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Electric Arc Exposure Tests

for DOE/Fluor-Hanford

April 2006

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

Electric Arc Exposure Tests

Face shields, Spectacles, or Hoods for use in Electric Arc

April 2006

Certificate of Performance

This is to certify that the tests documented in this report were conducted at Kinectrics High Current Laboratory using ASTM International Standard Test Method F2178-2002 Standard Test Method for Determining The Arc Rating Of Face Protective Products.

Requested by: Paul Case
DOE/Fluor-Hanford

Approved by Hugh Hoagland
Hugh Hoagland Consulting, Inc.

This report was prepared by Hugh Hoagland Consulting, Inc. as an account of work performed for DOE/FLUOR-HANFORD
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DOE/Fluor-Hanford
Evaluation of Hood with Facepiece

Full Scale Arc Tests at Kinectrics High Current Laboratory
April 2006

At the request of Mr. Paul Case, DOE/Fluor-Hanford, electric arc exposure tests were conducted on several samples of the respirators used by DOE/Fluor-Hanford. Mr. Paul Case arranged with Hugh Hoagland Consulting, Inc. to conduct tests at the High Current Laboratory of Kinectrics in Toronto and review the data.

The face shields were evaluated with using ASTM F2178-2002 Standard Test Method for Determining The Arc Rating Of Face Protective Products. This method allows for testing face protective products for ignition, melting and burn prediction.

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.

Test Samples: DOE/Fluor-Hanford sent to Hugh Hoagland Consulting, Inc. several samples of respirators used for protection from radioactive materials for evaluation for use in electric arc exposures.

MSA® Full face, Black, Silicone Respirator
Scott® Full face Black silicone respirator with overhead mesh P/N 804057-01

Test Method: ASTM F2178-2002 uses a high current laboratory, a controlled arc source, flame resistant mannequins and instrumented monitor sensors. The Kinectrics High Current Laboratory uses a 100 MVA supply (100 million volt-amperes). This supply feeds, through co-axial circuit, the current to the arc electrodes which are enclosed by a modified Faraday “cage” to minimize the effects of magnetic fields on the directionality of the arc. The test apparatus is enclosed in a test cell to minimize or eliminate the effect of rain, wind and temperature. The test setup is shown in Figure 1 below. The fault current, the duration of the arc, the arc length, and the test specimen distance from the arc set for each test. The current offset is controlled by point on wave switching of the 60 Hz supply controlled within 0.01 cycles. Monitor

sensors on each side of the mannequins measure the incident energy (E_i) for the mannequin.

