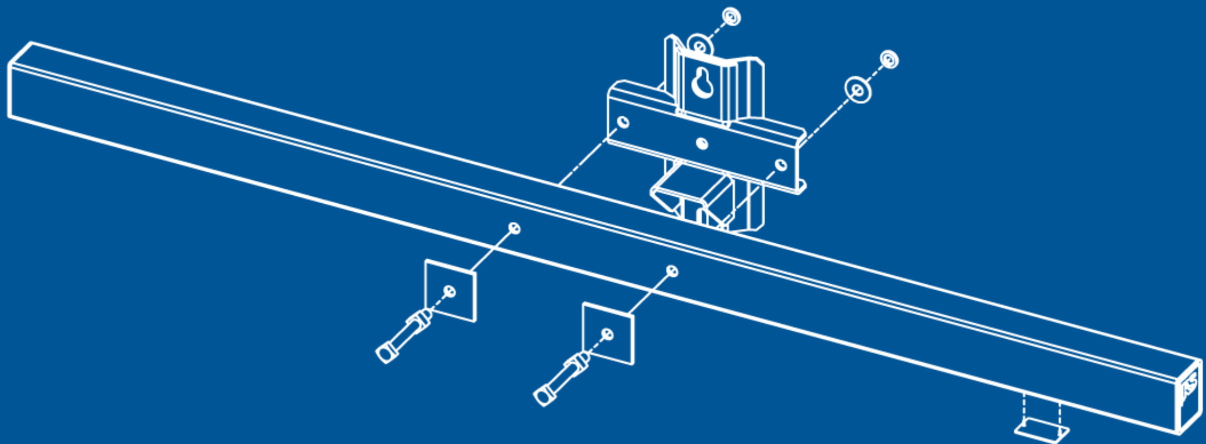
RS-TIS-CA V1.1

TECHNICAL INFORMATION SUMMARY

RS PowerON™ Crossarms

PowerON™
Crossarms



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TESTING APPROACH

The testing required for development and certification of RS PowerON™ Crossarms has been carefully considered. RS PowerON™ Crossarms followed a comprehensive test plan guided by industry standards, using world class third-party labs in conjunction with our industry aligned in-house testing facilities to certify the product. This document summarizes the extensive tests completed for the RS PowerON™ Crossarms. For further detailed questions, or to receive copies of the supporting technical bulletins, please contact RS Technologies Inc. at info@RSpoles.com.

TEST METHODS

IEEE 4-2013	Standard for High-Voltage Testing Techniques
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D2584	Ignition Loss of Cured Reinforced Resins
ASTM D3039	Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
ASTM D3171	Standard Test Methods for Constituent Content of Composite Materials
ASTM D5961	Standard Test Method for Bearing Response of Polymer Matrix Composite Laminates
ASTM D6641	Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials Using a Combined Loading Compression (CLC) Test Fixture
ASTM D8019	Standard Test Method for Determining the Full Section Flexural Modulus and Bending Strength of Fiber Reinforced Polymer Crossarms Assembled with Center Mount Brackets
ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Non-metallic Materials

STANDARDS & REFERENCES

NESC C2:2017	National Electrical Safety Code
G.O. 95	Rules for Overhead Electric Line Construction
CSA 116:18	Fibre-reinforced polymer composite crossarms
1728H-701	RUS Specification for Wood Crossarms
1728F-803	RUS Specification and Drawings for 24.9/14.4 kV Line Construction
1728F-804	RUS Specification and Drawings for 12.47/7.2 kV Line Construction

RS PowerON™ CROSSARM DESIGN FEATURES

Fiber-reinforced polymer (FRP) composite crossarms are widely used throughout overhead electrical systems. While all composite crossarms have superior performance advantages over wood crossarms, RS's exclusive use of polyurethane resin results in the highest performing composite crossarms available. The information in this section further details the RS advantage.

