Test Report

Accelerated Aging Tests of Fiberglass-Reinforced Composite Utility Poles

Submitted to:

By:

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Introduction

Composite utility poles represent economical and environmentally friendly alternatives to traditional wood utility poles. However, the use of these poles is contingent on their ability to withstand the same environmental conditions as wood poles, such as, humidity, temperature cycles, ultra-violet rays etc. Accelerated aging studies can be performed on the composite to assess its ability to withstand these environmental conditions and this study evaluates the composite material used in the utility pole. A second study evaluates material used in the cross-arm and will be documented separately.

This study is being performed by the University of Delaware Center for Composite Materials (UD-CCM) at the request of Powertrusion International, Inc. Founded in 1974, UD-CCM is an internationally recognized, interdisciplinary center of excellence for composites research and education. UD-CCM has been an Army Center of Excellence since 1986 and currently hosts 3 Centers of Excellence in composites: Composite Materials Research (CMR) and Composite Materials Technology (CMT) funded by the Army and the Advanced Materials Intelligent Processing Center (AMIPC) funded by the Navy. UD-CCM currently provides technology transfer, analysis and testing services, processing techniques and educational services to over 30 companies, who are members of the Industrial Consortium. The companies range from large established firms (Boeing, Lockheed etc.), diverse firms (Greene Tweed, Advanced Ceramics etc.) to technical specialty firms (PowerTrusion, VersaCore etc.).

Proposed Approach

The accelerated aging study was performed in accordance with ASTM G154 for samples provided by Powertrusion. The test involved cycles of condensation and UV exposure and for the current study, the cycle was as follows: 4 hrs of UV with 313 nm lamps at 60 C and 4 hrs of condensation at 50 C. This is the default cycle from ASTM G 53 and Cycle 2 as described in ASTM G 154.

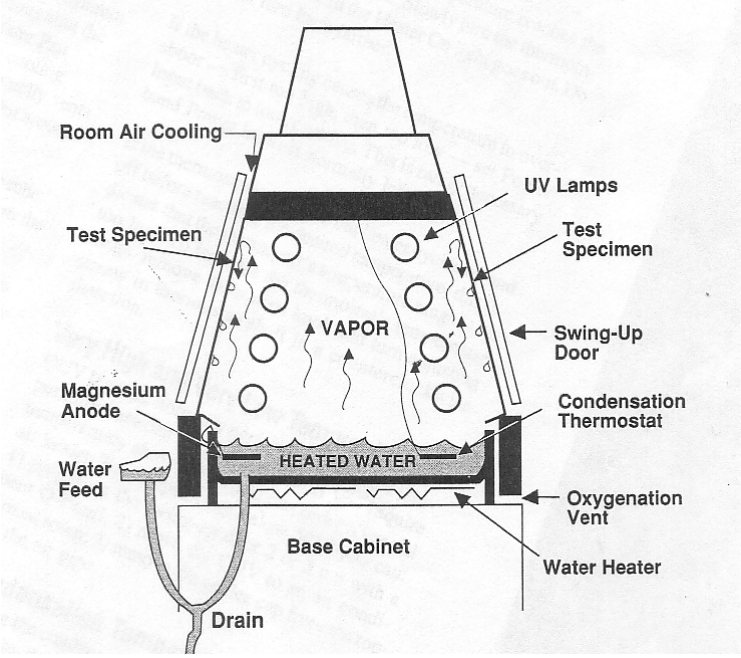
The test was performed for up to 1000 hours of UV exposure on the pole material, with mechanical testing performed on specimens at steps of 0, 500 and 1000 hours. The aging study was performed in a QUV Accelerated Aging test setup. Flexure tests were used to assess the mechanical properties of the exposed surface as a function of aging, by performing 3-point bending tests (ASTM D790).

Specimen Dimensions

Specimen dimensions are based on the QUV tester. The tester can accommodate 26 samples with dimensions of 12” (Length) by 3” (Width) with a maximum thickness of 0.8”. For the 3-pt bending test, dimensions are 6” x 0.5” (24:1 length:thickness) and each UV specimen can provide three (3) flexure specimens.

Test Procedure

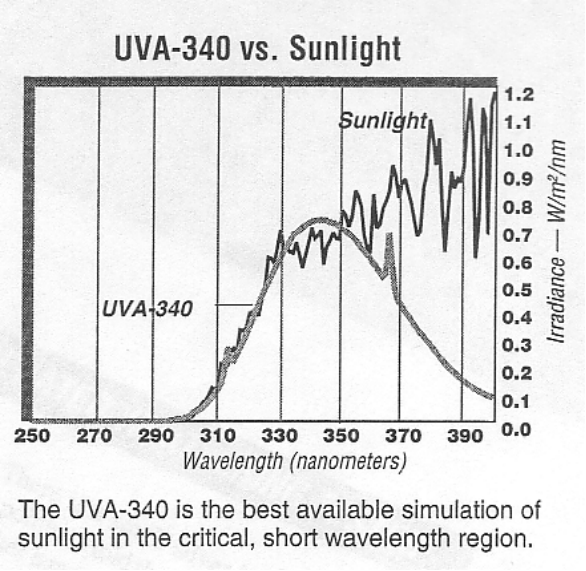
Test specimens were loaded in the QUV tester shown in the Figure below and subjected to the selected UV and Condensation cycles: 4 hrs of UV with 313 nm lamps at 60 C and 4 hrs of condensation at 50 C. UV lamp replacement procedure was followed after every 400 hours of UV exposure, as documented in the QUV Operating Manual. This ensures consistent exposure energy to the composite material.



