

Analyzing the thermal damages of an electric arc

BOX TEST and / versus OPEN ARC

ELECTRIC ARC

An arc, is a conductive electrical interconnection between electrodes of different potentials.



ELECTRIC ARC CONSECUENCES

Increase pressure

- High temperatures
- Hot molten metal splashes
- Heat flow effects
- Noise.
- UV emissions
- Hot oil
- Physical shocks



ELECTRIC ARC How can we avoid worse consequences

- Using appropriate Protective Equipment :
 - Protective clothing shall be worn in the closed state.
 - Use other protective equipment (helmet with face shield, gloves and boots)
- Do not use the PPE's together with garments made with melting fabrics.
- User should not repair teared garments.

ELECTRIC ARC

There are different methods to study the behavior of materials and garments for workers that can be exposed to an electric arc risk:

"BOX TEST"

EN 61482-1-2 PPE CAT III. High risk

"OPEN ARC RATING"

EN 61482-1-1 PPE CAT III. High risk

REQUIREMENTS

EN 61482-2 PPE CAT III. High risk



BOX TEST EN 61482-1-2:2015

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ELECTRIC ARC: BOX TEST Evaluation of materials for "BOX TEST"

Fabrics and garments EN 61482-1-2:2007 EN 61482 -1-2:2014

Gloves AITEX's OWN METHOD, (DEVELOPMENT)

Face shields IEC/CD 62819 (IN DEVELOPMENT) GS-ET-29:2011-05

STANDARD`s AIMS:

- To evaluate garment's thermal protection.
- Consequences not aggravated by clothing itself.

Is based on the generation of an constrained and directed electric arc using a plaster box





"CE" certification for garments

Fabrics:

Samples needed : 4 samples of 500 mm x 500 mm

Requirements: Study the behavior of the material when

it is exposed to an electrical arc and the heat transfer through it.

Garment:

Samples needed: 1 garment

Requirement: analyze pockets, closures, fastening and design elements when garment has been exposed to an electric arc of the class marked by the fabric test.

ACCEPTANCE CRITERIA

Quantitative evaluation

- Eitrans < E stoll
- Afterflame < 5s
- Hole through the inner side < 5mm

Qualitative evaluation

• No melting through the inner side

SAMPLE 1



TEMPERATURE (ºC)

MUESTRA/SAMPLE 2



(S)

0

ENERGIA INCIDENTE TRANSMITIDA

Before Test

After test







FABRIC TEST CLASS 1 4kA



FABRIC TEST CLASS 2 7kA

Garment test

ACCEPTANCE CRITERION Quantitative evaluation

- Afterflame < 5s
- Hole through the inner side< 5mm

Qualitative evaluation

- No melting through the inner side
- Closures continue working



Before Test



After test



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GARMENT TEST CLASS 1 4kA



GARMENT TEST CLASS 2 7kA

ELECTRIC ARC: BOX TEST IEC/CD 62819 FACE SHIELD PROTECTOR ACCEPTANCE CRITERION

Quantitative evaluation

- Eitrans < E stoll
- Afterflame < 5s
- Internal hole < 5mm

Qualitative evaluation

 No melting through the inner side



IEC/CD 62819 FACE SHIELD PROTECTOR

After test





FACESHIELD

ELECTRIC ARC: BOX TEST AITEX OWN METHOD GLOVE TEST ACEPTANCE CRITERION

Quantitative evaluation

- Eitrans < E stoll
- Afterflame < 5s
- Hole through the inner side< 5mm

Qualitative evaluation

 No melting through the inner side



ELECTRIC ARC: BOX TEST AITEX OWN METHOD GLOVE TEST

Before Test

After test







DIELECTRIC GLOVES

S BILEX textile research institute

OPEN ARC EN 61482-1-1:2005

Open Arc laboratory sited in Valencia, Spain, it is a new construction (2012) with the latest technologies.



Special facilities as meetings and showrooms to launch new products.



Two simultaneous testing rooms to offer a very good delivery time.



ELECTRIC ARC: OPEN ARC Evaluated materials for "OPEN ARC"

Fabrics ASTM F1959 / F1959M:2014, EN 61482-1-1:2009

Garments ASTMF2621-12, EN 61482-1-1:2009 ASTM F 1891-12 for rainwear garments

Gloves ASTM F2675/2675M-13, (IN STUDY FOR EUROPE)

Face shields ASTM F2178-12, IEC/CD 62819 (IN DEVELOPMENT)

> Harness ASTM F887-13, (IN STUDY FOR EUROPE)

•The test method is based on the generation of a multidirectional electric arc

•The electrodes are two and vertically opposed 200 to 600

•Samples are located around the electrodes, spaced at a minimum of 120°

1200

•The materials used in these methods are in the form of flat specimens (method A) and garments (method B).

TEST CONDITIONS

Arc duration:

0.05s -1.5s

- The electrodes are made of stainless steel
- Gap between electrodes:300mm
- Gap between the sample and the electrodes:
 300mm
















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FABRIC TEST

1- Incident energy (measured in the monitoring sensors):

Heat energy (total heat), expressed in kJ/m² (cal/cm²) received at a <u>unit</u> surface area as a result of an electric arc

2-Energy "Pass-Through" (measured in the panel sensors):

Heat energy (total heat), expressed in kJ/m² (cal/cm²), which pass through the material.

STOLL CURVE EVALUATION FOR POSSIBLE THERMAL PROTECTION 2nd DEGREE BURNS



The aim of the fabric test

Determine the arc rating (ATPV or EBT50) of materials intended for use in protective clothing for workers exposed to the thermal effects of electric arcs.

