

**Ergodyne, a Division of Tenacious Holdings, Inc.
1021 Bandana Boulevard East Suite 220
US-55108 St. Paul**

Att: ADRIA HARDY

**REPORT ISSUED BY THE RESEARCH ASSOCIATION OF THE TEXTILE
INDUSTRY, AITEX**

N° 2015US0279

Applicant

Ergodyne, a Division of Tenacious Holdings, Inc.
1021 Bandana Boulevard East Suite 220
US-55108 St. Paul

**Date of
reception**

25/11/2015

Date Test

Starting: 02/12/2015
Ending: 14/12/2015

Description and identification of samples

- "MODACRYLIC TWILL FABRIC"

Sample description according to the information supplied by the customer:

Woven fabric, colour black, twill, style Liner shell material, 60% modacrylic, 40% cotton, weight 200 g/m² or 6 oz/yd²

Test Carried out

- ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV OR E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV OR E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Test results

The test program includes minimum of twenty individual panel arc trials.

The following test data was recorded for each trial:

Arc exposure electrical conditions: arc trial number, RMS arc current, peak arc current, arc voltage, arc duration, energy dissipated in arc, plots of arc current and arc voltage.

Temperature rise response from two monitor sensors for each panel in each trial, plot of average responses from two monitor sensors.

Pictures after arc exposure.

Video.

Essential test data and test results are presented in the following pages as follows:

Arc rating: ATPV or E_{BT50} or both and plots of the burn injury probability (ATPV) or break open probability (E_{BT50}) or both versus E_i .

Heat attenuation factor (HAF) and plot of HAF on E_i .

Test specimen description and order of layer.

Distance from an arc center line to the panel surface.

Subjective evaluation.

Pictures after arc exposure.

Ignition probability value (if determined during testing).

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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Standard

ASTM F1959 / F1959M - 13

Test conditions	
Date test.	14/12/2015
Arc current	(8 ± 1) kA
Stainless steel electrodes, gap of the electrodes	(300 ± 5) mm
Distance between the electrodes and sample	(300 ± 5) mm
Fuse wire	0.5 mm
Number of samples tested	21
Starting and ending pre-treatment date	02/12/2015 - 03/12/2015
Starting and ending conditioning date	04/12/2015 - 14/12/2015
Conditioning	24 h; 21 ± 1°C, 65 ± 2 % Hr.

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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Reference MODACRYLIC TWILL FABRIC

Sample type

Woven fabric, colour black, twill, style Liner shell material, 60% modacrylic, 40% cotton, weight 200 g/m² or 6 oz/yd², according information supplied by the customer.

Pre-treatment

3 washing cycles at 49°C, according to standard AATCC 135:2012, method 3IV and type Aiii drying

Washed sample weight before test

210,4 g/m²

Deviation from the standard

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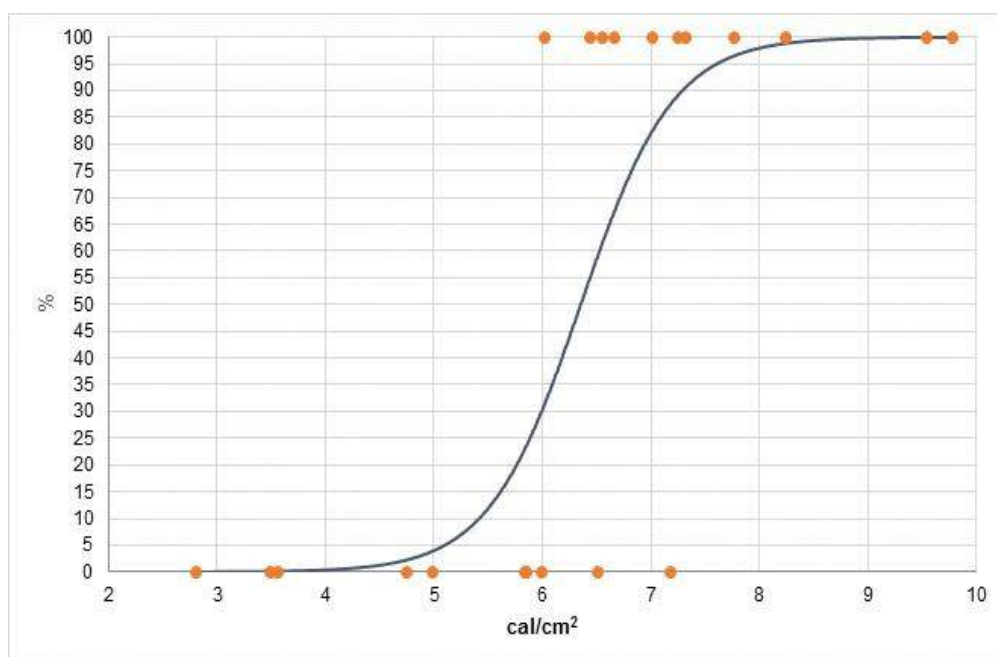


RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Determination of E_{BT50} , 50% of Probability broken

E_{BT50} :	6,4 cal/cm ²
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Probability %	5	10	20	30	40	50	60	70	80	90
E_i cal/cm ²	5,1	5,4	5,8	6,0	6,2	6,4	6,5	6,7	6,9	7,3

E_{BT50} points above	6
E_{BT50} points 20%	12
E_{BT50} points below	8
Points mix zone	7

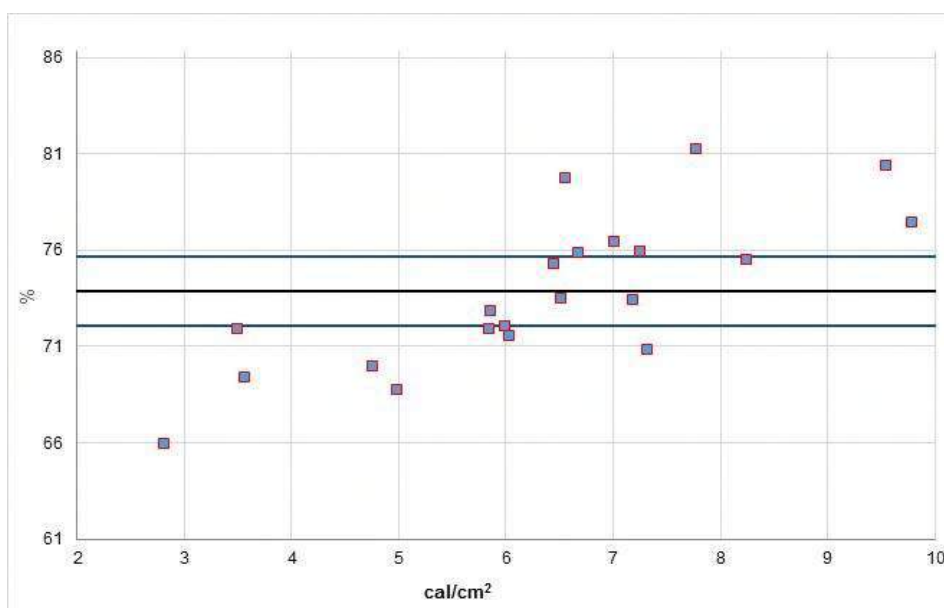
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Determination of HAF, confidence Intervals 95%

HAF:	73,5 %
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% HAF value :	73,5
Upper Confidence Level %:	75,3
Lower Confidence Level %:	71,7
Points above:	7
Points below:	8
Points between:	6
Total Points:	21

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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Summary of measured energy and subjective evaluation:

Test	Time (ms)	Cycles 50Hz	Ei cal/cm ²	SCD cal/cm ²	HAF %	Burn	Break Open
1-A	163,6	8,18	9,8	0,95	77,2	Y	Y
1-B	163,6	8,18	9,5	0,31	80,2	Y	Y
1-C	163,6	8,18	8,2	-0,13	75,2	N	Y
2-A	143,8	7,19	7,3	-0,03	70,6	N	Y
2-B	143,8	7,19	7,2	-0,16	73,2	N	N
2-C	143,8	7,19	7,8	-0,28	81,0	N	Y
3-A	125,8	6,29	6,0	-0,31	71,3	N	Y
3-B	125,8	6,29	6,0	-0,4	71,8	N	N
3-C	125,8	6,29	7,0	-0,33	76,2	N	Y
4-A	103,6	5,18	5,8	-0,36	71,6	N	N
4-B	103,6	5,18	5,0	-0,42	68,5	N	N
4-C	103,6	5,18	6,6	-0,16	79,5	N	Y
5-A	62,8	3,14	3,6	-0,65	69,2	N	N
5-B	62,8	3,14	2,8	-0,73	65,7	N	N
5-C	62,8	3,14	3,5	-0,72	71,6	N	N
6-A	113,2	5,66	6,7	-0,12	75,6	N	Y
6-B	113,2	5,66	6,5	-0,36	73,2	N	N
6-C	113,2	5,66	7,2	-0,32	75,7	N	Y
7-A	103,8	5,19	6,4	-0,4	75,0	N	Y
7-B	103,8	5,19	5,8	-0,45	72,6	N	N
7-C	103,8	5,19	4,7	-0,42	69,7	N	N

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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Summary of measured energy and subjective evaluation:

