

DETERMINATION OF THE ARC RATING FOR EYE AND FACE PROTECTIVE PRODUCTS

Requesting Agency or Producer (client):

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Test Standard: ASTM F2178/F2178M-20

Test Report: K-580778-2204F05-R00

Test Date: June 29, 2022

Specimen Description:

Hood, Model Number ArcTex30-H,
Lens: Paulson Manufacturing, IM22-AFA2-40-V-HT, Polycarbonate, Grey, Thickness 0.06",
Polycarbonate, Hard Hat: Great Polictrade, MSA V-Gard, Class E, Type I,
Chin Protector: Paulson Manufacturing, Style CB6-HD, Blue,
Fabric: 2 Layers, Westex by Milliken, Style 0451, Twill, 88% FR Cotton, 12% Nylon, Khaki, 9.0
oz/yd² 305 g/m², over Springfield DH65, Twill, 48% Tencel Lyocell, 40% Modacrylic,
12% Para-aramid, Khaki, 6.5 oz/yd² 220 g/m²

Results:

The following arc rating was determined using the iterative procedure (Procedure A) in ASTM F2178-20. The material performance and observations are given in Section 4 of this report.

Arc Rating: Arc Thermal Performance Value, ATPV = 33 Cal/cm²

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For questions about the validity of this test report, please contact testing@arcwear.com



Revision History

Rev	Description		
00	Initial report creation		
	Issue Date	Prepared by	Approved by
	July 6, 2022	Sanket Vohra	Claude Maurice
Rev	Description		
	Issue Date	Prepared by	Verified by

QUALITY MANAGEMENT

The test is performed by Kinectrics Inc. personnel at 800 Kipling Avenue, Toronto, Ontario, M8Z 5G5, Canada to the above-mentioned Standard and accredited by the Standards Council of Canada (SCC) to conform to the requirements of ISO/IEC 17025:2017. Accreditation by the Standards Council of Canada (SCC) is a mark of competence and reliability. A copy of Kinectrics' ISO 17025 certificate of registration is available online at <http://www.kinectrics.com/About-Kinectrics/Pages/Quality-Management.aspx> .

- **The test performed does not apply to electrical contact or electrical shock hazard**
- **The test result is applicable only to the Test Specimens delivered to Kinectrics, other material, garment design or color may have a different response.**
- **It is the clients' responsibility to provide full and accurate information about the items supplied.**
- **No test is done to validate the fiber content or composition of the test item**
- **Photographs of the test specimens and waveforms of the arc current, voltage and calorimeters with the circuit and arc exposure calibration records are available from Kinectrics and provided to the client separately from this report.**

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1 Test Standard:

Electrical arc test according to ASTM F2178/F2178M-20

This procedure is followed for a determination of the arc rating (AR) of either ATPV, EBT or Limit of Use for eye and face protective products under laboratory conditions using a vertical open arc and exposed to a heat flux of approximately 2100 kW/m² (50 cal/cm²s).

1.1 Test Description:

The products covered by this standard are in the form of face shields attached to the head by protective helmets (hard hats), headgear, hood assemblies, safety spectacles or goggles.

Face shields, safety spectacles or goggles are tested with or without other face and head protective products, for example, sock hoods, balaclavas, sweatshirt hoods or jacket hoods.

Although some products may provide coverage on the side and the back of the head, this test method only verifies the arc thermal protection from the front. No exposure from the side or back is performed unless indicated in the test procedure and results. The effectiveness or performance of any rear vents or screen has not been evaluated by this test unless clearly stated in the observation and interpretation of results.

When fabrics are designed into the protection provided for eye or face protective products, the producer is required to first determine the arc rating of the fabric system by test method ASTM F1959/F1959M. Products having a fabric protection product may not require a full iterative test procedure to determine the arc rating provided the level of thermal protection of the lens or visor meets the criteria for following Procedure B.

During the tests, the amount of heat energy transmitted through the specimen is measured and compared to the Stoll criteria. The determination of the Arc Rating (ATPV and/or E_{BT}) is done by logistic regression analysis once the break-open (BO) and Stoll responses are recorded. When break-open to the inside is observed within 20% of the response crossing the Stoll criteria, both values are determined. Material evaluation for ignition, melting and dripping is also recorded.

