



RS Composite Utility Pole Inspection and Maintenance Guide

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1 Introduction

Composite poles have been successfully used in transmission and distribution grid applications since the 1960's. The RS composite utility pole has ultra-violet (UV) protection integrated into the pole wall laminate enabling the pole to achieve its exceptionally long service life without requiring scheduled maintenance.

This guide details the performance expectations of RS poles over their service life and recommends various inspection procedures which are designed to supplement a utility's existing inspection work methods. RS Technologies Inc. (RS) recommends that a utility adhere to their established grid infrastructure inspection frequency until such time as the utility elects to decrease the inspection frequency for RS composite poles.

Although scheduled maintenance is not required, the hardware attachments on RS composite poles will need to be maintained in accordance with a utility's work methods and/or the hardware manufacturer's recommendations. Damage to the pole over the course of its service life may necessitate repair and/or replacement of RS modules

2 General Information

The RS modular utility pole's composite material consists of glass fiber (continuous roving E-glass) and a proprietary polymer matrix system containing both aromatic and UV stable aliphatic polyurethane resin.

Non-UV stable composite materials are susceptible to degradation from prolonged exposure to UV light. When combined with other weathering factors such as high temperature and moisture, UV exposure may promote even greater surface damage to a composite as these factors often work together to cause more harm than any one factor acting alone.^[1] The possible damage caused by weathering and UV light exposure includes loss of gloss, color fading, yellowing, cracking, checking, chalking, embrittlement, loss of mechanical strength and de-lamination. In extreme cases, such damage may eventually lead to glass exposure (fiber blooming) resulting from the breakdown of the resin from the outermost reinforcing glass fibers.

To prevent the damaging effects of UV light and achieve an extended service life for products made with fiber reinforced polymers (FRP), some composite product manufacturers have used various methods such as paint and veil cloth coatings on the outer surface to place a physical barrier between the composite and the weathering factors. Although coatings are commonly used in the industry and may be initially effective, they can be easily scratched and damaged, thereby decreasing their protective benefits.

RS Technologies integrates a highly UV stable aliphatic polyurethane system into the outer layer of the sidewall (or laminate) of all modules to protect RS poles from UV degradation and virtually eliminate maintenance. Incorporating a UV barrier in the pole wall composition is unique in the composite utility pole industry. RS's continuous winding process produces a monolithic laminate with an integrated UV solution that will last for the life of the pole, and eliminates the need for scheduled maintenance.

It is well documented that products containing UV stable aliphatic polyurethanes have achieved long service lives in various architectural and industrial applications. In addition to good weathering properties, polyurethane parts made using aliphatic isocyanates also provide excellent chemical resistance.^[2, 3, 4]

3 RS Testing

3.1 Accelerated Weather Testing of RS Poles

It is critical to test the long term durability, weatherability and UV light stability of composite grid infrastructure products. Natural exposure testing is the best method to use, since it is realistic, inexpensive and easy to perform, however the duration of the tests would need to be measured in years, not hours. Accelerated weathering test methods are used in conjunction with longer term natural exposure tests to provide more immediate predictive results.

Two commonly used accelerated test options are xenon arc (Q-Sun) light stability tests (ASTM G 155-05a: Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials) and fluorescent UVA (QUV) accelerated weathering tests (ASTM G 154-06: Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials). These tests provide relatively fast and reproducible results. The xenon arc method is essentially an attempt to reproduce sunlight itself, within the 295-800 nm range. The QUV method does not attempt to reproduce sunlight, just the damaging effects of the UV-A band of sunlight that occurs in the 300-400 nm range. It is based on the concept that short-wave UV causes the most weathering damage for polymeric materials exposed outdoors. While a xenon arc tester is a better match with sunlight in the long-wave UV and visible spectrum, the QUV method, with UVA-340 nm lamps, provides the best available simulation of sunlight in the critical short-wave UV region. [1]

Non-UV stabilized FRP parts exposed to short-wave UV light typically exhibit signs of degradation such as gloss deterioration, strength loss, yellowing, cracking, crazing and embrittlement. A major benefit of using the QUV method is that it allows the most realistic simulation of UV exposure combined with moisture. Because most of this moisture is the result of dew, the QUV uses a unique condensation mechanism to reproduce outdoor moisture.

