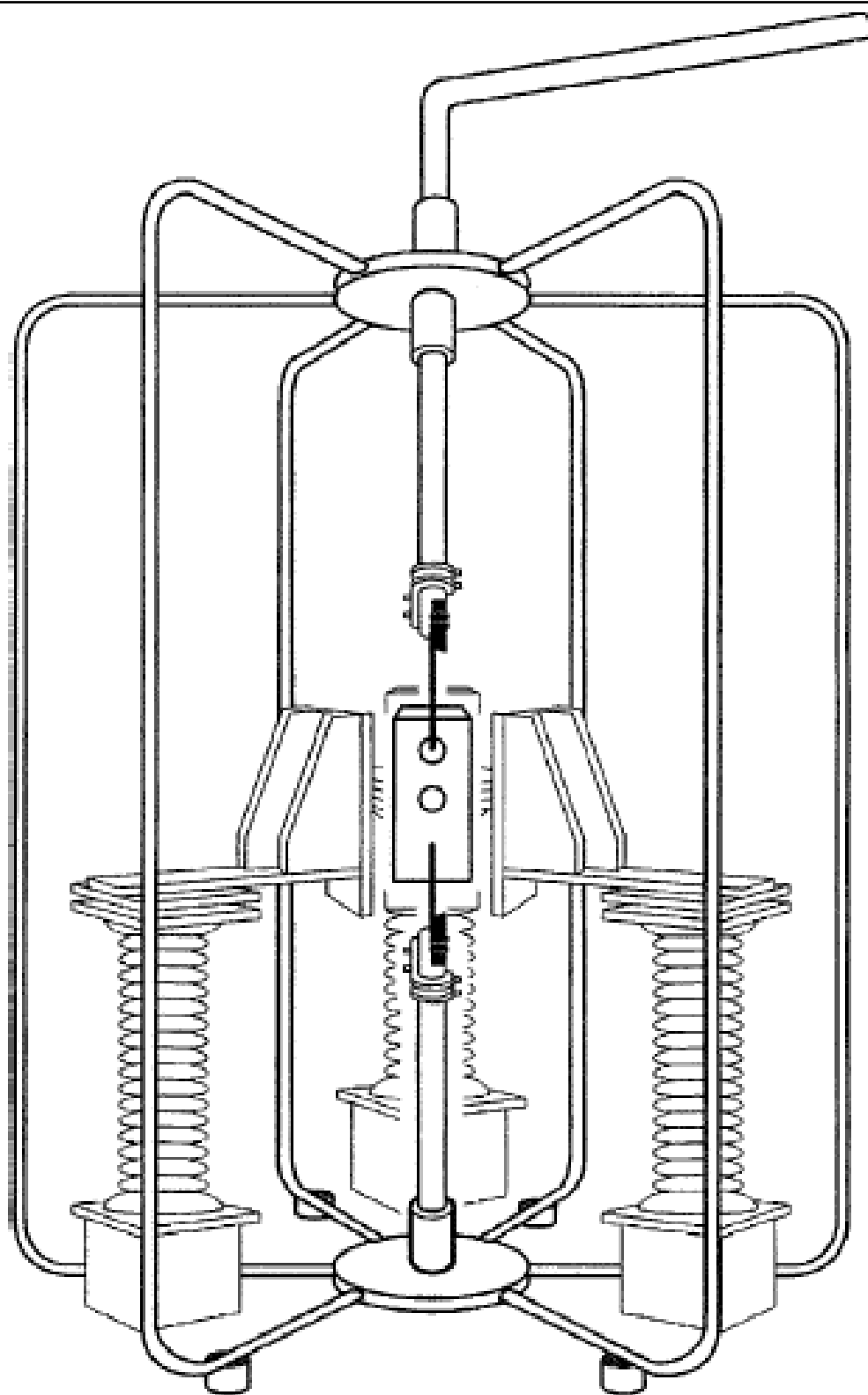


Figure 1. Test Set Up With Cage

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.