Test	After flame	Ablation	Melting	Dripping	Charring	Embrittlement
1-A	0,0	Y	N	N	Y	Y
1-B	0,0	Y	N	N	Y	Y
1-C	0,0	Y	N	N	Y	Y
2-A	0,0	Y	N	N	Y	Y
2-B	0,0	N	N	N	Y	Y
2-C	0,0	Y	N	N	Y	Y
3-A	0,0	Y	N	N	Y	Y
3-B	0,0	N	N	N	Y	Y
3-C	0,0	Y	N	N	Y	Y
4-A	0,0	N	N	N	Y	N
4-B	0,0	N	N	N	Y	N
4-C	0,0	Y	N	N	Y	Y
5-A	0,0	N	N	N	Y	N
5-B	0,0	N	N	N	Y	N
5-C	0,0	N	N	N	Y	N
6-A	0,0	Y	N	N	Y	Y
6-B	0,0	Y	N	N	Y	Y
6-C	0,0	Y	N	N	Y	Y
7-A	0,0	Y	N	N	Y	Y
7-B	0,0	N	N	N	Y	N
7-C	0,0	N	N	N	Y	N

Y Yes N No

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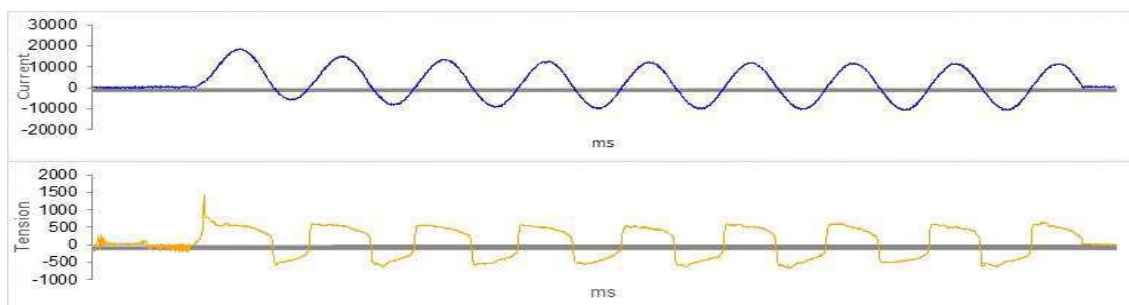
RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

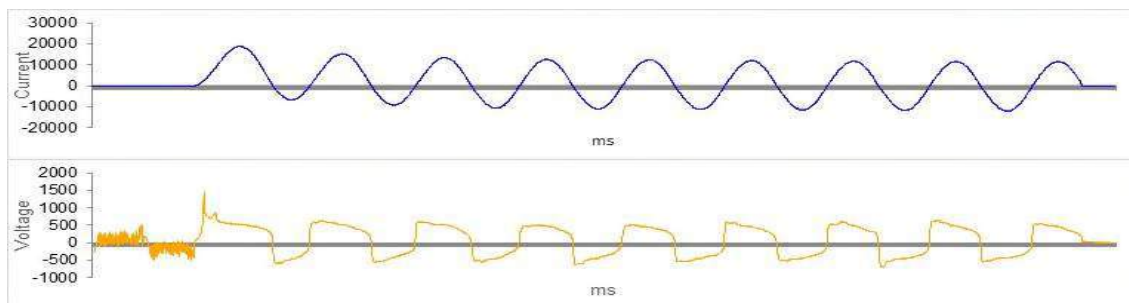
Calibration shot

INITIAL CALIBRATION



Ei Panel A	9,6 cal/cm ²	Ei Panel B	8,3 cal/cm ²	Ei Panel C	7,8 cal/cm ²
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FINAL CALIBRATION



Ei Panel A	8,2 cal/cm ²	Ei Panel B	8,8 cal/cm ²	Ei Panel C	8,4 cal/cm ²
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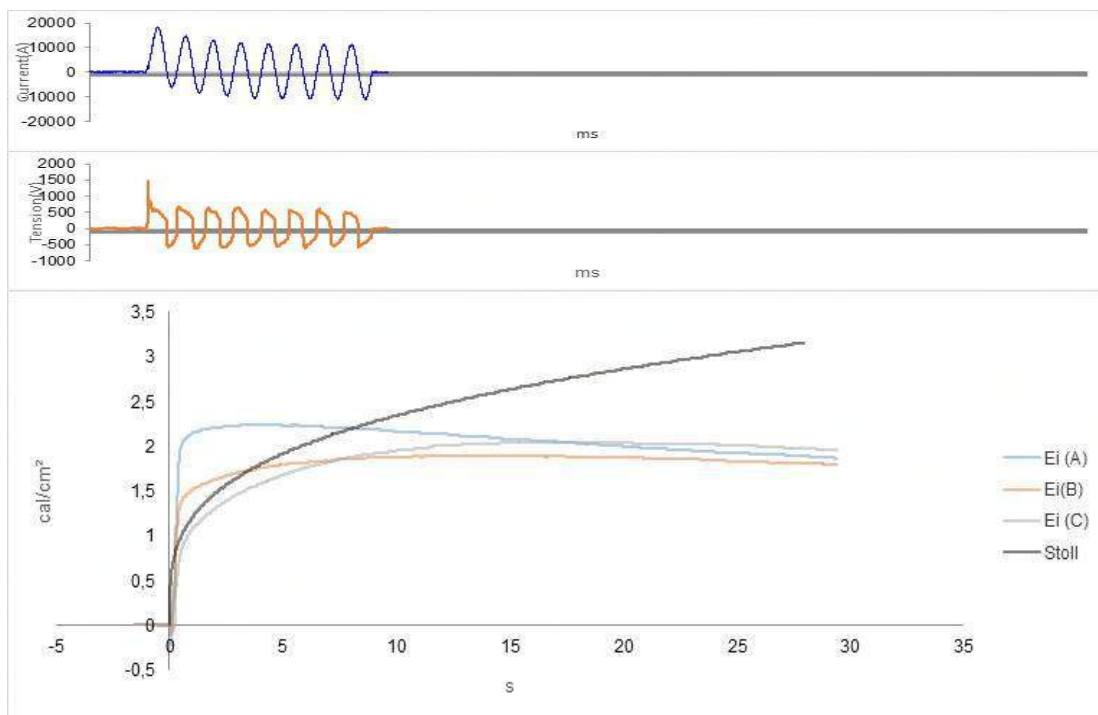
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 1



