Testing Overview (USA)
RS Technologies

www.RStandard.com

Email info@grouprsi.com
Toll Free +1 877 219 8002
Phone +1 403 219 8000
Fax +1 403 219 8001

2421 – 37th Avenue NE, Suite 400
Calgary, AB T2E 6Y7
1. Bending Tests
   - 1.1 Horizontal Bending Tests ................................................................. 2

2. Structural Tests
   - 2.1 Pole Wall Loading Tests ................................................................. 4
   - 2.2 UV and Weathering Tests ................................................................. 5

3. Electrical Tests
   - 3.1 60 Hz Voltage Dry Flashover and Withstand Tests ....................... 6
   - 3.2 60 Hz Voltage Wet Flashover and Withstand Tests ....................... 6
   - 3.3 Leakage Current Measurements ...................................................... 7
   - 3.4 Dielectric Tests Before and After Humidity Exposure ................... 7
   - 3.5 60 Hz Voltage Puncture Tests ......................................................... 7
   - 3.6 Fault Current Withstand Tests ......................................................... 7
   - 3.7 Contamination Tests ...................................................................... 8

4. Polyurethane Resin Tests
   - 4.1 Version Resin Material Properties and Characteristics
     • 4.1.1 Polyurethane Resin Material Properties and Characteristics ........ 9
     • 4.1.2 Polyurethane Resin Toughness Evaluation ................................. 9
     • 4.1.3 Polyurethane Resin Impact Properties ....................................... 9
     • 4.1.4 Izod Impact Test ...................................................................... 9
     • 4.1.5 Unnotched Impact Test ............................................................... 9
     • 4.1.6 Water Absorption Test ............................................................... 10
     • 4.1.7 Interlaminar Shear Test ............................................................. 10
     • 4.1.8 Specific Gravity ..................................................................... 10
     • 4.1.9 Ignition Loss Test ................................................................... 10
     • 4.1.10 Coefficient of Linear Thermal Expansion .................................. 10
     • 4.1.11 Glass Transition Temperature ................................................. 10
     • 4.1.12 Specific Heat .......................................................................... 10
     • 4.1.13 Tensile Fatigue Test ................................................................. 10
     • 4.1.14 Creep Test ............................................................................. 11
   - 4.2 Version Resin Toughness Evaluation ............................................. 11
   - 4.3 Version Resin Impact Properties ..................................................... 11

5. Miscellaneous Tests
   - 5.1 Pole Step Static Load Test ............................................................... 12
   - 5.2 Pole Step Dynamic Load Drop Tests .............................................. 13
   - 5.3 Wind Blown Sand Tests ................................................................. 16
   - 5.4 Fast Moving Brush Fire Test .......................................................... 17
1. Bending Tests

1.1 Horizontal Bending Tests

Overview
To evaluate the strength and behavior of RStandard® poles under flexural loading, RS performs full-scale destructive testing on the entire range of pole sizes. This testing was originally performed by EDM International Inc. (EDM) – a recognized industry leader in the testing and research of utility products. After developing an approved in-house testing facility, which was designed and constructed to EDM’s specifications, horizontal bending tests are now performed at our test facility in Calgary, Alberta, Canada (See Figure 1 for test set-up). The test set up and test method is based on the ASTM test standard, ASTM D1036 – Standard Test Methods of Static Tests of Wood Poles. Based on the data from each test, RS can determine pole loading and deflection levels throughout the bending test, up to and including the point of failure if the test was taken to destruction.

Procedure
A pole is secured at the base and the ground line location, and a horizontal load is applied at 2 ft. [61 cm] from the pole top until the desired load or deflection level is achieved, or until failure. Each test begins with assembling a pole in the testing yard. The pole is assembled module-by-module using come-alongs, and the joints are drilled and bolted as they would be in a field installation.

Next, either a base plate or wooden brace is installed in the butt of the base module to simulate the constraint of the ground during embedment. Using forklifts, the base of the pole is then loaded into the horizontal test frame. To prevent the pole from sagging, the tip is strapped into a wheeled steel cart placed two-thirds of the way up the pole from the base.
Once the pole is loaded into the test frame, it is secured to the frame with opposing straps. One strap is attached at the base, and the second is attached to simulate the ground line location. These straps secure the pole in the test frame to simulate direct embedment conditions. After the pole is strapped into the test frame, measurements are taken to document where the load will be applied and where the deflection will be measured. See Figure 2 for pole set-up procedures.