The QUV accelerated weathering test was selected by RS and was combined with mechanical testing to observe and evaluate any degradation of the material. Mechanical tests were performed on each sample, after a designated QUV exposure time, to determine the extent, if any, of changes in the mechanical properties of the laminate in comparison to those of unexposed control samples kept from the same pole section.

To allow for the determination of the QUV test acceleration factor, an aliphatic resin top-layered pole manufactured in April 2005 was placed outside in Calgary, Alberta, Canada, such that it would be exposed to natural sunlight and weathering. The QUV test started at the Q-Lab Weathering Research Service Center in Florida, USA, on May 26, 2005 and finished in March, 2007 using ten test samples, with one reserved as a control sample for visual observation.

The sizes of the samples were calculated in order to obtain a minimum of three specimens each for flexural strength and modulus, plus inter-laminar shear strength (according to the ASTM Standard D 790 and ASTM D 2344, respectively) at each exposure interval. The test specimens were cut from the exposed block one inch away from the edges, so as not to have the edge effect on the results (See Figure 1).

Exposed samples were mechanically tested at the following intervals (in hours): 500h, 1,000h, 2,000h, 4,000h, 6,000h, 8,000, 10,000h, 12,000h and 14,000h and a visual observation report was prepared by Q-Lab. The exposed sample at the end of the test is shown on the left in Figure 1.



Figure 1: Weathering and UV Exposed Sample vs. Control Sample. (14,010h of QUV exposure on the left, with the unexposed control sample on the right). The one inch edge as shown on the exposed sample was removed prior to testing.

Based on 14,010 hours of accelerated QUV and 2.5 years of natural sunlight exposure testing, it was determined that RStandard poles have an expected service life of 80 years with an approximate 30% strength decrease at the end of the service life. Table 1, below, lists the predicted flexural strength retention at different geographical areas after different service periods based on the life prediction model.^[5] In all cases, RS internal safety factors have been applied to RS pole performance specifications that exceed 130% so that even after 80 years of service, pole strength will remain at the initial published values and pole performance will continue to satisfy application requirements.

Location	10 years	20 years	40 years	60 years	80 years
Calgary, Alberta	92%	87%	82%	80%	79%
Tucson, Arizona	88%	83%	80%	76%	74%
Toronto, Ontario	88%	83%	79%	77%	75%
Miami, Florida	84%	79%	76%	72%	70%

Table 1: Laminate flexural strength retention for different locations and service periods.

RS poles have been placed in service in many harsh UV and humidity environments (examples are Western Texas, Brazil, Mexico and the Caribbean islands) since 2006 with no reported changes in appearance or performance since their installation.

3.2 Electrical Testing and Performance of RS Poles

RS has conducted a number high voltage electrical isolation tests, including dielectric strength and flashover.^[6] RS's FRP material met the standard electrical requirements for an approved "hot stick or insulated boom." The independent test report noted that "the dielectric puncture strength is one of the pole's most valuable properties" and suggested that "the designer of power transmission lines should take full advantage of this puncture strength to improve the overall insulation strength of the lines or for other applications."

The effect of moisture on the dielectric strength of RS utility pole section samples was also tested in accordance with Clause 9.1 of IEC 61235. The test results showed that there were no flashovers or punctures, no visible signs of tracking or erosion on the surface, and no perceptible temperature rise at the end of 100 kV 60 Hz testing. The tested RS pole samples meet the requirements of IEC 61235.

For RS poles installed in the field, only the laminate in the base module would be exposed to moisture wicking from the surrounding soil. Achieving equilibrium moisture content depends on both the soil moisture content and the relative humidity. The worst case would be when poles are installed in standing water. A water wicking study completed by RS showed that for a 35.4 in. [90 cm] pole section with 1/3 of the sample being submerged in water, saturation was found to occur after 14 weeks and the maximum moisture gain for the entire 35.4 in. [90 cm] pole section was 0.35%.^[7] Considering the excellent compatibility between the E-glass fibers and RS's polyurethane resin which achieves a low void content, it is expected that the moisture absorption from the soil will be limited to the cut surface around the bottom ring of the base pole which is normally embedded in the ground, and that the substantially larger portion of the pole that is above ground would be expected to remain dry. Based on this, the dielectric strength is expected to remain unaffected over the pole's service life.