Current Total RMS (kA)	8,3	Current Peak (kA)	18,3	Arc Voltage (V)	1476,0
Duration (cycles n°)	8,2	Duration (ms)	163,6	Arc Energy (kJ)	561,3

sensor response	PANEL A	PANEL B	PANEL C
Ei	9,78 cal/cm ²	9,53 cal/cm ²	8,24 cal/cm ²
SCD	0,95 cal/cm ²	0,31 cal/cm ²	-0,13 cal/cm ²
HAF	77,15 %	80,15 %	75,20 %

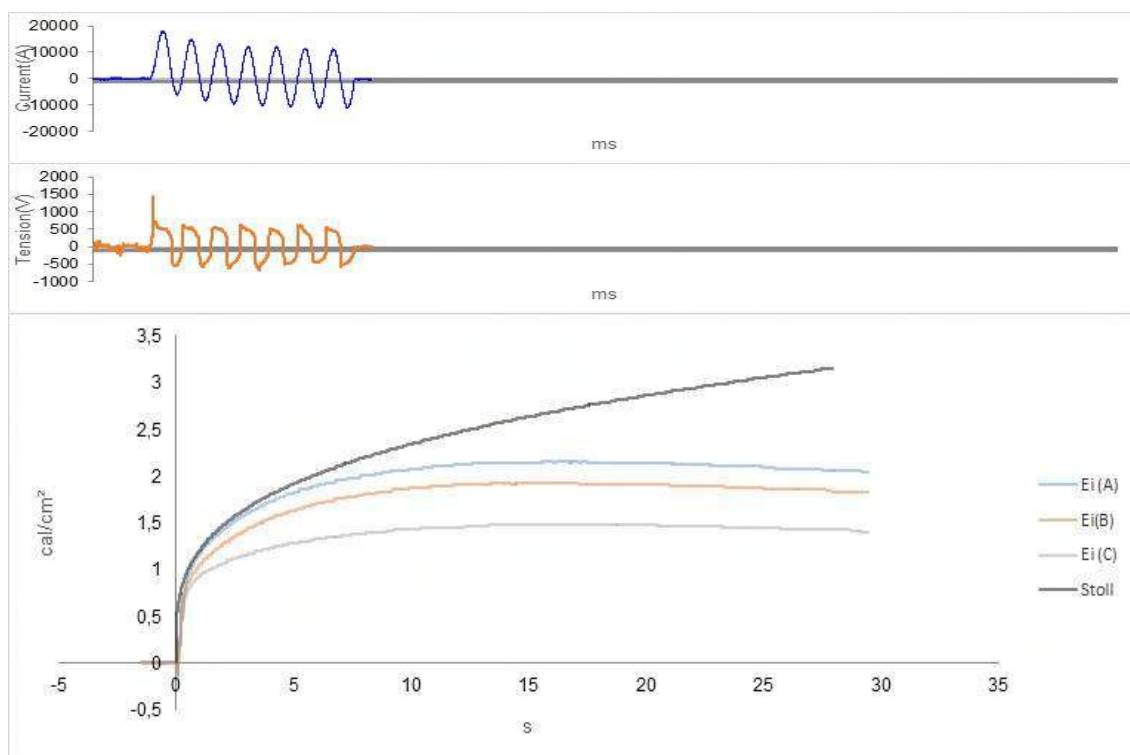
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 2