Industry Standard Cross-Section

Standard 3-5/8 in. x 4-5/8 in. [92.1 mm x 117.5 mm] profile with gentle corner radiuses for durability and ease of handling.

Highest UV Performance

Only 100% UV stabilized aliphatic polyurethane resin is used in the composite material. This provides the highest UV protection available of any resin system resulting in the longest service life.

Longest Service Life

The industry leading UV stability of the aliphatic polyurethane composite structure combined with the polyurethane topcoat work together to result in a minimum service life of **80 years** (**20 years longer than any other competitor**), based on accelerated weathering and UV testing. This enables service life matching with RS's PowerON composite poles, resulting in the longest service life for a total no scheduled maintenance, highest resilience system solution. The use of UV stable aliphatic resin results in proven UV protection in the event that the topcoat is damaged over the course of the service life.

Highest Structural Performance

Due to fiber wet out optimization, polyurethane resin enables the highest fiber volume possible in the finished laminate, resulting in the strongest crossarms per unit volume. When paired with an RS PowerON composite pole, this results in the most effective system solution for resilient grid hardening.

Clear Allowable Load Calculations

Some composite crossarm manufacturers quietly recommend a maximum working load of only 50% of their arm's mean ultimate strength. As a true engineered composite material, RS's low coefficient of variation (CoV) of the ultimate load values enables a straightforward 5% lower exclusion level (LEL) approach for allowable load calculations. RS clearly publishes the 5% LEL allowable load which permits the line designer to easily select the correct PowerON crossarm for the application. Furthermore, RS's low CoV results in an allowable load that is almost 100% more than competitors using the 50% strength reduction approach with the same beam size and similar initial mean ultimate loads.

Field Drillable & High Torque Capable Without Inserts

RS PowerON Crossarms can be field drilled anywhere on the centerline of the crossarm without the use of any secondary inserts due to high density closed cell polyurethane foam (10 pcf) throughout the interior of the crossarm. This high-density foam provides additional side wall support and ensures superior torque resistance. Torque values over 400 ft.-lb. [542 Nm] can be achieved using 5/8 in. [M16] or 3/4 in. [M20] bolts when coupled with the proper hardware.

No Permanent Deformation of Brackets in High Loads

Center mount tangent and deadend brackets exhibit no permanent deformation when tested to the maximum rated load values.

Permanently Affixed Endcaps

Endcaps are permanently affixed to the crossarm using a patent-pending internal mechanical attachment method. This internal self-locking mechanism completely eliminates loss of endcaps in the field.

Lowest Moisture Ingress

Fiber-reinforced aliphatic polyurethane composites have the lowest water ingress compared to crossarms manufactured with other resin systems. Per RS testing, saturation is less than 1.5%. This very low moisture ingress reduces moisture swelling effect on the composite laminate, thereby ensuring the longest life with no structural degradation. After 5,000 hours, there is less than 10% degradation in resin dominated compression strength (per ASTM D6641) and flexural strength (per ASTM D790) after QUV exposure with alternating sunlight and moisture cycles.

Highest Dielectric Properties

Demonstrated higher Basic Insulation Level (BIL) performance in lightning flashover tests. This is attributed to the integrity of the aliphatic polyurethane composite, resulting in higher glass fraction, combined very low moisture ingress potential and high density closed cell foam filling. After greater than 1,000 kV flashover testing, no arc damage was present as verified through burning or tracking indications on the structure. The 1,000 kV test exposure is over twice as high as the next reported competitive value.

No Hazardous Air Pollutants

The RS polyurethane resin system contains no hazardous airborne pollutants (HAPs) or volatile organic compounds (VOCs) in production. Polyester resin, used by most other manufacturers, contains volatile solvents such as styrene, which is reasonably anticipated to be a human carcinogen, according to the Department of Health and Human Services (DHHS) and National Toxicology Program (NTP). The PU resin creates an inert material with no residual trapped solvents when cured that is environmentally safe with absolutely no leaching of chemicals.