3.3 Lightning Strike Effects on RS Poles

Since both the glass fibers and the polyurethane matrix used in RS poles are non-conductive, RS composite utility poles are excellent insulators, and as such, do not readily pass the electrical current generated by lightning strikes to the ground. It is expected that nearly all of the energy from a lightning strike will be conducted to ground via the power conductors or ground wire.

The average lightning strike results in a current flow of 25,000 amps, with only 3% of the strikes being above 100,000 amps. [8] To determine the impact on the pole wall due to the heating of ground wires during a lightning strike, 60 Hz fault current tests were conducted on RS pole sections. The tests showed that with 27.3 kA fault current for three cycles, only small areas of discoloration were observed on the pole surface (See Figure 2), although the copper conductor heated to over 1,292° F [700° C] and became discolored and oxidized. Based on these tests, RS expects that lightning strikes are unlikely to affect the performance of RS poles.

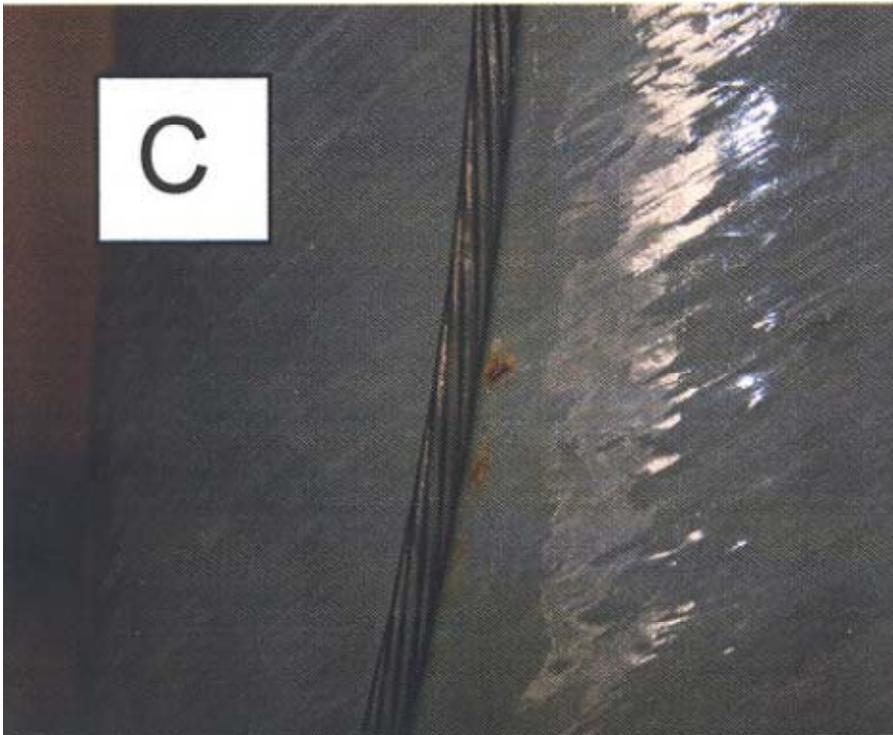


Figure 2: Surface impact of 27.3 kA, 3 cycles fault current with #4 AWG copper conductor at 1,344° F [729° C].

4 Inspection

Unlike wood poles, where core samples are typically required in order to gauge the structural integrity, the inspection of RS poles is simple and non-invasive.

RS recommends that a utility adhere to its established grid infrastructure inspection frequency until such time as the utility elects to decrease the inspection frequency for RS composite poles.