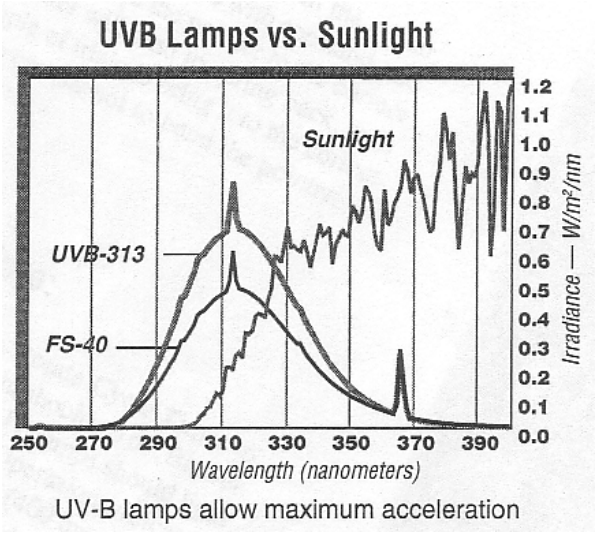
QUV Tester for Accelerated Aging Study

UV Lamp Selection

For the current study, UVB 313 nm lamps were selected. The Figure below shows the spectral intensity of the two commonly used lamps in UV aging studies: 340 nm and 313 nm. Of the two lamps, the 340 is the best match for direct sunlight, however the 313 provides greater energy and hence maximum accelerated aging. For this study, UVB-313 was selected as the lamp to not only provide accelerated aging but also to provide a higher intensity radiation compared to sunlight.



The UVA-340 is the best available simulation of sunlight in the critical, short wavelength region.



UV-B lamps allow maximum acceleration

Test Matrix

The proposed test matrix is shown in the Tables below. Material evaluation was performed at the intervals listed below and included weight change and 3-pt flexure tests.

Test Matrix for Accelerated Aging Study*

Test Type	Material	Hours
Aging	Pole	0, 500, 1000

*All samples subject to 4 hrs UV at 60 C and 4 hrs condensation at 50 C

Test Matrix for Material Evaluation

Test Type	Material	Test Schedule (hours)
Weight Check	Pole	0, 500, 1000
3-pt flexure (UV side up)	Pole	0, 500, 1000
3-pt flexure (UV side down)	Pole	0, 500, 1000

UV Dosage

The aging cycle used in this test was: 4 hrs of UV with 313 nm lamps at 60 C and 4 hrs of condensation at 50 C. For the 2500 hr test, this correlates to 1250 hours of UV exposure and 1250 hours of condensation exposure. A comparison of estimated UV dosage levels of various light sources is shown in the Table below (*Atlas SunSpots, Vol 30, Issue 64*).

The annual TUV at AWSG in Florida was estimated at 275 MJ/m^2 based on several years of data. To attain the same level of total dosage would require 1800 hrs of UV exposure using the UVB 313 nm light source, used in this test. *In comparison, the current test represents the equivalent of 70% of the total UV dosage per year assuming AWSG at Florida*.

Ceveat:

No guarantee is implied that identical specimens receiving the same total radiant exposure from different sources or from repeated exposure of the same source will exhibit identical changes of properties for one, or more of the following reasons:

1. Materials are selectively sensitive to the wavelength distribution of energy
2. Photochemical reactions are temperature sensitive
3. The effect of moisture may cause physical or chemical degradation during exposure

Light Source	Hourly TUV Exposure kJ/m²	Exposure Time, h. (rounded to nearest 10 hour)	Intensification Factor H_s/h_{TUV}
CIE 85 Table #4 & Peak Optimum Sunlight	189.1	1450	3.0
Average Optimum Sunlight, 26° South	92.8	2960	1.5
Xenon S/S @0.55 W/m² @340nm	169.4	1620	2.7
Xenon B/SL @1.40 W/m² @420nm	176.4	1554	2.8
Metal Halide @1020 W/m², Total Irradiance	235.5	1170	3.7
Enclosed Carbon	241.0	1140	3.8
XW Sunshine Carbon	211.2	1300	3.4
UVA 340	130.6	2100	2.1
UVB 351	176.2	1560	2.8
UVB 313nm	152.6	1800	2.4

Notes:

1) *If one assumes that annual TUV at AWSG, Miami is accumulated over an average of 12 hours per day, 365 days per year, the total hours of accumulation is 4380.*
2) *Typically, laboratory sources can be operated at various levels of irradiance. The numbers in this table relate to a specific nominal irradiance. Consult Atlas for the operating ranges of specific instruments of interest.*
3) *Irradiance for the various light sources was integrated over the effective range of the sunlight measuring instrument, 295–385nm. Kinmonth may have used 300–400nm for artificial sources, thereby accounting for some of the differences between these numbers and his.*