To measure deflection during the test, position transducers (deflection sensors) are attached at the tip, ground line location and base of the pole. For the purpose of the test, the base of the pole is assumed to be rigid. The ground line and base position transducers provide data on how much the base of the pole shifts in the test frame (due to movement in the test fixtures, stretch in the straps, etc). This data allows the tip deflection to be corrected.

A 12,000 lb. [5,442 kg] capacity winch is then connected to the pole at the load point 2 ft. 4 in. [61 cm] below the nominal tip. A load cell in-line with the winch cable measures the force being applied to the pole. The load cell and all three position transducers are integrated into a data acquisition system which records real-time data from these sensors.

After a safety check and walk-around to verify proper test set up, all bystanders are cleared from the area except for testing personnel responsible for operating the data acquisition equipment and the winch controls. Once the testing personnel are ready to begin, a flashing strobe light and siren are turned on to alert people of testing-in-progress. The winch is switched on and the pole is tested. After the test is complete, the pole is removed from the test cell and the load-deflection data is processed.
2.0 Structural Tests

2.1 Pole Wall Loading Tests

Overview
As FRP poles behave differently than their wood, concrete and steel counterparts, guidelines have been developed regarding hardware attachments. RS has completed an extensive series of tests to help determine the strength of the RStandard® pole wall under a variety of different loading scenarios. These tests were performed by Intec in Seattle, WA – a company that specializes in testing advanced composite materials and structures. The data from this testing has been used to develop comprehensive guidelines regarding the application of hardware on RStandard poles.

Procedure
This testing consisted of setting up a variety of bolted hardware connections and testing them to failure. This was accomplished by securing pole sections to a load frame and using hydraulic actuators to apply various load cases to the composite pole wall. This testing yielded information about bolt sizing, bolt spacing, proper load paths, bearing strength of holes, sizing and attachment of load spreader plates and ways to field-modify existing connections to gain extra safety. Figure 11 illustrates the test set-up.

Figure 11: Pole wall loading test set-up
2.2 UV and Weathering Tests

Overview
Over time, unprotected composite utility poles can be prone to UV degradation and weathering effects. Aromatic, non-UV stable resins are the primary resin used to bind fibers together in composite poles. Discoloration, fiber blooming and potential structural degradation of the pole can result if aromatic resin is left exposed and unprotected.

To combat these effects, RStandard composite utility poles outermost layers consist of aliphatic formulated polyurethane resin (i.e. solvent-free isocyanate). This provides the exposed layers of the pole with superior UV-stability and weather resistant characteristics. Unlike other composite utility poles which utilize veils or coatings, this outer-layer of aliphatic resin is chemically bonded (i.e., cross-linked) with the underlying aromatic polyurethane resin, an integral part of the pole wall and cannot be scratched or flaked off.

To determine the long-term durability and performance of this protective outer layer of aliphatic resin, RS has undertaken a long-term chamber study to simulate UV exposure, moisture and high temperature effects. RStandard samples have been subjected to 14,000 hours of accelerated UV/weathering exposure by Q-Lab Weathering Research Service (Q-labs) in Florida, USA in accordance with ASTM Standard G154 Cycle 1. This exposure simulates short wavelength UV rays, which is the form of UV that typically causes polymer degradation such as gloss loss, strength loss, yellowing, cracking, crazing and embrittlement. This testing also involved a unique condensation mechanism used by Q-Labs to reproduce moisture and simulate outdoor conditions.

After certain intervals of accelerated UV exposure, samples were visually inspected by Q-Labs and sent to RS for structural testing.

Procedure
Samples were prepared as 1 ft. x 0.5 ft. [0.35 m x 0.15 m] sections cut from a typical RStandard pole wall cross-section. The size of the samples were calculated in order to obtain an average of four testable specimens for flexural strength, flexural modulus and interlaminar shear strength according to the ASTM Standard D790[6] and ASTM D 2344[7], respectively. The test specimens were cut from the exposed block 1 in. [2.5 cm] away from the edges not to have the edge effect on the results.