4.1 Overall Condition Inspection

A visual inspection should include the following checks:

- Inspect for excessive leaning of the pole which may indicate damage at or below the ground line or a change in the earth or backfill material surrounding the pole.
- Inspect for erosion of the earth around the pole that would alter the depth of set of the pole which would affect the pole's stability.
- Check for physical damage such as scratches, gouges and impact damage. If any damage is found, refer to the Maintenance portion (Section 5) of this document for further instructions. Remove any unauthorized attachments from poles (e.g. signs, posters, etc.) to ensure that there is no pole wall damage hidden by the attachments.
- Inspect for signs of pole burning or lightning strikes and tracking. If any damage is present, contact RS Technologies with details and pictures to determine if any corrective action is required.
- Inspect, particularly around the circumference of the base module, for signs of charring as the result of a fire. RS poles have undergone fire testing and post-wildfire testing has indicated that under typical brush fire conditions the poles retain their published strength.^[9] Regardless of this test result, if any pole is found to have been exposed to a fire, contact RS Technologies with details and pictures of the fire exposure to assess the condition of the pole.
- Any open holes in RS poles should be plugged to prevent water and/or pest ingress. Plastic hole-plugs are available from RS Technologies. Contact RS Technologies with a list of hole diameters to ensure the correct hole plugs are used.
- If graffiti is present, it can be removed with a pressure washer, if desired. Alternatively, RS has approved the following industrial graffiti remover compounds for use on RS poles. (See Table 2)

Manufacturer	Product Name	Product Code	Phone	Website
Dustbane	Graffiti Remover	50174 (510g)	1-800-387-8226	www.dustbane.ca

Table 2: RS approved graffiti removing compounds.

During the inspection of an RS pole, if there are any questions regarding the aesthetics, structural capacity or condition of the pole, contact RS Technologies.

4.2 RS Pole Hardware Inspection

- Check the pole for the RS pole ID tag confirming the specific pole information. The pole ID tag is typically located about 4-6 ft. [1.2-1.8m] above the ground line. See Figure 3, below, for an example of the pole ID tag.

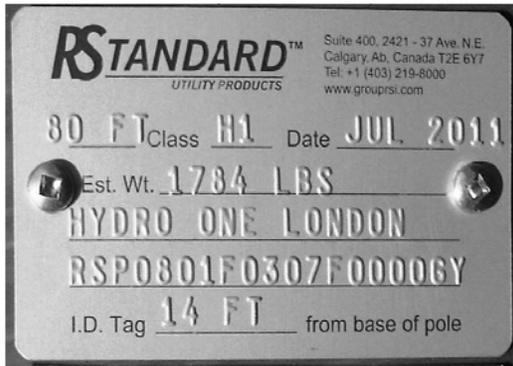


Figure 3: Pole ID tag example

Unless otherwise requested, RS follows the pole ID tag location to be consistent with CAN/CSA 015-05 for different pole lengths per Table 3 below:

Total Pole Length	Pole ID Tag Location (from the base of the pole)
≤ 50 ft. [15m]	10 ft. [3.0m]
>50 ft. [15m] and ≤ 90 ft. [27.5m]	14 ft. [4.3m]
> 90 ft. [27.5m] and ≤ 120 ft. [36.5m]	18 ft. [5.5m]
> 120 ft. [36.6m]	Determined on a case-by-case basis with asset owner.

Table 3: Pole ID tag locations based on total pole length.

- Inspect the pole ID tag elevation relative to the ground line to ensure that the pole is not settling into the ground, therefore reducing the conductor clearance. From the pole ID tag example in Figure 3 above, an 80 ft. [24.4m] pole is typically embedded 10% of the pole length plus 2 ft. [0.6m] in the ground. This results in an 80 ft. [24.4m] pole being embedded 10 ft. [3m] in the ground resulting in a distance of 4 ft. [1.2m] from the pole ID tag to the ground line. If this distance is less than 4 ft. [1.2m], it indicates that the pole is settling into the ground and may require further action. If a pole ID tag is not present, contact RS Technologies for a replacement pole tag.
- Confirm that the black pole top cap is present, unbroken and attached with four (4) self tapping screws (See Figure 4).



Figure 4: Black pole top cap installed with four (4) self tapping screws.

- Confirm that each slip joint is secured with two (2) blind nut assemblies, located 180° apart from each other at the same elevation. At the time of installation, the bolt heads of the blind nuts at the slip joints would be located at the base end of the slot. If the slip joint has settled over time, which the design of the RS pole allows for, the position of the blind nut bolt head relative to the position of the slot will have changed. See Figure 4, below, which shows how the blind nut should appear in relation to the slot at the time of installation and with varying amounts of joint settling.