No Rot, No Leaching

Fiber-reinforced polyurethane composites will not rot or decay like wood arms. The composite material is inert and will not interact with other materials or leach preservatives into the environment.

Impervious to Insects

There are no food sources for insects to pursue with the inert polyurethane-based composite, given the absence of organic matter as found in wood. Composite material is fully dense with no surface porosity, therefore the material is of no interest to insects to penetrate further.

STRUCTURAL TESTING

Structural performance of RS PowerON™ Crossarms has been verified through extensive mechanical testing conducted on coupon level (ASTM D790, D3039, D6641) and on full scale crossarm articles (ASTM D8019).

Coupon level testing was completed at Owens Corning Laboratory in Granville, OH at different intervals of QUV exposure from 1,000 hours up to 8,000 hours to determine structural degradation rate following continued QUV exposure. The recent analysis at 5,000-hour threshold coupon data shows no reduction of mechanical properties including tension, compression and shear; QUV exposure degrades the resin binding system supporting the glass fiber and is measured through flexural/compressive strength degradation over the exposure timeframe.

The full scale crossarm structural testing was conducted at RS Technologies Inc. in Tilbury, Ontario using test fixture built in compliance with the ASTM D8019 standard, including test execution and test reporting requirements (see Figure 1).

Figure 1 – Full-scale crossarm test fixture per ASTM D8019 at RS Technologies Inc.

Crossarms were tested to failure for each configuration including tangent and deadend assemblies. Ultimate loads and deflections were recorded for each side of the crossarm. The mean and standard deviation were computed for each crossarm configuration, and the Coefficient of Variation (COV) was determined accordingly. Based on data analysis, a 5% lower exclusion limit (LEL) ultimate load was determined for each crossarm configuration for vertical and horizontal loading. The 5% LEL ultimate load values and deflections were tabulated for each configuration.

ULTRAVIOLET (UV) RADIATION PROTECTION AND WEATHERING EXPOSURE TESTING

RS has a long history of developing industry-leading UV resistant polyurethane products. RS PowerON™ Crossarms utilize an aliphatic polyurethane resin system combined with E-glass fibers to form the composite arm. Additionally, a secondary two component polyurethane coating is applied to achieve long lasting 80-year service life performance. These details are illustrated in Figure 2.

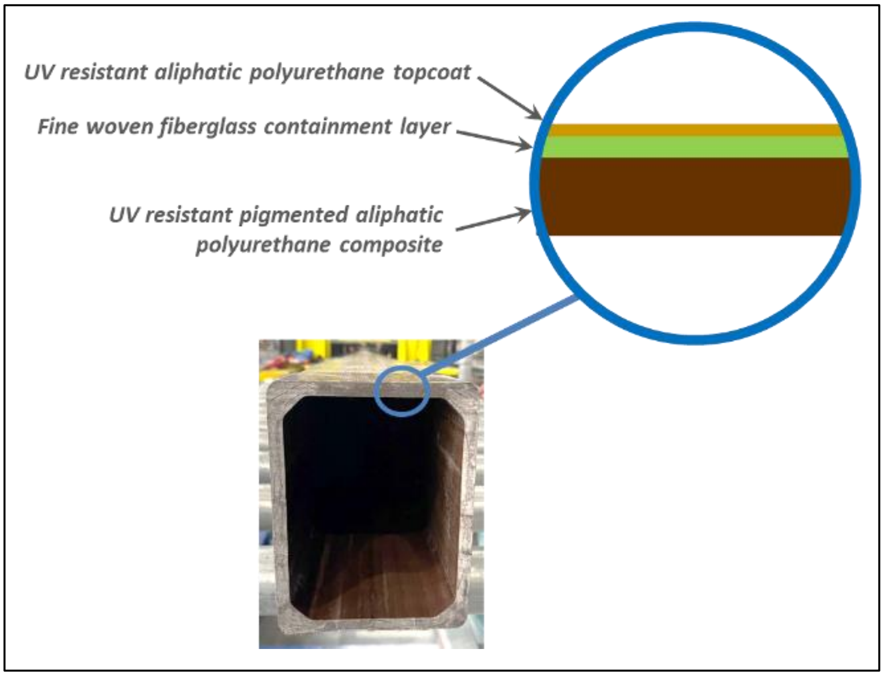

Figure 2 – Description of weathering exposure protective system for PowerON™ Crossarms.

