ANSI C29.18 PROTOTYPE/ CEA LWIWG 02 DESIGN TEST REPORT
Report No. EU1535-H

Silicone Rubber
46 kV Veri*Lite Line Post 80S046

This test report records the results of laboratory tests made on the Ohio Brass Silicone Rubber Veri*Lite Line Post, Catalog Number 80S046.

Tests were performed in accordance with ANSI C29.18 and CEA LWIWG 02 standards.

The Catalog Number 80S046 Silicone Rubber Veri*Lite Line Post insulator meets all applicable requirements of these standards.

R. A. Bernstorf

Michael G. Comber

Allen Bernstorf
Principal Engineer

Michael G. Comber
V.P. Engineering

Introduction:

This report details the testing performed to verify the suitability of materials and method of manufacture for silicone rubber housed Veri*Lite Line Post (VLLP) insulators, catalog number 80S046, intended for application on 46 kV lines. Testing was performed in accordance with ANSI C29.18 (2003) and LWIWG-02 (1996). Test protocols from LWIWG-02 (1996) will be referenced.

5.1 Water Penetration Test

Test Specimens

- Select three insulators for this test, and set aside an additional identical insulator for the Power Frequency Voltage Test.

Test Procedure

- Measure the hardness of two sheds of each insulator in accordance with ASTM D2240 with a Shore A Durometer.
- Boil each insulator in water having 0.1% by weight of NaCl, for 100 hours.
- At the end of boiling, allow each insulator to remain in the water until the water cools to about 50° C. Maintain this temperature in the water until the following tests start. Specimens shall be rinsed with de-ionised water prior to the test. All tests shall be completed within 48 hours.

Test Evaluation

- Visual Examination
  - Inspect the housing of each insulator.
  - There shall be no cracks and no signs of dissolving or crumbling.
- Hardness Test
  - Measure the hardness of two sheds of each insulator in accordance with ASTM D2240 with a Shore A Durometer at the same temperature ±5K (Kelvin) that the pre-boiling measurements were taken.
  - The hardness must not change from the pre-boiled specimen by more than 20%.
- Steep-Front Impulse Voltage Test
  - Subject each insulator to a steep-front impulse of at least 1000 kV/μs in accordance with Clause 9.2.5 of IEC Standard 60-1. Each insulator must be subjected to 10 positive impulses and 10 negative impulses.
  - Each impulse must cause and external flashover.
  - Punctures must not occur.

- Power Frequency Voltage Test
  - Determine the power frequency flashover voltage, in accordance with the procedure described in Clause 7.1.2 of ANSI Standard C29.11, using the additional new insulator, identical to those tested.
  - The three aged insulators shall be tested and evaluated in accordance with Clause 7.1.6.3 of ANSI Standard C29.11.

Test results: **Satisfactory**

See appendix A for test results and background information.

5.2 Aging or Accelerated Weathering Test

Test Specimens

- Select three specimens of shed and housing materials for this test (with markings included, if applicable).

Test Procedure

- Test each specimen for 1000 hours by one of the following test methods. Marking must be directly exposed to UV light.
  - Xenon-Arc Methods: ASTM G 26 or ASTM D2565.
  - Fluorescent UV Method: ASTM G 53

  NOTE: Tests without water are not permitted.

Test Evaluation

- Surface defects such as cracks and blisters are not permitted.
- Markings on shed or housing material must be legible.

Test results: **Satisfactory**

See appendix A for test results and background information.

5.3 Dye Penetration Test

The test specimens, test, and evaluation of three insulators shall be in accordance with Clause 7.4.1. of ANSI Standard C29.11, with the exception that the housing material shall not be removed, so that the integrity of the bond shall be tested.

Test results: **Satisfactory**

See appendix A for test results and background information.

5.4 Water diffusion test

The test specimens, prestressing, test, and evaluation of three insulators shall be in accordance with Clause 7.4.2 of ANSI Standard C29.11, with the exception that the housing material shall not be removed.

Test results: Satisfactory

See appendix A for test results and background information.

5.5 Power arc test

Test specimens

- Select three insulators for this test.

Test procedure

- Tension each insulator to 6 kN and hold for the duration of this test.
- Initiate an arc across each insulator by a copper shorting fuse wire having 0.127 mm diameter. The arc shall burn 15 to 30 cycles and its current magnitude (I) determined by the ampere-time product (Ixt), shall be equal to 150 kA•cycles minimum.