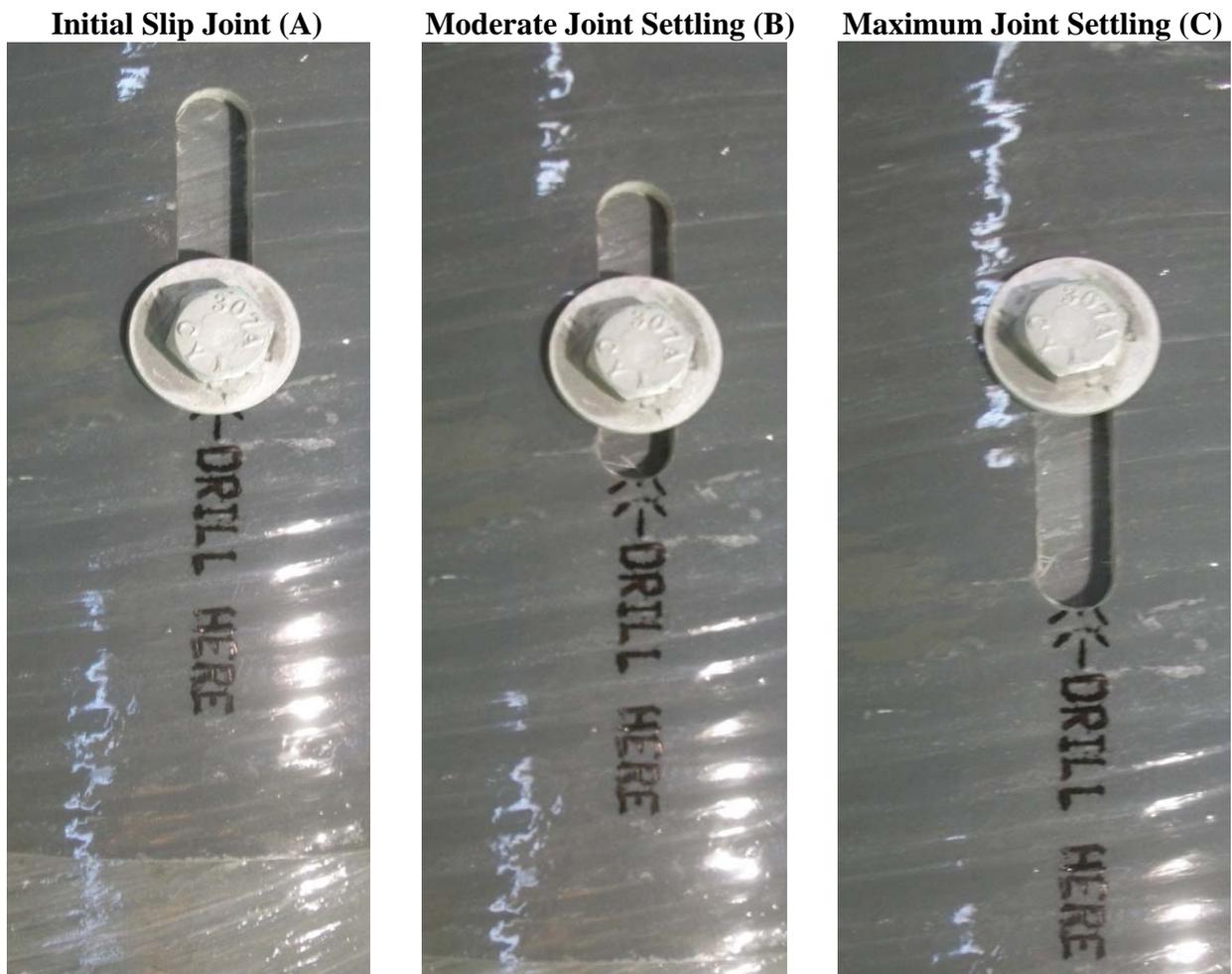


Figure 4: Blind nut bolt head positions after initial installation (A), moderate slip joint settling (B) and maximum slip joint settling (C).

RS pole slip joints may settle over time on applications with high vertical loads or incorrect initial slip joint assembly. If joint settling occurs, the blind nut bolt head position will change relative to the slot with a portion of the slot becoming visible underneath the bolt head. If upon inspection no portion of the slot is visible above the bolt head, as shown in Figure 4 (C) above, contact RS Technologies as this indicates that the slip joint has settled the maximum distance and further settling could result in laminate damage.