Using the ASTM G154 standard and the QUV chamber for controlled accelerated exposure testing, RS has developed significant experience with external QUV lab testing, internal QUV testing and field correlation with composite structures in service. The effects of weathering and UV are conducted using ASTM G154 Cycle 1, which uses a UVA-340 lamp with 0.89 W/m^2 and exposure cycle of 8 hours UV at 140°F [60°C] black panel temperature, followed by four hours of darkness with condensation at 122°F [50°C] black panel temperature. Measurements were conducted on the uncoated polyurethane composite substrate and the polyurethane coating over composite substrate. The results of UV testing are as follows:

- Polyurethane Composite Substrate = 8,745 hours = 40 Years in Miami, FL
    a. Test sample feels rough to touch;
    b. Some gloss present on test sample;
    c. No fiber blooming visible;
    d. Test sample has a faded area and has light appearance of color;
    e. No loose fibers seen under microscope.

- Polyurethane Coating = 8,000 Hours = 37 Years in Miami, FL
    a. Retains gloss and color at 90% of original; and
    b. Minimal sign of any breakdown or erosion.

The performance of the crossarm system can be characterized by the additive effect of the polyurethane composite substrate QUV performance plus the two-component polyurethane coating QUV performance. Therefore, total accumulated QUV exposure is determined as:

Polyurethane Composite Substrate + Polyurethane Coating = 8,745 + 8,000 = 16,745 hours

This total accelerated exposure duration is equivalent to 77 years in Miami, FL without any fiber blooming. Furthermore, the superior color and gloss retention of the RS Polyurethane Coating after 8,000 hours means that the RS crossarm will retain hydrophobicity longer than any other crossarm product on the market, which translates into superior electrical performance over the life of the crossarm.

The industry has moved to a minimum of 10,000 hours exposure requirement without any indication fiber blooming. Based on the above data, the RS PowerON™ Crossarm system will far exceed the 10,000 hours of QUV exposure with no indication of fiber blooming, passing the test and ensuring the longest life available on the market today. PowerON™ Crossarms have a minimum service life of 80 years.

MAXIMUM BOLT TORQUE TESTING

This test was conducted to investigate the bolt torque required to crush the walls of the pultruded RS PowerON™ Crossarms. The crush test results were used as a reference for acceptable maximum bolt torques for hardware installation on RS Crossarms. Five bolt torque tests were conducted on the five different crossarm samples. The tests were conducted on the 3-5/8 in. [92.1 mm] side of the crossarm using a 3/4 in. [M20] bolt and a 3-1/2 in. x 3-1/2 in. x 3/8 in. [89 mm x 89 mm x 9.5 mm] flat square washer and a manual torque wrench fitted with a digital torque adaptor. The holes used were located approximately 4 in. [102 mm] from the end of the test samples.

The through-bolt was installed with 3-1/2 in. x 3-1/2 in. x 3/8 in. [89 mm x 89 mm x 9.5 mm] flat square washers on both top and bottom faces of the crossarms. The nut was installed by hand until tight. A manual torque wrench was used to apply increasing installation torque to the through-bolt nut. A digital torque adapter was used to measure the torque at any given instant. Maximum possible torque was applied in each case to try and reach the failure of crossarm walls. However, no failure was observed on any samples. The torque was applied to reach the maximum capacity of the wrench (600 ft.-lb. [813.5 Nm]; the reported torque values for all the tests were between 500 ft.-lb. and 563 ft.-lb. [677.9 Nm and 763.3 Nm].