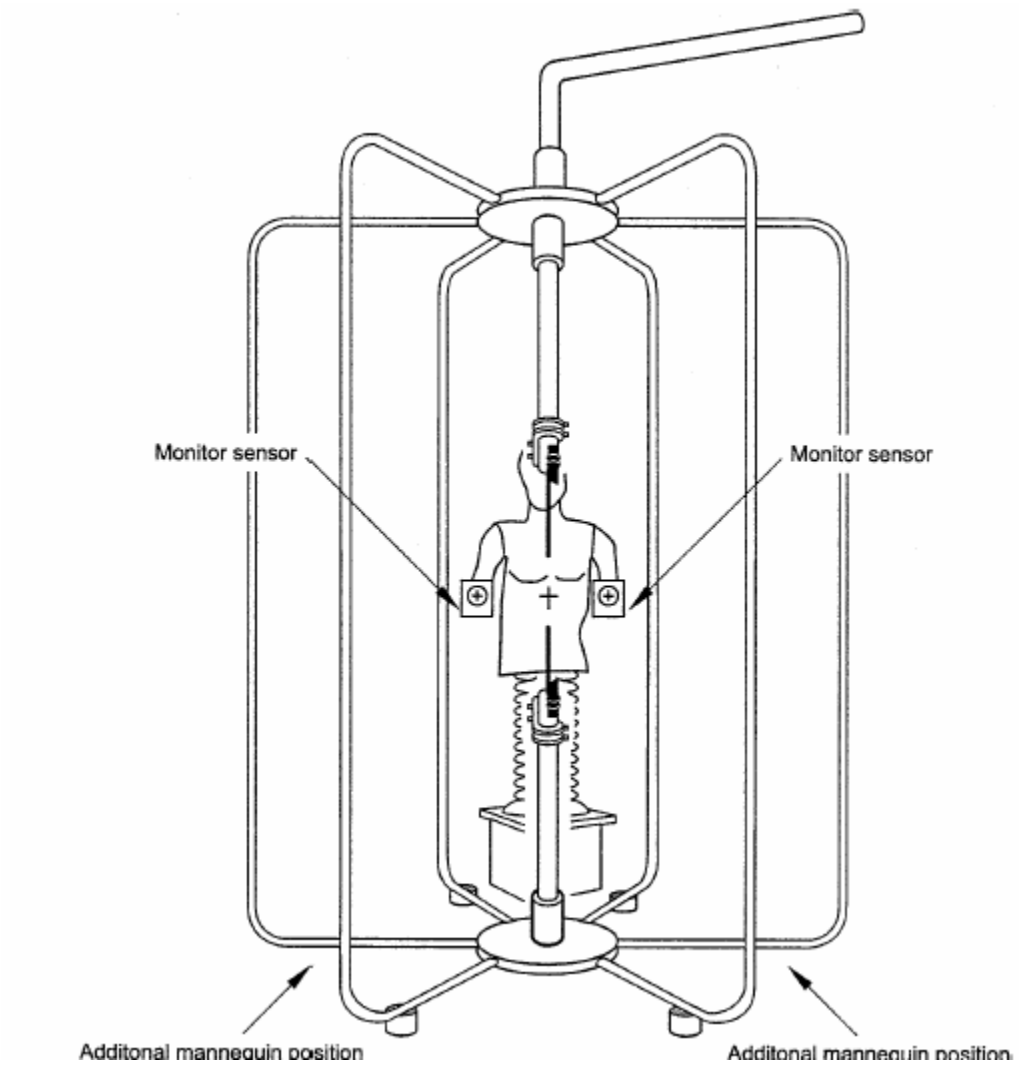


Figure 1 Test Set Up With Cage

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 large currents in the test circuit. The monitor sensors on each side of the panels measure the heat across materials. The temperature rise of the sensors are evaluated to determine the results of each test, however, each test must be evaluated using the recorded data and the visual observations. The arc voltage, current, duration and energy and the temperature rise for each sensor are shown on the attached graphs in the Appendix.

Instrumented Mannequin Head: The head on the mannequin is instrumented and the arc is focused in the center of the nose. The head has

four sensors located in the chin, eyes and mouth locations as illustrated in Figure 2. The standard requires a logistical regression of the point at which the Stoll burn criteria predicts a 50% probability of the onset of second degree burn.