4.3 General Hardware Inspection

- Inspect all non-RS hardware attachments including through bolts, pole bands, cross arm and cross brace hardware, mounting brackets, square curved washers, pole steps, climbing ladders, fall arrest systems, guying tees, guy wires, guy wire anchors, ground wire clips, etc.
- Ensure that all hardware is properly positioned and that no sharp edges or hardware cleats are damaging the pole wall surface. If the pole wall is damaged, contact RS Technologies.
- Tighten any loose hardware, including pole bands, to the original equipment manufacturers' fastening specifications.
- RS recommends that through bolts have a torque setting of 30 to 50 lb-ft. [40-68 N-m]. Through bolt torque above this recommendation can ovalize the pole's cross section. If ovalization occurs when tensioning through bolts, back the nut off two to three turns.
- At through bolt locations, inspect the vertical bearing surface of the pole wall that is in contact with the bottom surface of any bolts to ensure that there is no laminate damage caused by high vertical loads placed on the through bolts.

5 Maintenance

RS poles do not require scheduled maintenance due to the use of aliphatic polyurethane in the pole wall laminate. It is, however, expected that during transportation, assembly, installation and over the 80 year service life of the pole, the structures will be subjected to contact with foreign objects that could scratch, gouge or otherwise damage the pole wall. RS has prepared a work instruction document titled WI-7015 - Inspection and Repair of Damage to RS Poles (Rev A). [10]

Poles should be inspected for laminate damage, and assessed based on the various photos shown below. For detailed evaluation and repair instructions, please refer to RS work instruction WI-7015 - Inspection and Repair of Damage to RS Poles (Rev A). [10] This work instruction categorizes the following conditions that may or may not require maintenance and/or module replacement:

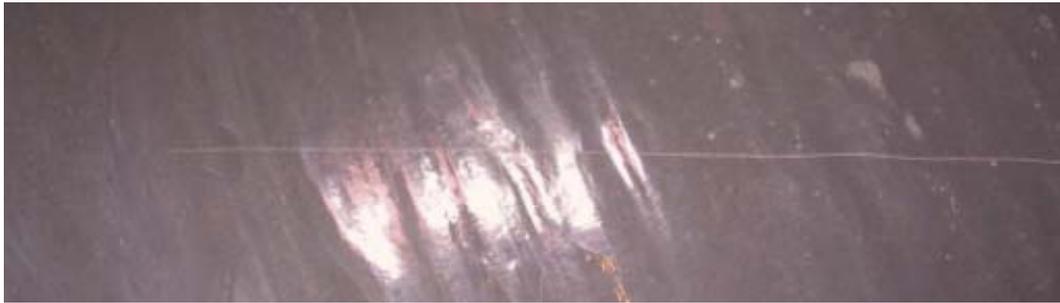


Figure 5: Light superficial damage (scratch), no maintenance required.

