

Hugh Hoagland Consulting, Inc.

**ArcWear.com**

R&D  
Electric Arc Exposure Tests

For Xcel Energy

**Shirt**

**5.2 cal/cm<sup>2</sup> Arc Rated**

January 2008

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

**Xcel Energy**  
**Evaluation of Arc Rated Clothing**  
**ASTM 1958/F1958M 99 (2005)**

R&D Arc Exposure Tests at Kinectrics High Current Laboratory

At the request of Ms. Karyn Davis, electric arc exposure R&D tests were conducted on one sample of arc protective clothing for Xcel Energy. Ms. Karyn Davis arranged with Hugh Hoagland Consulting, Inc. to conduct tests at the High Current Laboratory of Kinectrics in Toronto and review test data.

The sample of the Shirt was tested according to:

ASTM International Standard Test Method for Determining the Ignitability of Non-flame-Resistant Materials for closing by Electric Arc Exposure Method Using Mannequins F 1958/F1958M 99 (2005).

This Standard evaluates personal clothing products for ignition, melting and afterflame.

**Test Samples**

The samples as tested are described in the Table below:

Part number	FR Shirt
Arc Rating	5.2 cal/cm <sup>2</sup>
Number of samples tested	one

**Test Method**

***Test apparatus***

The ASTM F 1958/F 1958M-05 Standard requires testing conducted in a high current laboratory with a controlled arc source. Test apparatus is required to be equipped with arc electrodes and flame resistant mannequins 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.

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
- temperature rise for monitor sensors
- video

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

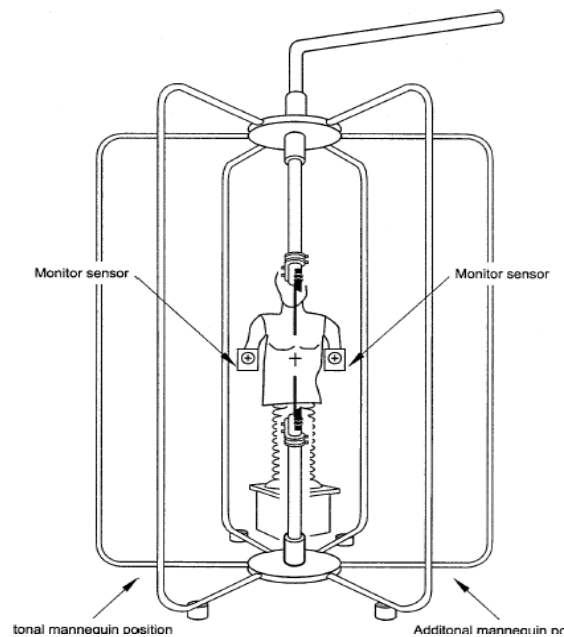


Figure 1. Test Set Up With Cage

The center of the arc (mid point of a gap between the electrodes) is adjusted horizontally with the center of the chest.

Monitor sensors measure the incident energy ( $E_i$ ) for the mannequin. Each monitor sensor is equipped with one copper calorimeter.

## 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 mannequin measure the heat across test object. The temperature rises of the sensors are evaluated to determine the results of each trial.

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

## Test Results

Detailed test data and graphs are shown on attached page.

Test observations are shown in the table below.

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

Trial # 08-186		
Mannequin		B
Incident energy $E_i$ , cal/cm <sup>2</sup>		7.06
Ignition		No
Afterflame, s		0
Break open		No