ARC RATING

Arc Thermal Performance Value (ATPV), cal/cm²

Incident energy attributed to the 50% probability that heat transfer through the test specimen reaches the Stoll curve (prediction of second degree burn injury) Energy to Break Open Value (Ebt50), cal/cm²

Incident energy attributed to the 50% probability that breakopen occurs

BREAKOPEN

Breakopen dimensions

Area of 300mm²

or

Length of 25mm in any direction



ABLATION

- Physical response evidenced by formation of one or more openings in one or several outer layers of a multilayer system (with the exception of the inner layer)
- Ablation in one or more fabric layers, in a multilayer system, can reduce the energy through the sample



Heat Attenuation Factor (HAF) haf point:

Percentage of the incident energy which is blocked by a material at an incident energy level equal to ATPV





Corriente total RMS (kA) Current Total RMS (kA)	8,1	Corriente Pico (kA) Current Peak (kA)	17,9	Voltaje del Arco (V) Arc Voltage (V)	1518,0
Duración (nº ciclos) Duration (cycles nº)		Duración (ms) Duration (<u>ms</u>)	343,8	Energía Arco (kJ) Arc Energy (kJ)	1142,7

Respuesta de los sensores Sensor plot	PANEL A	PANEL B	PANEL C 18,0 cal/cm ² 0,0 cal/cm ²	
Ei	22,9 cal/cm ²	17,7 cal/cm ²		
SCD	0,2 cal/cm ²	-0,1 cal/cm ²		
HAF	88,7 %	87,0 %	86,8 %	

How is calculated the arc rating? 1st shot



How is calculated the arc rating?

2^{sd} shot



How is calculated the arc rating? 3rd shot





The aim of the garment test Evaluation of the garment response, including all the garment findings, sewing thread, fastenings, fabrics and other accessories.

Tested on a male mannequin torso exposed to an arc, causing an incident energy onto the surface of the garment slightly above the arc rating of the material or the total assemblage of materials

Garment test





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GARMENT TEST

ELECTRIC ARC: OPEN ARC Garment test

Before Test

After test







GARMENT TEST



JACKET 125 cal/cm²



COMPLETE SET

ELECTRIC ARC: OPEN ARC ASTM F2675/2675M:13 Gloves

TEST CONDITIONS

- Is required a minimum of 20 values to calculate the "arc rating" in a statistically safe way
- Obtained values:HAF
 - ATPV or E_{BT} or Ignition₍₅₀₎





DIELECTRIC GLOVES

Face shield

ASTM_F2178=2012 The aim of the face shield test

Determine the arc rating (ATPV or EBT50) of face shield protectors for workers exposed to the thermal effects of electric arcs

ELECTRIC ARC: OPEN ARC ASTM_F2178=2012 Face shield

TEST CONDITIONS

- Is required a minimum of 20 values to calculate the "arc rating" in a statistically safe way
- Obtained values:
 HAF
 ATPV or E_{BT}





FACE SHIELDS

ASTM F887:2013 The aim of the harness test

Evaluation of the harness response, including all the findings, sewing thread, fastenings, fabrics and other accessories when tested on a male mannequin torso exposed to an arc.

ELECTRIC ARC: OPEN ARC ASTM F887:2013 Harness test

TEST CONDITIONS

- It is required a minimum of 6 specimens tested. Three specimens on the forward and three on the back.
- Test energy:
 40 cal/cm²
- Fall:
 - It is required the fall test once tested (point 22.7 of the open arc standard)





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HARNESSES

ELECTRIC ARC

BOX TEST

-Unidirectional

-Current (4kA y 7kA)

-Test time (500ms)

-Distance between elec. 3 cm

-Voltage (400V)

-Results (Pass/Not pass)

ATPV

-Multidirectional

-Current(8kA)

- -Test time (between 50 and 1500ms)
- Distance between electrodes 30 cm
- Voltage (from 2000V)
- Results (Based on a energy)



CURRENT STATUS OF THE ELECTRIC ARC STANDARDS

Review EN 61482-1-1:2009

- Contains parameters not allowed in Directive 89/686/EEC for product certification :
 - ARC RATING includes values that present a possible 2nd degree burn
- Homogenize both arc test methods (BOX TEST AND OPEN ARC)

Review EN 61482-1-1:2009


SOLUTION

Inclusion of the "incident energy limit" (Elim) as the future value of ARC RATING

1st option: ELIM is the higher value of incident energy found below the mixed zone without breaking and without reaching the Stoll curve



2^{sd} option: ELIM is the average of the three highest incident energy data points of the data set below the mix zone without breakopen and without reaching Stoll curve.



ACTUAL STATUS

- Fulfill the PPE's directive
- Homogenize both arc test methods

(BOX TEST AND OPEN ARC)



REVIEW REASONS

Harmonization of concepts and criteria between the two electric arc test methods (BOX TEST AND OPEN ARC)

THE FUTURE IN THE ELECTRIC ARC STANDARDS

CERTIFICATION

- OPEN ARC: Harmonized, homogenised and certifiable (ELIM)
- BOX TEST: Homogenised

DIELECTRIC TEST TO RUBBER GOODS

- Aitex can performance the dielectric tests to:
 - ▶ Gloves IEC 60903, ASTM D120
 - Sleeves IEC 60984
 - Helmets EN 50365
 - ► Footwear EN 50321
 - Blankets IEC 61112 CC
 - Up to 50kV AC and 100kV DC (Class 00 to class 4)



DIELECTRIC TEST TO RUBBER GOODS

Ageings and pretreatments:

- ► Wash&Dry
- Ozone
- Acid

...

- Low temp (-40°C)
- Oil resistance



DIELECTRIC TEST TO RUBBER GOODS





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TEŞEKKÜRLER

Mobile: (+34) 672213814 Email: <u>ocerrada@aitex.es</u> Skype: ocerrada_aitex www.aitex.es