Current Total RMS (kA)	8,4	Current Peak (kA)	18,2	Arc Voltage (V)	1452,0
Duration (cycles n°)	7,2	Duration (ms)	143,8	Arc Energy (kJ)	483,7

sensor response	PANEL A	PANEL B	PANEL C
Ei	7,31 cal/cm ²	7,18 cal/cm ²	7,76 cal/cm ²
SCD	-0,03 cal/cm ²	-0,16 cal/cm ²	-0,28 cal/cm ²
HAF	70,57 %	73,18 %	80,98 %

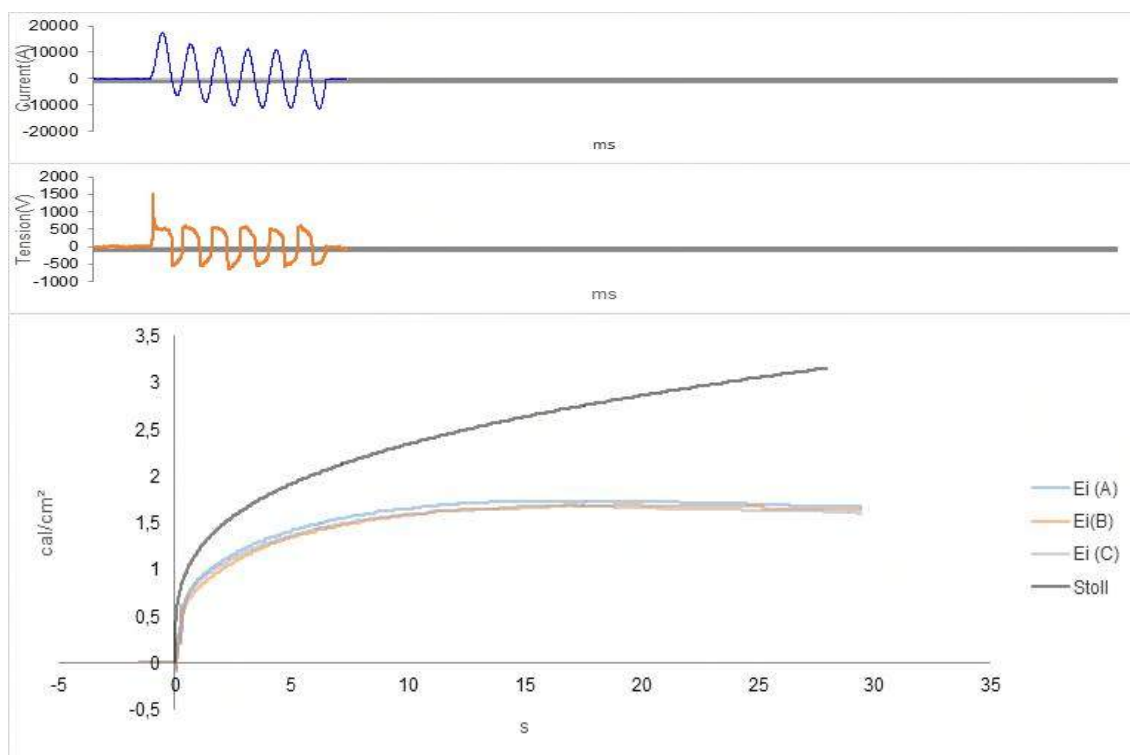
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 3



Current Total RMS (kA)	8,0	Current Peak (kA)	17,6	Arc Voltage (V)	1518,0
Duration (cycles n°)	6,3	Duration (ms)	125,9	Arc Energy (kJ)	414,2

sensor response	PANEL A	PANEL B	PANEL C
Ei	6,02 cal/cm ²	5,98 cal/cm ²	7,00 cal/cm ²
SCD	-0,31 cal/cm ²	-0,40 cal/cm ²	-0,33 cal/cm ²
HAF	71,30 %	71,75 %	76,18 %