At Q-Labs, samples were exposed to accelerated UV light using UVA 340 nm lamps, equivalent to 0.77 W/m2 [v1.0 calibration], 8 h UV light @ 140°F [60°C] and 4h condensation @ 122°F [50°C]. To date Q-Labs has provided visual observation reports on samples in the following hours of exposure: 500h, 1,000h, 2,000h, 4,000h, 6,000h, 8,000, 10,000h, 12,000h and 14,000h.

As the samples arrived after each designated exposure time, mechanical tests were performed on the weathered and UV exposed samples at the RS test lab. The included ASTM D2344 flexural testing and ASTM D2344 interlaminar shear testing.
3. Electrical Tests

Overview
RS has undertaken a variety of electrical tests on RStandard® poles through Kinectrics – an independent test laboratory located in Toronto, Ontario, Canada specializing in testing procedures for the utility industry. The goal of these tests was to determine the dielectric and insulating properties of RStandard poles in various electrical exposure situations.

3.1 60 Hz Voltage Dry Flashover and Withstand Tests
The dry flashover and withstand tests were performed using clauses 4.2 and 4.4 of ANSI C29.1 as a guide. The dry withstand voltage of the pole was initially set to be 97% of the dry flashover voltage value and verified through testing. The duration of the withstand tests was one minute. The test was repeated at a lower level to see if a flashover occurred at the previous trial voltage. The test indicated that under dry conditions, RStandard poles are a good insulator (See Figure 12).

3.2 60 Hz Voltage Wet Flashover and Withstand Tests
The wet flashover and withstand tests involved mounting RStandard pole sections in vertical, 45 degree and horizontal orientations. The samples performed in accordance with clauses 4.3 and 4.5 of ANSI C29.1 with a 1 mm/minute [2.36 in./hour] precipitation rate per clause 9.1 of IEC standard 60060-1 (See Figure 13).
3.3 Leakage Current Measurements
RStandard® poles met and exceeded the leakage current requirements of an approved “hotstick” or insulated boom. The maximum leakage current on an RS pole section was 54 uA at a voltage of 240 kV (See Figure 14).

3.4 Dielectric Test Before and After Humidity Exposure
Before humidity exposure, the RStandard samples were initially measured for maximum leakage current of 50 kV for one minute. After 168 hours of humidity exposure, the samples were retested. The results revealed no flashovers, punctures or visual signs of tracking (See Figure 15).

3.5 60 Hz Voltage Puncture Tests
Three tests were conducted to assess the dielectric puncture strength of RStandard poles using puncture voltage levels of 240 kV and 250 kV. The result was an average dielectric puncture strength of approximately 774 kV/in. [30 kV/mm] of wall thickness, based on a wall thickness of 0.32 in. [8 mm] (See Figure 16).

3.6 Fault Current Withstand Tests
A series of tests were performed on #4 and #2/0 copper wires. Fault currents of 3.0 kA to 27.3 kA were applied with fault durations varying from 1/20 seconds to 4.5 seconds. Additionally, conductor temperatures of 1,981° F [1,083° C] were used. Under the worst case sustained fault current the pole surface experienced limited charring, with no apparent structural damage (See Figure 17).
3.7 Contamination Tests

RStandard® wall samples were subjected to contamination levels up to 240 ug/cm² to simulate contamination on a porcelain insulator. A mixture of salt water and fine clay was used to as the contamination media, which did not adhere well to the pole wall due to the pole’s excellent hydrophobic characteristics. The test showed at least the same insulation strength as porcelain insulators under the same very heavy contamination (See Figure 18).

[Image: Contamination Test Surface and Chamber]

Figure 18: Contamination Test Surface and Chamber

Summary of Key Findings Attained From Electric Tests:

• Under the standard “hotstick” test, RStandard pole sections are good or better than a hotstick or insulated boom;

• RStandard poles have a high dielectric puncture strength of approximately 774 kV/in. [30 kV/mm] of wall thickness;

• The pole surface is very hydrophobic, making it difficult for contaminations to stick; and

• In the event a high fault current travels down a copper ground wire, the pole surface will experience no adverse structural effects.
4. Polyurethane Resin Tests

RStandard® poles are manufactured with a polyurethane resin developed by RS Technologies. To understand the capabilities of the polyurethane resin, RS has conducted numerous tests through the Alberta Research Council, an independent research testing group based out of Edmonton, Alberta, Canada.