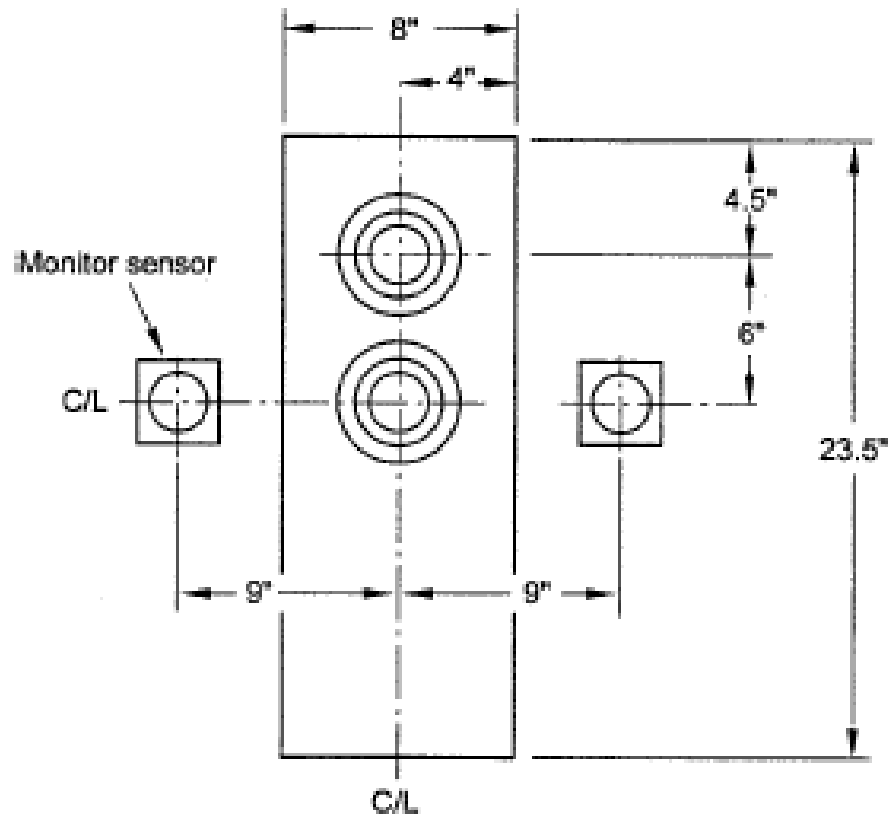


Figure 2. Instrumented Panel and Monitor Sensors

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.

Following test data was recorded for each trial:

- arc exposure electrical conditions (arc test and arc trial numbers, RMS arc current, peak arc current, arc voltage, arc duration, energy dissipated in arc, plots of arc current and arc voltage)
- temperature rise of monitor and panel calorimeters
- photographs of exposed fabric swatches
- video

Above mentioned test data is part of report and is available for download from ArcWearOnline.com arc testing website. Test data is accessible only to

Flamesafe and protected with
Flamesafe unique password.

Test data CD or DVD is available at additional request.

Test observations, result(s) of statistical analysis, and graphs are shown on attached three pages. Photograph below demonstrates exposed swatches at ATPV/EBT level or close to it.



Conclusions

The material under test received the arc rating below:

Customer	Flamesafe
Layer 1	
Fabric design	6.8 oz/yd ² , 230 g/m ² Interlock Knit, 100% Cotton
Style	ILUCO 38160
Color	Navy
Laundered weight (LW)	8.1 oz/yd ² , 274 g/m ²

Arc Rating: ATPV = 13.9 cal/cm²

Date:
Wednesday, October

Report #
K-418292

High Current Test Laboratory Kinectrics Inc., Canada Test Summary

Client

Flamesafe Workwear

Fabric description

FSM, ILUCO 34190 6.8 oz/yd² 230 g/m² Interlock Knit, 100% Cotton, Navy LW 8.1 oz/yd² 274 g/m²

Reference Standard

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

Test Parameters:

Test current: 12

Number of samples analysed: 21

Distance to Fabric: 12

Incident Energy Range: 9 to 19 cal/cm²

Arc Gap: 12

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.

Arc Thermal Performance Value, ATPV = 13.9 Cal/cm²
Heat Attenuation Factor, HAF = 86.0%

Panel data and observations of the fabric 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 material. 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 at:

Hugh Hoagland
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Contact information

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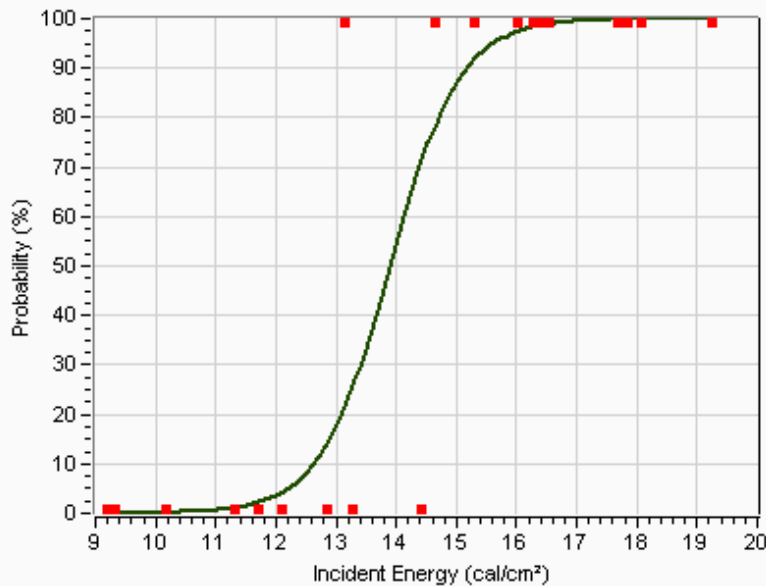
ASTM F1959/F1959M-06ae1
Standard Test Method for Determining the Arc Rating of Materials for Clothing