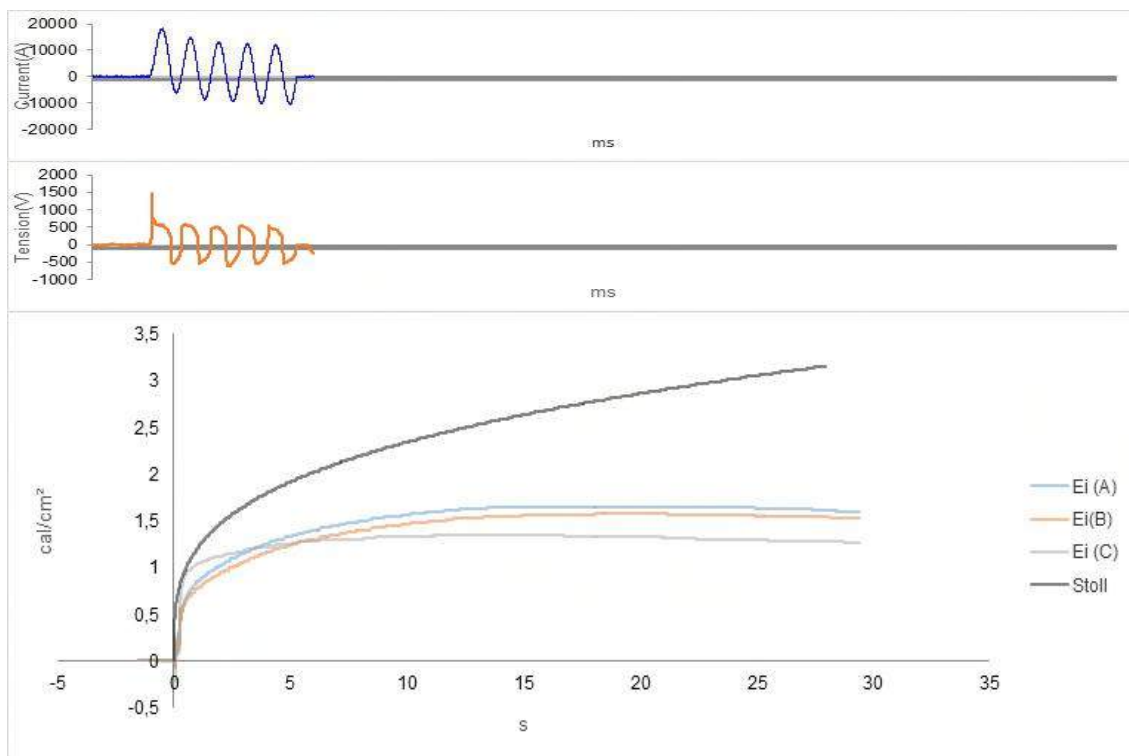
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 4



Current Total RMS (kA)	8,7	Current Peak (kA)	18,3	Arc Voltage (V)	1470,0
Duration (cycles n°)	5,2	Duration (ms)	103,6	Arc Energy (kJ)	361,3

sensor response	PANEL A	PANEL B	PANEL C
Ei	5,83 cal/cm ²	4,98 cal/cm ²	6,55 cal/cm ²
SCD	-0,36 cal/cm ²	-0,42 cal/cm ²	-0,16 cal/cm ²
HAF	71,62 %	68,48 %	79,49 %

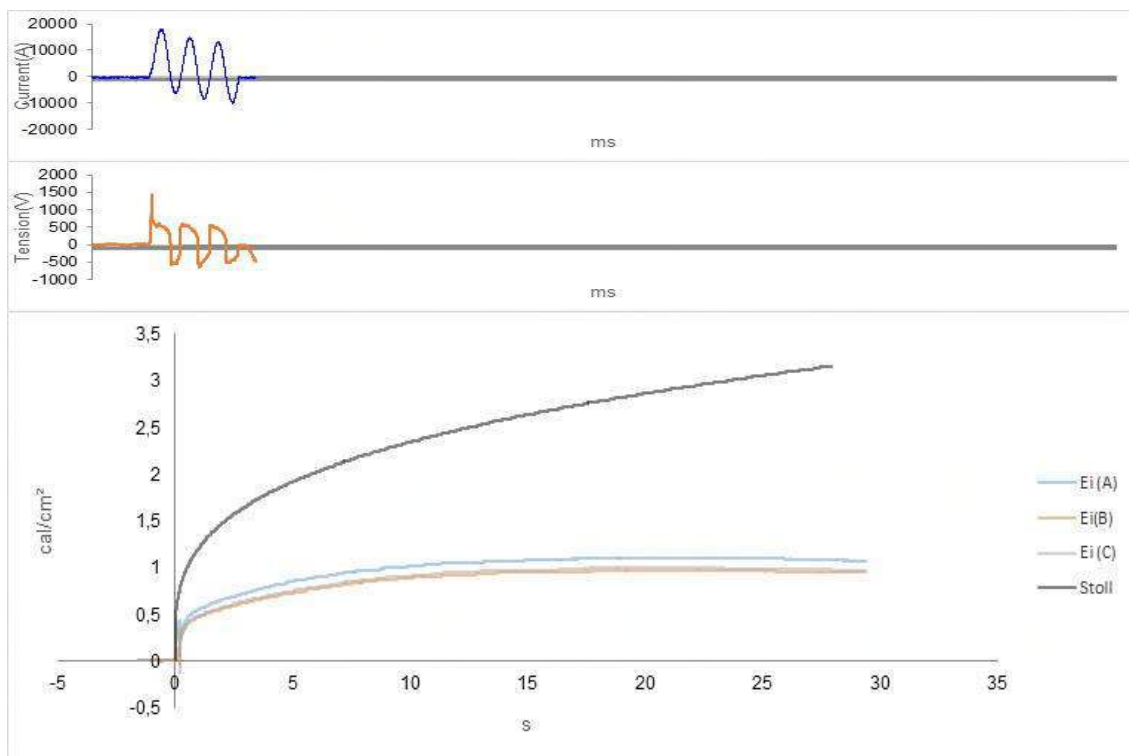
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 5