4.1 Polyurethane Material Properties and Characteristics

Overview
A variety of tests were performed on the RS polyurethane resin to evaluate its material properties and characteristics. These tests have been used to better understand the capabilities of the resin system used in RStandard poles.

Procedures
To determine the material properties and characteristics of the RS polyurethane resin, the following tests were performed:

4.1.1 Tensile Test
The tensile test was conducted in accordance with ASTM D3039. This test reports the tensile strength and modulus (stiffness) of a composite material with aligned fibers oriented in one direction.

4.1.2 Flexural Test
The flexural or bending test was conducted in accordance with ASTM D790, where a rectangular beam of material is end supported and loaded at its center.

4.1.3 Compression Test
The compression test was conducted in accordance with ASTM D695 and Boeing Specification Support Standard BSS 7260. Tabbed test specimens were prepared for both the longitudinal and transverse directions.

4.1.4 Izod Impact Test
The Izod impact test was conducted in accordance with ASTM D256. Specimens were prepared for both the longitudinal and transverse directions. The impact test specimens were notched, using an air cooled milling machine. The notching provided the specimen with a damage site for cracking caused by impact, so it is felt by some to be a more representative test for rating the impact properties of a real material.

4.1.5 Un-notched Impact Test
The un-notched impact test was conducted in accordance with ASTM D4812. This is a clean, polished specimen with no obvious place for an impact-generated crack to start. Specimens were prepared for both the longitudinal and transverse directions.
4.1.6 Water Absorption Test
The water absorption test was conducted in accordance with ASTM D570-98. Six 3 in. x 1 in. [7.6 cm x 2.5 cm] test specimens were obtained from each sample material and were evaluated in accordance with: (a) 24 hour immersion at ambient temperatures, (b) Long-term immersion at ambient temperatures, and (c) Immersion at 122°F [50°C].

4.1.7 Interlaminar Shear Test
The interlaminar shear test was conducted in accordance with ASTM D2344. Specimens were prepared for both the longitudinal and transverse directions. The test is conducted on a very short end supported beam with a bending force applied to its center. Shear between the lamina of the composite dominates, generating interlaminar shear stresses.

4.1.8 Specific Gravity
Specific gravity determinations were performed in accordance with ASTM D792 - Test Method A. The specific gravity is a method of stating the density of the material.

4.1.9 Ignition Loss Test
Ignition loss generates the amount of fiber in a composite sample on a weight percentage basis. The ignition loss tests were performed as per ASTM D2584-02. Each sample was tested in triplicate, with the average result being reported as the ignition loss (glass content).

4.1.10 Coefficient of Linear Thermal Expansion
The coefficient of thermal expansion is how much a material expands for a degree of temperature rise. The method used for determining the coefficient of linear thermal expansion was ASTM E831-00. The expansion coefficient was measured for each direction (length, width, and thickness). The expansion coefficients were calculated for the temperature range of 32°F [0°C] to 392°F [200°C]. The instrument used for the determinations was a TA Instruments TMA 2940 thermomechanical analyzer. The analyses were performed at a sample heating rate of 41 °F/minute [5°C/minute] from -22°F to 401°F [-30°C to 205°C].

4.1.11 Glass Transition Temperature
The glass transition temperature is the temperature at which the material undergoes a molecular arrangement change. It shows up as a slight change in density, modulus, and thermal expansion. Glass transition temperature determinations were performed in accordance with ASTM E1640-94. The instrument used for the determinations was a TA Instruments DMA 983 dynamic mechanical analyzer. Samples were run from ambient temperature to 257°F [125°C].

4.1.12 Specific Heat
The specific heat is the amount of heat per unit of mass required to raise the temperature by one degree Celsius. The specific heat was measured in accordance with ASTM E1269 using the differential scanning calorimeter (DSC). The specific heat values are used to calculate the thermal conductivity.

4.1.13 Tensile Fatigue Test
The tensile fatigue tests are performed in accordance with ASTM D3479. The specimens are subjected to tension-tension cyclic loading with upper range varying from 40-90% and a lower range of 10%. The number of cycles to failure is recorded. The frequency of the loading ranges from 2-4 Hz depending on the loading range.
4.1.14 Creep Test

The creep test is a flexural creep and was performed in accordance with ASTM D2990. The flexural coupons are end supported and loaded in the middle with loads that correspond to a percentage of the failure stress. The range of loads have been from 90% to 45% of failure stress. The time to failure is recorded, if the specimen does not fail the test is terminated after a minimum of 3,600 hours.