In summary, RS PowerON™ Crossarms can withstand at least 400 ft.-lb. [542.3 Nm] of torque load on a through-bolt connection with no significant deformation of the structure. RS recommends 75 ft.-lb. [101.7 Nm] of torque on the crossarm walls to ensure tight connection with lock washers. There is no advantage of applying more excessive torque on composite crossarms, as their coefficient of thermal expansion is similar to steel so they do not experience the shrinkage found in new wood arms that cause additional hardware tightening maintenance to avoid connections loosening over time. A 1/4 in. washer thickness is recommended for high torque applications exceeding the recommended torque levels.

Some cracks were observed in the foam at certain loads below maximum torque values, but no crack in the composite were identified. The only permanent deformation present was in the flat square washers, the spring washers and nuts in some samples at high torque loads.

INSULATOR PIN TORQUE TESTING

To ensure that the bearing strength of the RS PowerON™ Crossarms was adequate to handle the transverse loads of standard insulator pins mounted through the crossarm structure, a test was to replicate a transverse loading along the arm axis. A crossarm insulator pin with 1 in. [25.4 mm] nylon thread, 6 in. [152.4 mm] shaft length for insulator standoff and shank of 5/8 in. [15.9 mm] diameter x 6.5 in. [165.1 mm] length for mounting and securing through the crossarm was mounted and installed with flat square washers on each side and nut to secure the crossarm.

Failure loads of 1,151-1,354 lb. [5.12-6.02 Nm] were achieved at which point the insulator pin yielded in all cases without any audible or visual indication of composite laminate failure. Upon disassembly of the hardware, there was no indication of laminate damage or bearing issues with the composite hole opening. This result for standard insulator pins exceeds the (RUS) requirements for sustaining a 750 lb. [3.34 Nm] load without the composite crossarm wall crushing.

ELECTRICAL TESTING

All electrical testing was conducted at Powertech Labs in British Columbia, Canada using an RS crossarm mounted with brace-less center mount bracket.

Lightning Flashover

The test crossarms were mounted on a wooden pole (as shown in Figure 3) and subjected to 15 positive and 15 negative lightning impulses using the up-and-down method. The voltage was applied between the insulator mounting pins simulating the spacing of the two outermost electrical phases. After testing, the crossarms were subjected to an insulation resistance test along all suspect tracking paths. They were then dissected into 7-7/8 in. [200 mm] long sections centering on the mounting pin holes. The flashover voltage was corrected for atmospheric conditions in accordance with IEEE4, method 1. Average flashover results were 1301.6 kV positive and 1078.0 kV negative. The Coefficient of Variation (COV) for the three crossarms was below the 10% standard required for both positive and negative polarities. There was no visible burning or tracking and no internal damage to the composite matrix, resulting in a successful test.

Figure 3 – Electrical testing of RS PowerON™ Crossarms at Powertech Labs.

Power Frequency Flashover Under Dry Conditions

The crossarms were mounted on a wooden pole and subjected to five flashovers using a 60 Hz voltage source (see Figure 3). The voltage was raised to the flashover levels from approximately 75% of the expected flashover value at a rate of approximately 2% per second. The voltage was applied between the insulator mounting pins that would simulate the spacing of the two closest electrical phases. After testing, the crossarms were subjected to an insulation resistance test along all suspect tracking paths. They were then dissected into 7-7/8 in. [200 mm] long sections centering on the mounting pin holes. The flashover voltage was corrected for atmospheric conditions in accordance with IEEE4, method 1. Average results were 137.9-147 kV with a COV of 2.8%. There was no visible burning or tracking and no internal damage upon dissection, resulting in a successful test.