Current Total RMS (kA)	9,1	Current Peak (kA)	18,1	Arc Voltage (V)	1446,0
Duration (cycles n°)	3,1	Duration (ms)	62,8	Arc Energy (kJ)	232,1

sensor response	PANEL A	PANEL B	PANEL C
Ei	3,55 cal/cm ²	2,80 cal/cm ²	3,48 cal/cm ²
SCD	-0,65 cal/cm ²	-0,73 cal/cm ²	-0,72 cal/cm ²
HAF	69,16 %	65,67 %	71,64 %

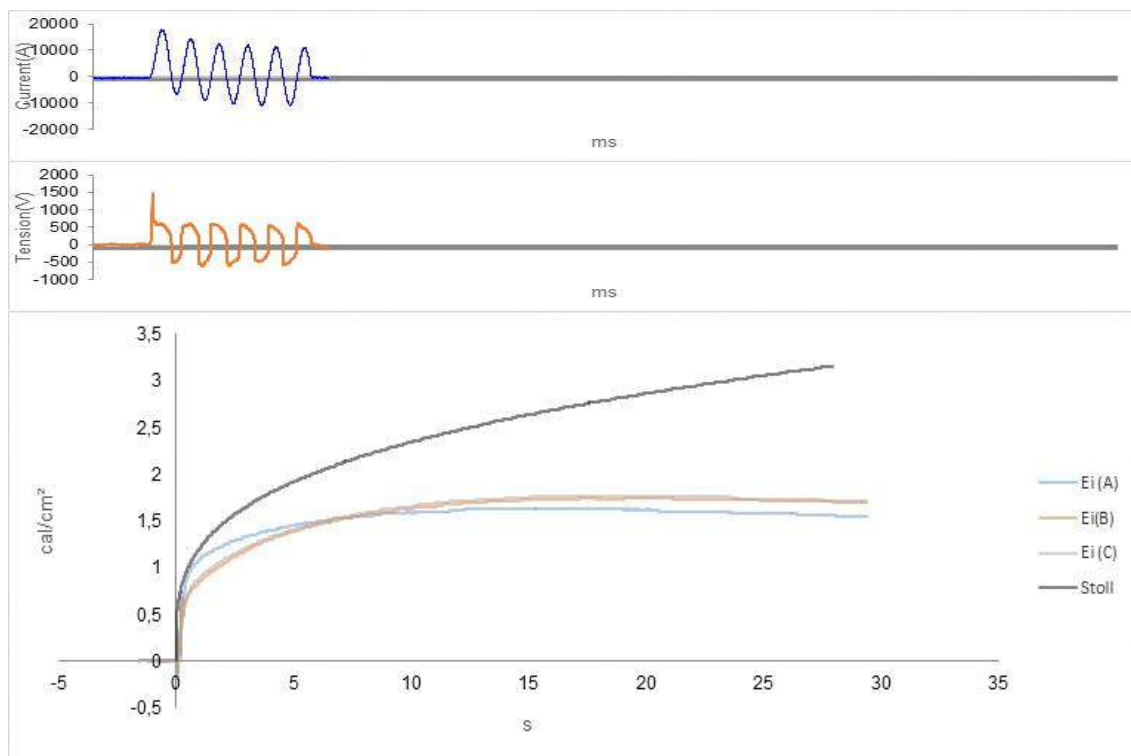
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 6



Current Total RMS (kA)	8,5	Current Peak (kA)	17,9	Arc Voltage (V)	1479,0
Duration (cycles n°)	5,7	Duration (ms)	113,3	Arc Energy (kJ)	404,6

Sensor response	PANEL A	PANEL B	PANEL C
Ei	6,66 cal/cm ²	6,50 cal/cm ²	7,24 cal/cm ²
SCD	-0,12 cal/cm ²	-0,36 cal/cm ²	-0,32 cal/cm ²
HAF	75,56 %	73,22 %	75,69 %

