

DETERMINATION OF THE ARC RATING FOR EYE AND FACE PROTECTIVE PRODUCTS

Requested by:

OEL
PO Box 445
Palmer Lake, CO 80133

Test Standard: ASTM F2178/F2178M-23a

Test Report: K-581314-2406F10-R00

Test Date: September 12, 2024

Specimen Description:

Hood, AFW40LF-BS-GTX,
Lens: Paulson, Model 40 Cal 3-PHASE / 3p40-h /9045000, Polycarbonate
Hard Hat: MSA Style 475358, Class E, Type 1
Fabric: W. L. Gore & Associates, Style W/O # EU 05991505, 8.7 oz/yd² 295 g/m²
Laminate with Knit Face and Woven Back, 25% Polyamide, 35% ePTFE,
20% FR Viscose, 19% Aramide,
1% Carbon Fiber, Blue Face, Gray Back

Results:

The following arc rating was confirmed using the performance verification Procedure B in ASTM F2178-23a. The lens has charring and surface flaking but no melting and short afterflame time. The hood fabric is charred and some flaking of the top layer laminate. The material performance and observations are given in Section 4.

Arc Rating: AR_{LIM} = 40 cal/cm²

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Revision History

Rev	Description		
00	Initial report creation		
	Issue Date	Prepared by	Approved by
	October 15, 2024	Claude Maurice	Stacy Klausing
Rev	Description		
	Issue Date	Prepared by	Verified by

For questions about this test report, please contact Contact.ArcWear@Kinectrics.com

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-23a

This procedure is followed for a determination of the arc rating of either ATPV, EBT or AR_{LIM} for eye and face protective products under laboratory conditions using a vertical open arc and exposed to a heat flux of approximately 2100 kW/m^2 ($50 \text{ cal/cm}^2\text{s}$).

1.1 Test Description:

The products covered by this standard are in the form of faceshields attached to the head by protective helmets (hard hats), headgear, hood assemblies, safety spectacles or goggles. Faceshields, safety spectacles or goggles are tested with or without other face and head protective products, for example, sock hoods, balaclavas, sweat shirt 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 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 previously established for the fabric component (F1959). 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	AR _{LIM}	The maximum arc thermal energy protection that has been assigned to the finished product. AR _{LIM} may be set equal to or lower than the ATPV of the component having the lowest Arc Rating after verification with testing.
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 (Hood or balaclava) as determined by ASTM F1959 or the shield/visor or other component part of the assembly as determined by ASTM F2178.
6	Thermal Performance	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 samples were received by Kinectrics on July 22, 2024 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, if provided by the client, is given in Table 3-1. The actual arc rating of the fabric is not verified or confirmed by the test in this report and the fabric report shall be obtained from the original requesting agency.

Photographs of the components and product label is shown in Figure 3-1.

Table 3-1: Protector Test Report and Measurements

Protector component information provided by Agency: Fabrics Arc Rating: Kinectrics Report #: K-352152-1912P04, 2019 Report ATPV = 43 cal/cm ²
Additional protector information: Measured Lens Thickness: 2.2 mm

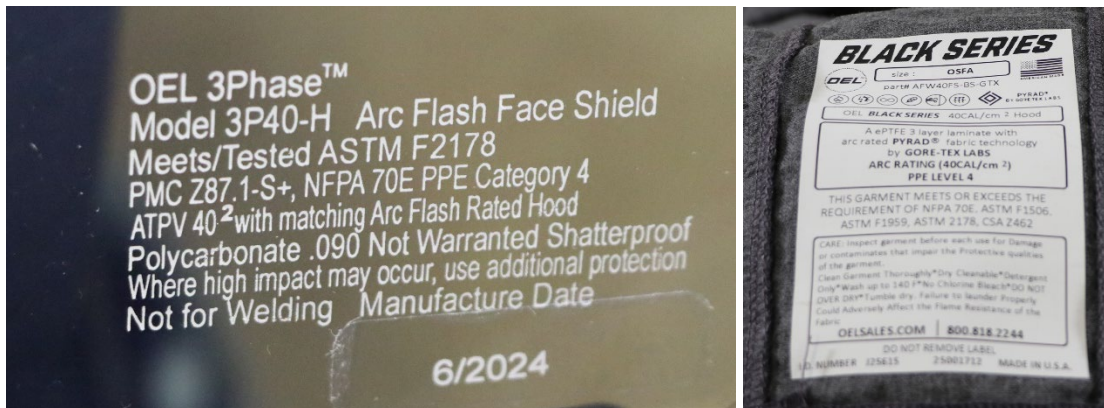


Figure 3-1: Photograph of tested product and label



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:

In the incident energy range tested, the front of the shield is charred and covered in black ashes on the surface. Slight deformation of the lens was observed. The fabric is charred with some flaking of the top layer laminate. The front bib is charred and has some shrinkage and tends to curl upward at the bottom edge. The observed afterflame is indicated in Table 5-1.