On Mannequin



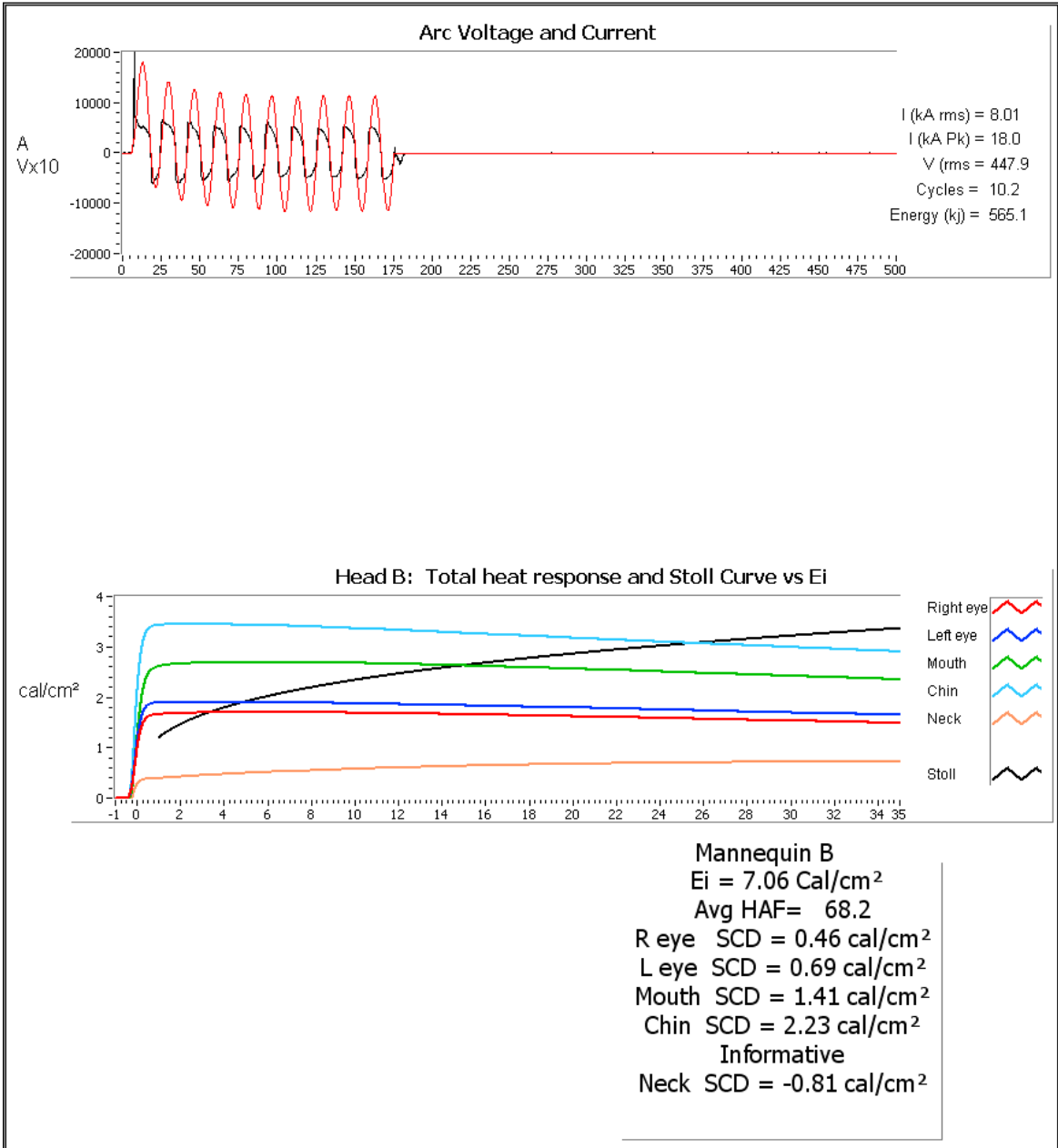
Inside view

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

**No afterflame, no ignition, no breakopen at the energy level 35% above the shirt rating.**

January 16, 2008	<b>High Current Test Laboratory</b> <b>Kinectrics Inc.</b> <b>Test Sheet</b>	 <b>KINECTRICS</b>
Test # 08-186		
WO#: K-422791		

Client: <b>Arcwear.com</b>	Description: Power Arc Tests with instrumented heads mannequin for determination of ATPV in accordance with ASTM F2178-02.  Xcel Energy FR Shirt
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PRIVATE INFORMATION, This test data shall not be disclosed or distributed without permission of the client.