Client: Flamesafe Workwear

Fabric: FSM, ILUCO 34190 6.8 oz/yd² 230 g/m² Interlock Knit, 100% Cotton, Navy LW 8.1

Description: oz/yd² 274 g/m²

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

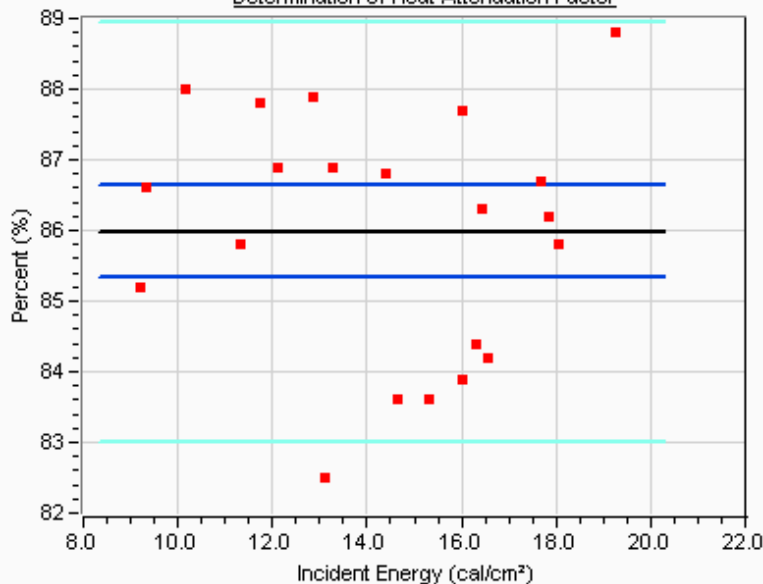


ATPV = 13.9 cal/cm²

Probability of Burn	Ei
5%	12.2
10%	12.6
20%	13.1
30%	13.4
40%	13.7
50%	13.9
60%	14.1
70%	14.4
80%	14.7
90%	15.2

Pts = 21
Pts above Stoll = 12
Pts Break-Open = 1
Pts always >STOLL = 11
Pts always <STOLL = 7
Pts within 20% = 14
Pts in mix zone = 3

Determination of Heat Attenuation Factor



HAF = 86.0 %

Confidence Intervals
95% CI = 85.3 , 86.6

Data pts
Best Fit
95% CI
95% CI pts

Kinectrics WFO: K-418292

Wednesday, October 27, 2010

Fabric Description: FSM, ILUCO 34190 6.8 oz/yd² 230 g/m² Interlock Knit, 100% Cotton, Navy LW 8.1 oz/yd² 274 g/m²

Test #	Panel	Cycles # (60Hz)	Ei cal/cm ²	SCD cal/cm ²	HAIF %	Burn yes/no	Break Open Y/N	After Flame sec.	Omit Y/N	Comment
1	10-4973	A	11.1	9.32	-0.70	86.6	Ilo	-	Ilo	
2	10-4973	B	11.1	9.20	-0.62	85.2	Ilo	-	Ilo	
3	10-4973	C	11.1	10.18	-0.71	88.0	Ilo	-	Ilo	
4	10-4974	A	15.2	11.72	-0.57	87.8	Ilo	-	Ilo	
5	10-4974	B	15.2	11.32	-0.51	85.8	Ilo	-	Ilo	
6	10-4974	C	15.2	13.26	-0.35	86.9	Ilo	-	Ilo	
7	10-4975	A	19.2	16.01	0.63	83.9	Yes	-	Ilo	
8	10-4975	B	19.2	14.41	-0.27	86.8	Ilo	-	Ilo	
9	10-4975	C	19.2	15.30	0.56	83.6	Yes	-	Ilo	
10	10-4976	A	23.2	17.68	0.49	86.7	Yes	-	Ilo	
11	10-4976	B	23.2	18.07	0.66	85.8	Yes	-	Ilo	
12	10-4976	C	23.2	19.26	0.31	88.8	Yes	Y	Ilo	
13	10-4977	A	21.2	16.54	0.63	84.2	Yes	-	Ilo	
14	10-4977	B	21.2	16.29	0.59	84.4	Yes	-	Ilo	
15	10-4977	C	21.2	16.42	0.37	86.3	Yes	-	Ilo	
16	10-4978	A	17.2	12.11	-0.58	86.9	Ilo	-	Ilo	
17	10-4978	B	17.2	12.86	-0.56	87.9	Ilo	-	Ilo	
18	10-4978	C	17.2	16.02	0.09	87.7	Yes	-	Ilo	
19	10-4979	A	18.2	14.66	0.39	83.6	Yes	-	Ilo	
20	10-4979	B	18.2	13.13	0.13	82.5	Yes	-	Ilo	
21	10-4979	C	18.2	17.84	0.57	86.2	Yes	-	Ilo	
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