1.2 Limitations of the Test Method:

This test does not purport to describe or appraise the effect of the electric arc fragmentation or propulsion of parts of equipment or molten metal splatter.

Other effects of an electric arc like noise, light emissions, pressure rise, hot oil, electric shock, and the consequences of physical and mental shock or toxic influences are not covered by this standard. The test result is applicable only to the test item as described and does not cover exchange or compatibility between different manufacturers of similar products. The test performed does not apply to electrical contact or electrical shock hazard. The test articles are tested as received; no test is performed to validate the material or fiber content or composition.



1.3 Requirements for Products Exposed to Electrical Arc:

Based on the reference standard, the following parameters in Table 1-1 constitute a requirement for assigning an arc rating for eye or face protective product. These parameters do not cover all requirements, additional requirements may be necessary to fully comply with the requisites for protective clothing against the thermal hazards of an electric arc.

Table 1-1: Criteria for Determining the Arc Rating

Parameter		Criterion
1	Procedure A	This is an iterative test procedure to determine the Arc Rating requiring a minimum of 20 data points for the logistic regression whose response fulfills the data point distribution requirements.
	Procedure B	This is a performance verification procedure that may be used in place of the iterative procedure when an Arc Rating has been established for the fabric component. A minimum of 6 data points is verified where the incident energy values exceed the fabric system arc rating or designated arc rating, and no sensor data exceeds the Stoll curve or has broken open of the specimen within 10 cal/cm ² of the target Arc Rating.
2	Specimen preparation	Eye and face protective products are a finished product of PPE tested as received.
3	Minimum Arc Rating	An eye or face protective product shall have a minimum AR of 4 cal/cm ²
4	Maximum Arc Rating	Due to the limitation of the test method and specified apparatus, the highest arc rating that can be assigned by this method is 100 cal/cm ² .
5	Arc Rating	The Arc Rating of the eye or face protective product shall not be higher than the lower arc rating of either the fabric system as determined by ASTM F1959, or the shield/visor assembly as determined by Procedure A.
6	Subjective Data	Systems having an arc rating below 20 cal/cm ² shall not exhibit ignition or melting and dripping below 20 cal/cm ² . System having an arc rating equal or higher than 20 cal/cm ² shall not exhibit ignition or melting and dripping in any of the exposures in the testing.
7	Afterflame	The average the afterflame time for all specimens with exergy within 20 % of the arc rating shall not exceed 30 s and no individual test specimen shall exceed 60 s. Any afterflame visible inside the hood through the window shall constitute a failure. Small afterflame instances (candle flame) on the exterior of the hood which does not pose a hazard to a wearer shall not exceed 120 s.

2 Test Condition:

The following test circuit parameters and conditions were used.

Arc current: 8 kA rms \pm 10%, 60 Hz, Nominal Heat Flux: 2100 kW/m² (50 cal/cm²s).
 Arc duration: Varied for range or Ei, Electrode gap: 305 mm \pm 5 mm
 Distance: Panel to electrode: 305 mm \pm 5 mm

Measurement Uncertainty: The measurement uncertainty, MU, for the measured values of this test method are well within the requirements of the test standard and are defined on a 95% confidence interval basis over the full test range, as follows:

Temperature:	\pm 2 °C	Incident Energy:	\pm 1.5%
Arc Current:	\pm 2.5%	Voltage:	\pm 2.5%
Time zero reference:	\pm 3 ms		

Variation in test method or conditions: No variations to standard method or product.

3 Test Specimen:

The test specimens were received by Kinectrics on June 22, 2022 and inspected to be in good condition. The detailed product information provided by the agency and/or producer is given on the front page of this report. When a protector has a rated lens or fabric component such as a hood or bib, the supporting test report number provided by the client is given in Table 3-1. If fabric weight or other measurement are made on the lens by Kinectrics, these are given in Table 3-1. Photographs of the components and product label is shown in Figure 3-1.

Table 3-1: Protector Test Report and Measurements

Protector component supporting test report provided by client: Kinectrics Report - K-418811-1509P11-R00, ATPV = 35 cal/cm ²
Additional protector measurements: Lens - 1.4mm Fabric L1 - 9.92 oz, 336.29 g Fabric L2 - 6.92 oz, 234.59 g"





Figure 3-1: Photograph of tested product and label

4 Results and Observations:

Measurement of after-flame time or ignition and subjective material evaluation was recorded and given in Table 4-1. The comparison of transmitted energy vs Stoll curve criterion was calculated and given in Table 5-1.