4.2 Polyurethane Resin Toughness Evaluation

Overview

A variety of mechanical tests have been performed on the RS polyurethane resin to determine its toughness. This testing was performed on the polyurethane resin and an alternative iso-polyester based resin to compare the toughness of each resin system. This comparison is relevant for analyzing the performance of RStandard® poles, which utilize a polyurethane system, because polyester-based resins are commonly used in other composite utility poles on the market.

Procedures

Five mechanical tests were used to evaluate toughness:

(a) Tensile test based on ASTM D638M;
(b) Izod impact test based on ASTM D256;
(c) Falling weight impact test at speeds of 4.92 ft./sec [1.5 m/sec], 9.84 ft./sec [3 m/sec] and 16.4 ft./sec [5 m/sec], using Instron Dynatup 8250H;
(d) Mode I double cantilever beam (DCB) test based on ASTM D5529-94a; and
(e) Mode II end-notch-flexure (ENF) test based on European Structural Integrity Society (ESIS) protocols published in 1993.

The results show that the RS polyurethane resin is tougher than traditional iso-polyester based resin, especially in delamination resistance under impact loading.

4.3 Polyurethane Resin Impact Properties

Overview

A variety of mechanical tests have been performed on the RS polyurethane resin to determine its impact properties. This testing was performed on the polyurethane resin, a polyester resin, a vinylester resin and epoxy. Due to cost limitations, polyurethane and polyester are the main resin systems used for manufacturing composite utility poles. Epoxy resins are cost prohibitive for utility poles, and are typically reserved for high performance applications.

Procedures

The tests performed included:

(a) Interlaminar shear;
(b) Izod impact notched/unnotched; and
(c) Transverse tensile strength.

These series of tests indicated that the RS polyurethane resin has a significant impact performance improvement over polyester resins. These tests also indicated that impact performance of the polyurethane resin is good, but not better, than epoxy and vinylester resins.
5. Miscellaneous Tests

5.1 Pole Step Static Load Test

Overview
To certify the static load capabilities of the Senior Industries SI-0040 climbing step, a climbing option recommending by RS, Senior Industries has performed a series of static load tests on an RStandard® composite pole section.

Senior Industries performed two tests to evaluate the static load capabilities of the SI-0040 climbing step as used on an RStandard composite pole:

(a) Downward force of 750-1,100 lbs. [340-499 kg], starting from 0 lbs.; and

(b) Downward force to 2,500 lbs. [1,134 kg], starting from 0 lbs.

Procedure
Both tests involved mounting a SI-0040 climbing step to a test fixture, which was then assembled onto a Tinius-Olsen Tensile tester. The tensile tester is designed to simulate loads at a rate of no more than 3 in./minute.

Sample 1:
The Tinius-Olsen Tensile tester was applied to the step, installed into an RStandard pole section (1 in. [2.5 cm] installation hole), with a downward force to 750-1,100 lbs. [340-499 kg] starting from 0 lbs. A chain was placed 5 in. [13 cm] from the pole section, within 1 in. [2.5 cm] of the pole step end. Sample 1 held force with less than 1 in. [2.5 cm] deformation per Senior Industries qualification standard on the step end where the pressure was applied, with permanent deformation of 1/4 in. [0.6 cm] occurring between 1,000 and 1,100 lbs. [454 and 499 kg]. The pole wall displayed no signs of damage or fatigue.

Sample 2:
The Tinius-Olsen Tensile tester was applied to the step, installed into an RStandard pole section (1 in. [2.5 cm] installation hole) with downward force to 2,500 lbs. [1,134 kg] starting from 0 lbs. A chain was placed 5 in. [13 cm] from the pole section, within 1 in. [2.5 cm] of the pole step end. Sample 2 was bent downward 2 in. [5 cm] on the step end where the pressure was applied. The pole wall displayed no sign of damage or fatigue.