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

Arc Rating requested by Agency:	40 cal/cm²
Incident Energy range for evaluation, (cal/cm ²):	44 to 60 cal/cm²
Number of samples analyzed:	6
# of samples having points above Stoll	0
Sensors exceeding Stoll	N.A.
Ignition of any materials:	NO
Item exhibiting Ignition	--
Average afterflame time (s):	1
Item exhibiting afterflame	Lens or visor
# of samples having break-open (to inside):	0
Item exhibiting break-open	N.A.
Melting and/or dripping:	NO
Item exhibiting melting and dripping	--
Deformation of lens/window:	Slight deformation



5 Data and Analysis Details:

A summary of the data from each arc exposure is given in Table 5-1.

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

	Test#	Panel	Ei Cal/cm ²	SCD Cal/cm ²	≥ Stoll	BO	AF Sec.
1	K-581314-2985	A	48.3	-0.52	No	N	1
2	K-581314-2985	B	55.0	-0.39	No	N	1
3	K-581314-2986	A	54.5	-0.45	No	N	1
4	K-581314-2986	B	60.2	-0.58	No	N	1
5	K-581314-2987	A	43.7	-0.45	No	N	1
6	K-581314-2987	B	49.4	-0.36	No	N	1

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

5.1 Interpretation of Results:

The purpose of Procedure B is followed to establish performance verification once the arc rating protective level of the fabric is known.

Based on the test results and observation, the assembly tested meet the requirements of Procedure B in Table 1-1 for validating an arc rating. A minimum of 6 data points were obtained having the incident energy value exceed the arc rating and having no sensor data exceed the Stoll curve or breakopen of the specimen within 10 cal/cm² of the specified arc rating.

For the purpose of the evaluation, the arc exposure level is higher than the indicate arc rating of the fabric, but the item of PPE shall not be used above the Arc Rating indicated by the producer.

6 Photographs:

Selected photographs of the samples are shown in Figures 6-1 to 6-4. Photographs of all samples tested are provided in the data package with this report. In some cases the fabric is very weak after the arc exposure and may exhibit break-open when removed from mannequin.



Figure 6-1: Samples as tested before the arc exposure.

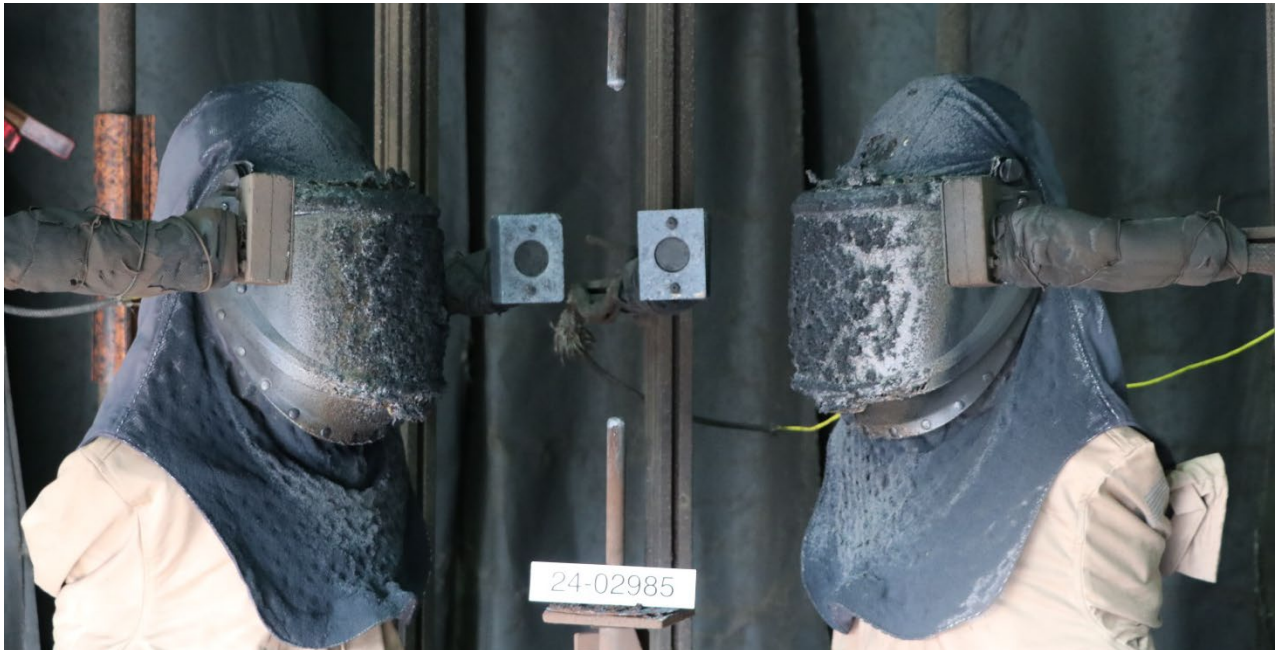


Figure 6-2: Samples after the arc exposure, 48, 55 cal/cm².



Figure 6-3: Samples after the arc exposure, 44, 49 cal/cm².



Figure 6-4: Sample after the arc exposure, 49 cal/cm².