A related Annex was also provided containing individual test sheets with the measured values for RMS arc current, peak arc current, arc voltage, arc duration and energy dissipated in the arc. The calorimeter response from each sensor for each of each test shot, photographs of the samples and video are also provided.

4.1 Observations:

Based on the analysis of the video and specimens after the test, the following observations and material evaluation are reported: There was no afterflame or melting and dripping of any component. The lens is heavily charred and has surface flaking of a surface coating. There was break-open of the first layer of the hood material but no penetration to the inside.

**Table 4-1: Summary of Test Data and Observations Near Rating**

Incident Energy range for evaluation, (cal/cm ²):	14 to 44 cal/cm²
Number of samples analyzed:	20
# of specimens having points above Stoll	8
Sensors exceeding Stoll	Eye and/or mouth sensors
Ignition of any materials:	No
Item exhibiting Ignition	None
Average afterflame time (s):	0
Item exhibiting afterflame	None
# of specimens having break-open (to inside):	0
Item exhibiting break-open	None
Melting and/or dripping:	No
Item exhibiting melting and dripping	None
Deformation of lens/window:	No

5 Data and Analysis Details:

A summary of the data from each arc exposure is given in Table 5-1. A plot of the logistic analysis with statistical information is given in Figure 5-1.

Table 5-1: Summary of Specimen Response for Each Test Shot

	Test#	Panel	E _i Cal/cm ²	SCD Cal/cm ²	≥ Stoll	BO	>Stoll sensors	AF Sec.
1	K-580778-1326	A	43.7	0.18	Yes	N		0
2	K-580778-1326	B	35.1	-0.24	No	N		0
3	K-580778-1327	A	40.9	0.11	Yes	N		0
4	K-580778-1327	B	36.5	0.15	Yes	N		0
5	K-580778-1328	A	36.0	-0.14	No	N		0
6	K-580778-1328	B	33.7	0.07	Yes	N		0
7	K-580778-1329	A	35.4	-0.02	No	N		0
8	K-580778-1329	B	30.1	-0.01	No	N		0
9	K-580778-1330	A	26.4	0.14	Yes	N		0
10	K-580778-1330	B	31.5	-0.29	No	N		0
11	K-580778-1331	A	23.5	0.30	Yes	N		0
12	K-580778-1331	B	25.8	-0.16	No	N		0
13	K-580778-1332	A	17.8	-0.15	No	N		0
14	K-580778-1332	B	20.2	-0.24	No	N		0
15	K-580778-1333	A	14.6	-0.12	No	N		0
16	K-580778-1333	B	14.5	-0.20	No	N		0
17	K-580778-1334	A	27.1	0.11	Yes	N		0
18	K-580778-1334	B	32.3	-0.02	No	N		0
19	K-580778-1335	A	26.1	-0.32	No	N		0



20	K-580778-1335	B	33.8	0.16	Yes	N		0

Note: Break-Open (BO) includes observation of Shrink-Open if observed

The Arc Rating indicated in the arc test report for the fabric is ATPV = 35 cal/cm². The ATPV rating as indicated on Lens is 40 cal. Based on observation of burns on the eyes and mouth, the performance of the lens supplied in the hood provided do not meet the printed ATPV = 40 cal/cm².

The ATPV determined for this assembly with this lens is 33 cal/cm² as shown in Figure 5-1. The graph shows a wide mix zone which may indicate variation in the performance of the lens.

5.1 Results of logistic regression:

When sufficient data points are available, the logistic regression analysis is applied. The ATPV or EBT is the value of incident energy corresponding to the 50% probability of exceeding the Stoll criteria or breakopen. The calculated ATPV or EBT is only informative and shall not be considered an Arc Rating unless indicated on the front page of this report. Arc Rating values below 10 cal/cm² are reported to the nearest 0.1 cal/cm², above 10 cal/cm² are reported to the nearest 1 cal/cm².