Summary
In every variation of the static load testing, the combination of the Senior Industries SI-0040 climbing step and the RStandard utility pole was found to consistently perform well under loads from the Tinius-Olsen Tensile tester. After every test, the pole section was found to be undamaged.
5.2 Pole Step Dynamic Load Drop Tests

Overview

To certify the fall arrest capabilities of the Senior Industries SI-0040 climbing step, a climbing option recommending by RS, a variety of dynamic load drop tests were performed on the pole steps and RStandard® poles. These tests were performed in Edmonton, Alberta, Canada at the test facility of Altalink – an Alberta based utility. The tests were designed to simulate a situation where a utility worker falls from a pole while climbing or working on the pole and their belt or other fall protection equipment catches on a climbing step.

Altalink carried out three variations of these tests:

(a) A 220 lb. [100 kg] weight dropped at a distance of 2.3 ft. [0.7 m] from the tip of a single step under ambient temperature conditions (repeated 3 times);

(b) A 220 lb. [100 kg] weight dropped at a distance of 2.3 ft. [0.7 m] from the tip of a single step under extreme cold temperature conditions (repeated 3 times); and

(c) A 220 lb. [100 kg] weight dropped at a distance of 4.6 ft. [1.42 m]. The weight was connected to the attachment points of a pole climbing strap, which had been looped around the pole above two opposing, offset steps (performed once).

Procedure

A 5 ft. [1.5 m] RStandard pole section was mounted on a steel I-Beam approximately 16.4 ft. [5 m] above the ground (See Figure 19). This configuration was used for all tests. Prior to each test the weight stack was hoisted to a pre-determined height using the rope and pulley system and secured in place. All of the ambient and cold temperature drop load tests used the same 0.75 in. [19 mm] drill hole for installing the sample steps. This hole was located 23 in. [584 mm] from the top of the pole section and was inspected for damage between each test. The test setup can be seen in Figure 20.

Figure 19: Pole section mounting
Test Method I – Dropped Load at Ambient Temperature
Ambient temperature: 77°F [25°C]
Drop Height: 2.3 ft. [0.7 m]

For the dropped load test at ambient temperature a 4 ft. [1.2 m] steel cable with eye hooks on each end was connected from the weight sack to the tip of the installed climbing step. The eye hook was secured to the step with tape to prevent slippage. See Figure 21 for pole step results after ambient temperature test.

Test Method II – Dropped Load at Extreme Cold Temperature
Ambient temperature: 77°F [25°C]
Drop Height: 2.3 ft. [0.7 m]
Time out of cooler: sample 1 = 1 min 05 sec; sample 2 = 1 min 13 sec; sample 3 = 0 min 47 sec

For this dropped load test, meant to simulate an extreme cold weather situation, each step had been held in a cooler of dry ice for nearly a week prior to the test. The cooler temperature was measured to be less that -58°F [-50°C]. Otherwise, the procedure was identical to that described in Test Method I. See Figure 22 for pole step results after cold weather test.
Test Method III – Dropped Load Test With Pole Climbing Strap
Ambient temperature: 77°F [25°C]
Drop Height: 4.7 ft. [1.42 m]

This test was meant to simulate a lines person working overhead on a pole with climbing steps installed and using a standard pole climbing strap. A typical working scenario was measure to determine the worst-case dropping distance if the worker was to fall. The steps were installed on opposing sides of the pole, with the left step located 30 in. [762 mm] from the top of the pole section and the right step offset 18 in. [457 mm] below that in a typical climbing configuration. The pole strap was looped around the pole section above the upper step and connected to the weight stack with the 2 ft. [0.6 m] steel cable (See Figure 23). After witnessing the results of the first pole strap test, it was determined that further tests were not required.

![Figure 23: Pole strap test setup](image)

Summary

In every variation of the dropped load test, the combination of the Senior Industries SI-0040 climbing step and the RStandard® utility pole was found to consistently perform well under significant dynamic loads. Not one step failed when loads were dropped at ambient or extreme cold temperatures. After every test the pole section was found to be undamaged.
5.3 Wind Blown Sand Tests

Overview
Blowing sand is encountered in all areas of the world. Products need to be tested for their ability to withstand abrasion by exposure to these conditions. Samples of RStandard® poles were subjected to blown sand testing using equipment designed for military applications in harsh climates. This testing was carried out at Dayton T Brown (NY) laboratories using the military test specification MIL-STD-810.