Power Frequency Flashover Under Wet Conditions

The crossarms were mounted on a wooden pole and subjected to five flashovers using a 60 Hz voltage source. The voltage was raised to flashover from approximately 75% of the expected flashover value at a rate of approximately 2% per second. The voltage was applied between the insulator mounting pins that would simulate the spacing of the two closest electrical phases. After testing, the crossarms were subjected to an insulation resistance test along all suspect tracking paths. They were then dissected by cutting 20 cm long sections centering on the mounting pin holes. The flashover voltage was corrected for atmospheric conditions in accordance with IEEE4, method 1. Average results were 53.4-60.8 kV with a COV of 5.4%. There was no visible burning or tracking and no internal damage upon dissection, resulting in a pass for this test.

Power Frequency Flashover After Thermal Cycling Conditioning

The crossarms were subjected to a flexural loading, equivalent to 50% of the rated vertical load, in an environmental chamber over a temperature range of -50°C to 50°C for 4 x 24 h cycles. Half the load was applied to each end of the crossarms.

Applied load:	3,000 lb. [1,361 kg] (50% of 6,000 lb. [2,722 kg] rated load)
Withstand Test voltage:	129.1 kV
Applied voltage:	128.9 kV (corrected for atmospheric conditions)

After removal from the environmental chamber, the crossarms were subjected to a 1-minute power frequency withstand test at 90% of the average flashover voltage determined in the dry flashover test above. NO external flashovers were observed, and there was no visible tracking or burning on any of the crossarms, resulting in a pass for this test.

CROSSARM TECHNICAL DATA

RS PowerON™ Tangent Crossarms

Beam Type: Series 30
Beam Profile Size: 3-5/8 in. x 4-5/8 in. [92.1 mm x 117.5 mm]

Bracket Type	Part Number	Crossarm Length		Mean Ultimate Vertical Load Per Side		5% LEL Allowable Vertical Load Per Side		Deflection per 1,000 lbs. [4.4 kN]	
		in.	mm	lb.	kN	lb.	kN	in.	mm
Standard Duty	T30S0072I	72	1830	10,790	48.0	9,730	43.3	0.18	4.6
	T30S0096I	96	2440	8,820	39.2	7,700	34.3	0.45	11.4
	T30S0120I	120	3050	6,860	30.5	5,900	26.3	0.79	20.1
	T30S0144I	144	3660	5,100	22.7	4,400	19.6	1.54	39.1
Heavy Duty	T30H0072I	72	1830	10,930	48.6	9,890	44.0	0.18	4.6
	T30H0096I	96	2440	9,740	43.3	8,580	38.2	0.44	11.2
	T30H0120I	120	3050	8,530	38.0	7,560	33.7	0.76	19.3
	T30H0144I	144	3660	7,360	32.7	5,830	25.9	1.52	38.6

RS PowerON™ Deadend Crossarms

Beam Type: Series 30
Beam Profile Size: 4-5/8 in. x 3-5/8 in. [117.5 mm x 92.1 mm]

Bracket Type	Part Number	Crossarm Length		Mean Ultimate Longitudinal Load Per Side		5% LEL Allowable Longitudinal Load Per Side		Deflection per 1,000 lbs. [4.4 kN]	
		in.	mm	lb.	kN	lb.	kN	in.	mm
Standard Duty	D30S0072I	72	1830	14,700	65.4	13,880	61.7	0.17	4.3
	D30S0096I	96	2440	13,150	58.5	12,330	54.9	0.38	9.7
	D30S0120I	120	3050	11,840	52.7	11,070	49.2	0.73	18.5
	D30S0144I	144	3660	10,590	47.1	9,850	43.8	1.35	34.3
Heavy Duty	D30H0072I	72	1830	16,270	72.4	15,300	68.1	0.15	3.8
	D30H0096I	96	2440	15,240	67.8	14,190	63.1	0.37	9.4
	D30H0120I	120	3050	13,870	61.7	12,890	57.3	0.71	18.0
	D30H0144I	144	3660	12,430	55.3	11,510	51.2	1.28	32.5