For determination of ATPV

Points above Stoll:	8
Points above mix zone:	3
Points in mix zone:	13
Points below mix zone:	4
Points within 20% of ATPV:	10

For determination of E_{BT}

Points with BO:	0
Points above mix zone:	0
Points in mix zone:	0
Points below mix zone:	0
Points within 20% of EBT:	0

Based on the analysis, ATPV = 33.4 cal/cm²

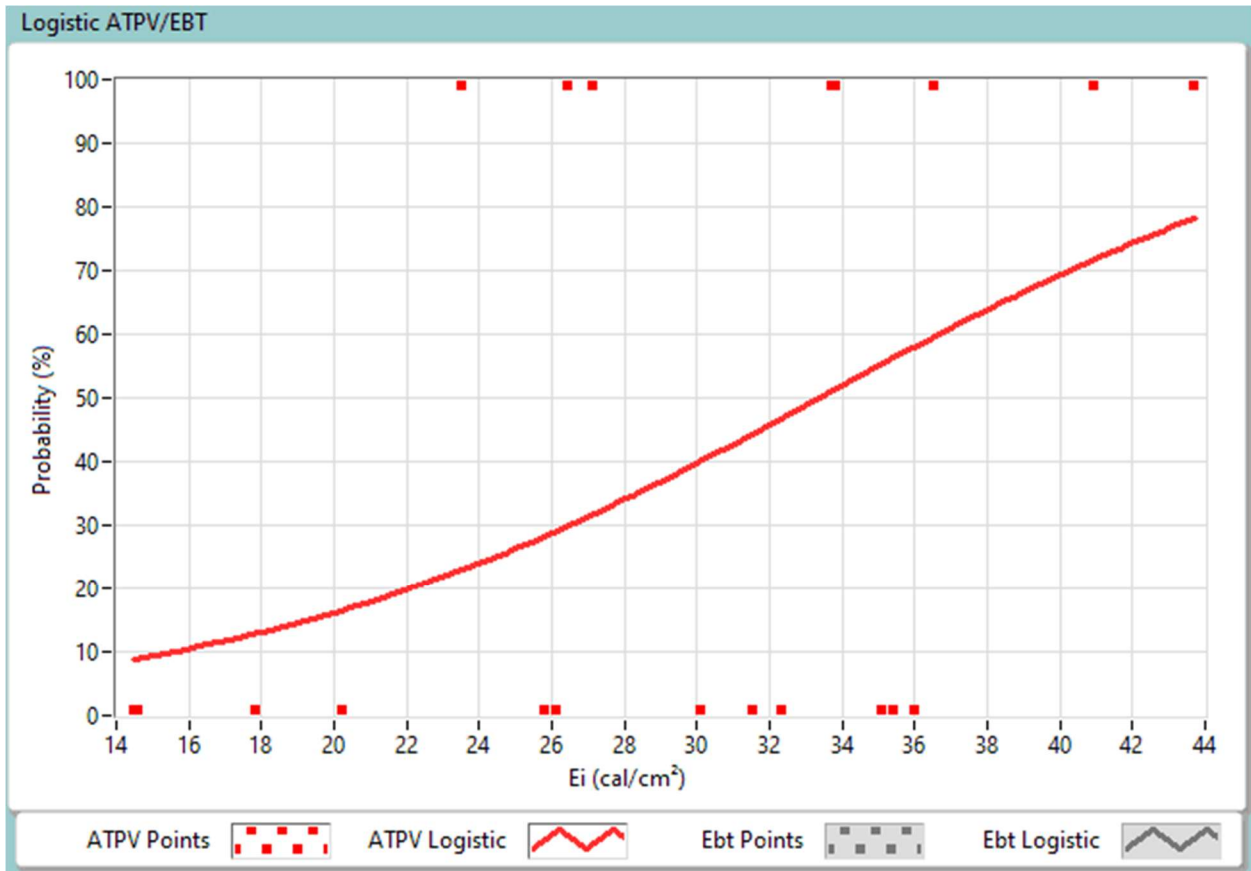


Figure 5-1: Plot of incident energy data points vs. probability with logistic regression for determination of ATPV and/or E_{BT}.

6 Photographs:

Selected photographs of the samples are shown in Figures 6-1 and 6-2.



Figure 6-1: Photograph of a specimen as tested before the arc exposure.



Figure 6-2: Photograph of a specimen after the arc exposure.

Note: arc exposure incident energy level near the Arc Rating of the material.