Test Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Speed</td>
<td>50 mph [80 km/h]</td>
</tr>
<tr>
<td>Temperature</td>
<td>140°F [60°C]</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>&lt; 2 %</td>
</tr>
<tr>
<td>Sand Concentration</td>
<td>2.15 g/m3</td>
</tr>
<tr>
<td>Test duration</td>
<td>90 minutes</td>
</tr>
</tbody>
</table>

Results

Appearance
RStandard surfaces exposed to the blown sand testing were dulled, but showed no indication of abrasion wear. Minute particles of sand were lodged in the surface causing slight discoloration on the surface. Light buffing of the surface recovered some of the gloss and returned the surface to its original color.

Physical and Mechanical Properties
The tested samples of RStandard poles samples showed no degradation in physical properties within the recorded standard deviations (see Figure 24).

<table>
<thead>
<tr>
<th>Density (g/cc)</th>
<th>Void Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>StDev</td>
</tr>
<tr>
<td>Before</td>
<td>1.87</td>
</tr>
<tr>
<td>After</td>
<td>1.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flexural Strength (MPa)</th>
<th>Flexural Modulus (GPa)</th>
<th>Interlaminar Shear Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>StDev</td>
<td>Actual</td>
</tr>
<tr>
<td>Before</td>
<td>435</td>
<td>43</td>
</tr>
<tr>
<td>After</td>
<td>428</td>
<td>67</td>
</tr>
</tbody>
</table>

Figure 24: Physical Properties of RStandard samples prior to and after testing.

Summary
RStandard composite pole samples showed no appreciable wear or properties degradation when subjected to limited wind blown sand testing.
5.4 Fast Moving Brush Fire Test

Overview
To simulate the effects of a fast moving brush fire on RStandard® composite poles, two sets of pole samples were subjected to flammability testing modeled after the California Department of Forestry and Fire Protection (DFFP) testing for fire shelter survival rating. This testing simulated controlled burns with temperatures up to 2,012°F [1,100°C].

Procedure
Two RStandard® pole samples were subjected to testing modeled after the DFFP. This testing adhered to the following conditions:

(a) 27.6 in. [70 cm] standing grass (or 3 in. [7.5cm] thick grass mat);
(b) 30° incline; and
(c) Uphill breeze at 9 to 12 mph [15 to 20 km/hr].

These parameters resulted in controlled burns with temperatures up to 2,012°F [1,100°C], 6.6 to 9.8 ft. [2 to 3 m] flame lengths and a flame front moving at 9.8 ft. /sec [3 m/sec].

The moving brush fire created a temperature profile (see Figure 25 below) that the RS lab modeled using a stationary torch with a flame temperature of 2,372°F [1,300°C]. The torch was set up to produce a flame in the vertical direction. A thermocouple wire was used to measure the temperature of the flame at specific distances from the flame tip in order to expose the sample pieces to similar temperatures at the durations experienced in a moving brush fire. Fire samples of both aromatic and aliphatic resin formulations were tested.

The pole samples tested were:

• Aliphatic exterior layers with aromatic interior layers (regular production pole)
• 100% aromatic layers

Results

![Figure 25: Comparison of temperature profiles](image)
From the information provided in Figure 25, it can be seen that the samples tested in the RS lab were subjected to conditions that, met or exceeded temperatures experienced during the DFFP controlled burn test.

None of the aliphatic exterior pole samples ignited during the test. The aromatic exterior poles did ignite approximately 36 seconds after the flame reached the maximum temperature, but the flame was inconsistent, and each sample self-extinguished as soon as the flame source temperature was reduced below 752°F [400°C]. It should also be noted that these aromatic exterior poles are not the poles produced for use by utility customers. See Figure 26 for pictures of both aliphatic and aromatic samples.

![Figure 26: Aliphatic (left) and aromatic (right) exterior poles with non burned samples](image)

**Summary**

From these tests it can be concluded that RStandard® composite utility poles can survive a moving brush fire as described by the California Department of Forestry and Fire Protection. There is some charring to the surface of the pole by the heat effects, but the depth of the charring is restricted to a depth of 0.02 to 0.04 in. [0.5 to 1.0 mm]. The composite material beneath the charring appears to be unaffected by the heat.
Disclaimer

The information contained herein is offered only as a guide for RStandard® poles and has been prepared in good faith by technically knowledgeable personnel. This document is provided for information purposes only, and due to ongoing continuous improvement efforts by RS Technologies is subject to change without notice. Please contact your RS Account Executive for updates.