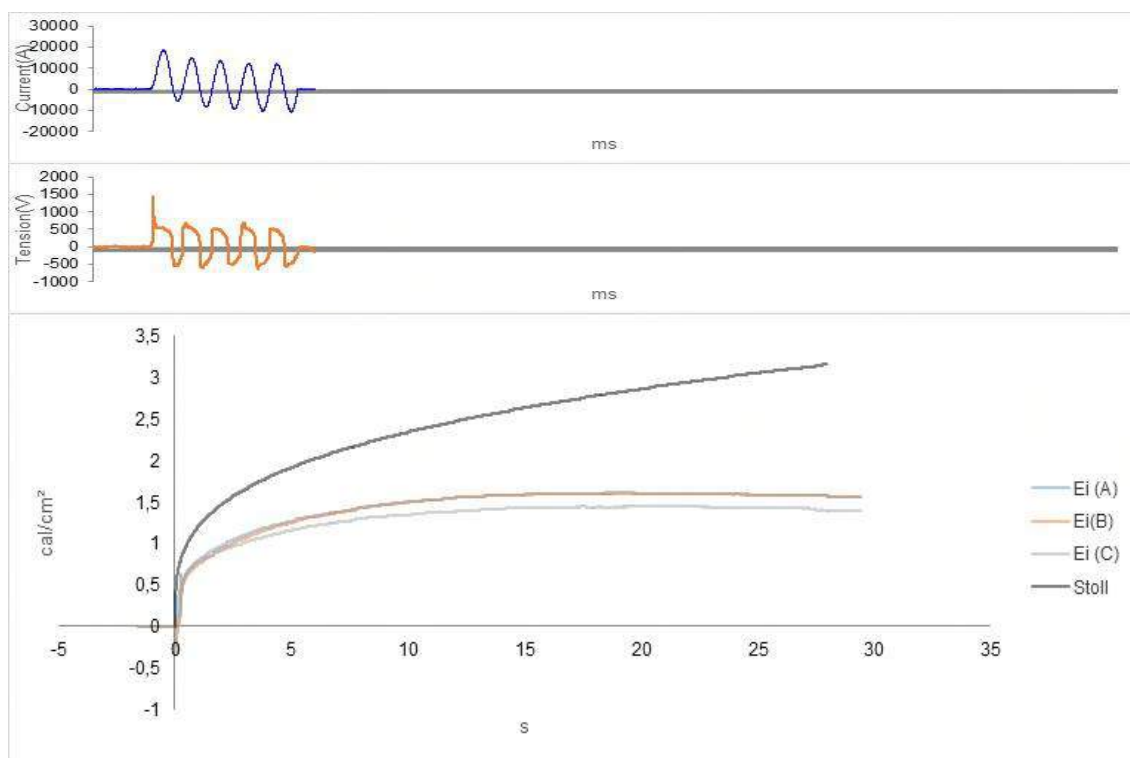
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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Electrical current and response sensor response:

Shot 7



Current Total RMS (kA)	8,7	Current Peak (kA)	18,9	Arc Voltage (V)	1452,0
Duration (cycles n°)	5,2	Duration (ms)	103,8	Arc Energy (kJ)	370,6

sensor response	PANEL A	PANEL B	PANEL C
Ei	6,43 cal/cm ²	5,84 cal/cm ²	4,74 cal/cm ²
SCD	-0,40 cal/cm ²	-0,45 cal/cm ²	-0,42 cal/cm ²
HAF	74,99 %	72,58 %	69,67 %

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RESULTS

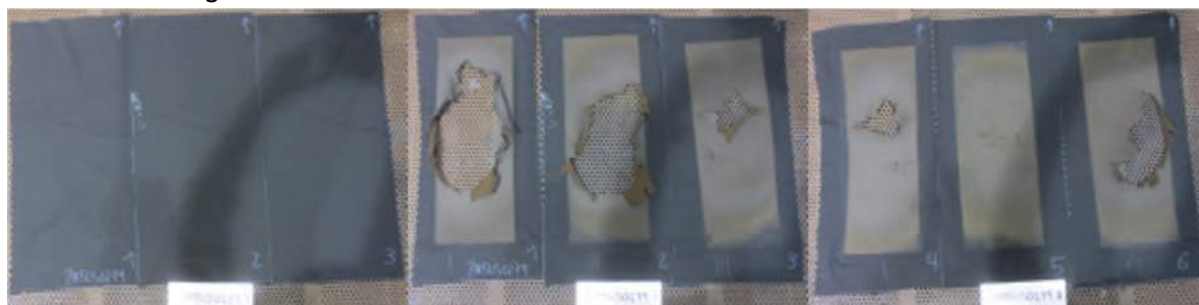
ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Tested material pictures:

Original

Shot 1

Shot 2



Shot 3

Shot 4

Shot 5



Shot 6

Shot 7



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RESULTS

ELECTRIC ARC EXPOSURE TEST: DETERMINATION OF THE ARC RATING (ATPV or E_{BT50}) OF FLAME RESISTANT MATERIALS FOR CLOTHING

Summary of results:

E _{BT50}	6,4 cal/cm ²
HAF	73,5 %

FABRIC TESTED ACCORDING TO THE STANDARD ASTM F1959 / F1959M - 13 FULFILLING THE REQUIREMENTS OF STANDARD ASTM F1506-10a.

ARC RATING

6,4 cal/cm²

Note

*According to ASTM F1506, arc rating values below 10 cal/cm² shall be reported to the nearest 0.1 cal/cm², and arc rating values above 10 cal/cm² shall be reported to the nearest 1 cal/cm².

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Lucia Martinez
Head of PPE's department

P.P

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