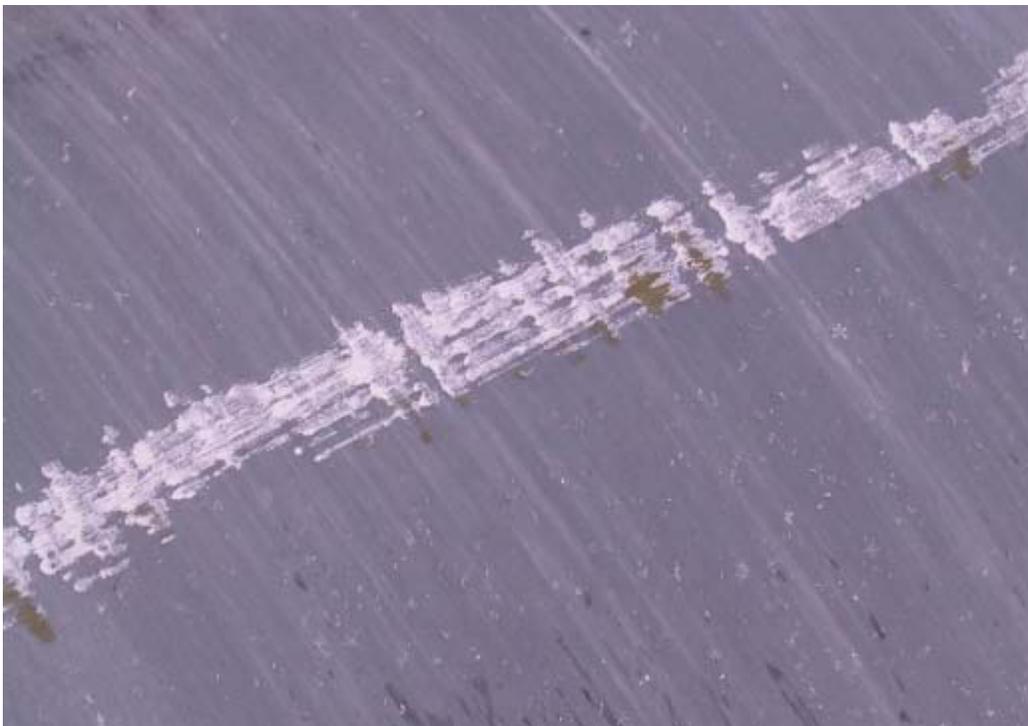


Figure 6: Superficial damage, maintenance may be required.



Figure 7: Surface gouge damage, maintenance required.



Figure 8: Surface gouge damage, maintenance required.



Figure 9: Structural damage, module replacement may be required.



Figure 10: Structural damage, module replacement required.

Note, if module replacement is required, the RS pole will need to be removed from the ground and one or more slip joints will need to be disassembled. Refer to RS work instructions WI-7013 - Pole Removal from a Soil Foundation (Rev B) and WI-7014 - Horizontal Disassembly using Boom Truck (Rev A). [11 and 12]

Hardware tightening and guy tensioning schedules typical to other structures should be maintained. Although no scheduled maintenance is required for RStandard poles, the auxiliary hardware attachments are required to be maintained per the utility's work methods and the hardware manufacturer's recommendations.

6 Pole Storage

During storage, RS poles do not need to be turned periodically nor is periodic inspection or maintenance required. If nested, RS poles should be stored with the shipping bolt oriented towards the ground to allow the smaller nested modules inside the base module to have base to tip contact with each other along the bottom surface of all modules (See Figure 11).

To reduce the potential for debris to enter the nested module sets, elevate RS poles off the ground using wood blocks or similar dunnage (See Figure 11).



Figure 11: Nested RS module sets stored on wood dunnage with the shipping bolt oriented towards the ground. Note: The shipping bolt is visible just inside the base of the two center module sets to the right of the green QC tag.

7 References

[1] Q-Lab Technical Bulletin LU-8009.1: QUV and Q-Sun; A comparison of Two effective Approaches to Accelerated Weathering & Light Stability Testing;

[2] Aliphatic Vs Aromatic Polyisocyanate: <http://www.specialchem4coatings.com/tc/aliphatic-polyisocyanate/index.aspx?id=aliphatic>;

[3] Guan, S, “One hundred percent solids aliphatic polyurethane coatings-from dream to reality”, Urethanes Technology, 29-31, June/July, 1997;

[4] Guan, S. “Assuring Quality When Applying 100 Percent Solids Polyurethanes”, Journal of Protective Coatings and Linings, 74, December, 1995;

[5] Brown, M. Berksoy, M. SAMPE Fall 2008 Tech Paper M140 - Life Cycle Predictions of PU Utility Poles;

[6] Z. Li, Selected Electrical Tests on FRP Poles Manufactured by RS Technologies, Kinectrics Report No.: K-012416-000-RC-0001-R00;

[7] Soon Moon: Water Wicking Test for RStandard Pole, RS Technologies Internal Test Report

[8] American Dynamics Lightning Protection Reference Guide

[9] RS Technical Bulletin - Fire Testing of RStandard Poles - 2 Nov 2011

[10] WI-7015 – Inspection and Repair of Damage to RS Poles (Rev A)

[11] WI-7013 - Pole Removal from a Soil Foundation (Rev B)

[12] WI-7014 - Horizontal Disassembly using Boom Truck (Rev A)

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