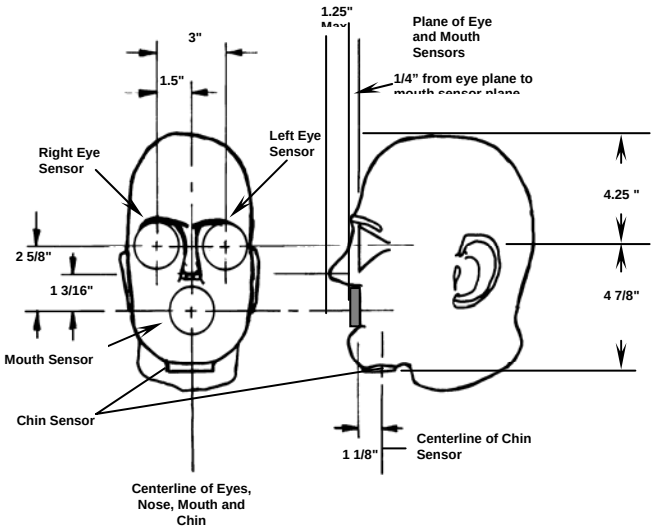


Figure 2

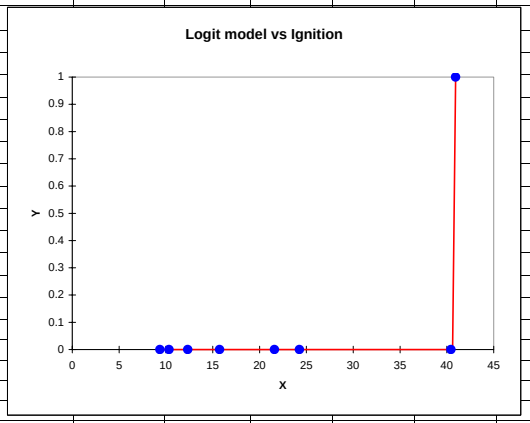
Conclusions: The probabilities of ignition estimates are VERY preliminary due to limited samples.

MSA® Full face, Black, Silicone Respirator
The probability of ignition is probably between 25 to 40 cal/cm² but most likely closer to 40 cal/cm²

Scott® Full face Black silicone respirator with overhead mesh P/N 804057-01
The probability of ignition is probably between 9-15 cal/cm²

MSA® Full face, Black, Silicone Respirator

Test #	E_i	Yes =1 No=0 Ignition	
06-1478A	9.36	0	
06-1478B	12.34	0	
06-1479A	24.26	0	
06-1479B	21.59	0	
06-1480A	40.93	1	Ignition of strapping
06-1480B	40.43	0	
06-1483B	15.73	0	
06-1484B	10.33	0	



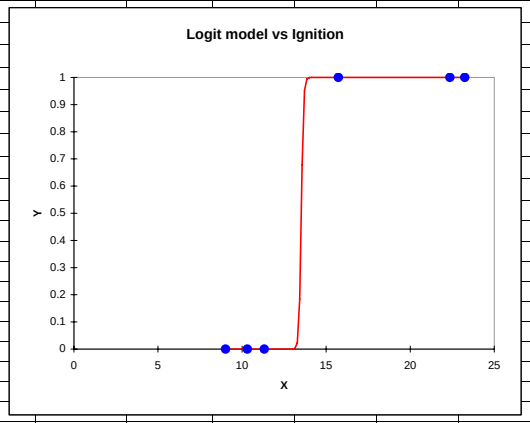
Probability analysis of Ignition Logistic model:

Ignition	Probability	X	
	1%	40.6	cal/cm^2
	5%	40.7	cal/cm^2
	10%	40.7	cal/cm^2
	20%	40.7	cal/cm^2
	30%	40.7	cal/cm^2
	40%	40.7	cal/cm^2
	50%	40.7	cal/cm^2
	60%	40.7	cal/cm^2
	70%	40.7	cal/cm^2
	80%	40.7	cal/cm^2
	90%	40.7	cal/cm^2
	95%	40.7	cal/cm^2
	99%	40.7	cal/cm^2

Probabilities are not accurate because inadequate mixed zone as obtained due to limited samples.

Scott® Full face Black silicone respirator with overhead mesh P/N 804057-01

Test #	E_i	Yes =1 No=0 Ignition	
06-1481A	11.32	0	Slight melting of mesh
06-1481B	10.32	0	Slight melting of mesh
06-1482A	23.25	1	Ignition of all strapping and some of mesh
06-1482B	22.36	1	Ignition of all strapping and some of mesh
06-1483A	15.73	1	Ignition in velcro strapping
06-1484A	9.02	0	Scott and MSA backward. Scott melted onto mannequin head but did not ignite.



Probabilities are not accurate because no mixed zone as obtained due to limited samples.

Probability analysis of Ignition Logistic model:

Ignition Probability	X	
1%	13.2	cal/cm^2
5%	13.3	cal/cm^2
10%	13.4	cal/cm^2
20%	13.4	cal/cm^2
30%	13.5	cal/cm^2
40%	13.5	cal/cm^2
50%	13.5	cal/cm^2
60%	13.6	cal/cm^2
70%	13.6	cal/cm^2
80%	13.6	cal/cm^2
90%	13.7	cal/cm^2
95%	13.7	cal/cm^2
99%	13.8	cal/cm^2