Test Evaluation

- Visual Examination
  - Inspect the housing and metal fittings of each insulator.
  - Each insulator is acceptable if there is:
    - No exposure of the core,
    - No mechanical separation of the insulator, and
    - No cracks in the housing.
- Moisture Penetration Test
  - Submerge each insulator end in dye, composed of 1 gram of fuchsin in 100 grams of methanol, for a minimum of 15 minutes.
  - Remove from the solution and wipe dry
  - Cut each insulator 90° to the axis of the core and about 50 mm from both metal fittings.
  - Cut both metal fittings on each insulator longitudinally into two halves and strip off the housing.
  - Evidence of the dye on the core rod shall constitute failure.

Test results: Satisfactory

See appendix A for test results and background information.

5.6 Tracking and Erosion Test

Test Specimens

- Select three insulators for this test, and set aside an additional identical unaged insulator for the Power Frequency Voltage Test.

Test Transformer

- The test circuit when loaded with a resistive current of 250 mA (r.m.s.) on the high voltage side shall experience a maximum voltage drop of 5% in its output voltage.

Test Procedure

- Test three of the insulators using one of the methods below:
  - Method 1:
    Each insulator is energized continuously on Wheel #1
  - Method 2:
    Each insulator is energized only in the vertical position on Wheel #2.

Method 1:
Description
Tracking Wheel #1 subjects composite insulators to a continuous, current limited 60 Hz voltage while rotating the insulators. Two series current limiting resistors, total value of 135 kΩ (225 W each), are dedicated for each composite insulator. The insulators are radially passed through a saline solution (NaCl in ultra pure de-ionized water as per ASTM Volume 11.01, Section DH93-91 Type I*), water spray at the bottom of the rotating cycle. The positioning of the spray nozzle and flow rate of the doped water shall be such that the insulator is completely wetted. The distance between the spray nozzle and the test sample shall not be less than 125 mm. The insulator shall be positioned in such a manner as to prevent accumulation of saline solution on the shed surface. After every four days of testing there shall be a rest period of 24 h. During the 24h rest period the test procedure remains unchanged except that the spray nozzles are shut off.

*The Barnstead Nanopure water system has been found adequate.

Test Parameters
Minimum electrical stress …… 35 V/mm of leakage distance
NaCl content of water ……0.22 ±0.01 g/l
Minimum duration of test with spray turned on ……1000 h
Speed of rotation……..60 ± 10 r/h

Method 2:

Description

In Tracking Wheel #2 the insulators go through four positions in one cycle. Each insulator remains stationary for about 40 s (or less if discharges stop earlier) in each of the four positions. The 90° rotation from one position to the next takes about 8 s. In the first part of the cycle the insulator is dipped into a saline solution (NaCl in ultra pure de-ionized water as per ASTM Volume 11.01, Section DH93-91 Type I*). The second part of the test cycle permits the excess saline solution to drip off the insulator ensuring that the light wetting of the surface gives rise to sparking across dry bands that will form in the third part of the cycle. In that part the insulator is submitted to a 60 Hz voltage. In the last part of the cycle the insulator surface that had been heated by the dry band sparking is allowed to cool. After every four days of testing there shall be a rest period of 24h. During the 24h rest period the test procedure remains unchanged except that the dip tank is empty.

*The Barnstead Nanopure water system has been found adequate.

Test Parameters

Minimum electrical stress …… 35 V/mm of leakage distance
NaCl content of water ……1.40 ± 0.06 g/l
Minimum duration of test with the dip tank full. ……30000 cycles

Test Evaluation

- Each insulator is acceptable if there is:
  - No tracking (a Meg Ohm-meter shall be applied along a suspect path, using 1 kV DC or higher. The probes shall be between 5-10 mm apart. A resistance of less than one megaohm shall constitute failure),
  - No erosion to the core, and
  - No shed or housing puncture.

- Immediately after the tracking wheel test each aged insulator and the additional unaged insulator shall be tested and evaluated to the following tests which must be completed within 48 hours. The insulator shall be rinsed in de-ionised water prior to the following tests:
  - Steep-Front Impulse Voltage Test detailed in Clause 5.1 of this report.
  - Power Frequency Voltage Test detailed in Clause 5.1 of this report.

The test was performed in accordance with method 2.

Test results: **Satisfactory**

See appendix A for test results and background information.

5.7 Working Cantilever Load Test

Test Specimens

- For this test, select three insulators of the longest type to be qualified, using the standard stud fitting with 7/8" base threading.

Test Procedure

- Gradually load the insulator to 1.1 times its working cantilever load rating at a temperature of 20°C ±10K and hold for 96 hours. The load shall be applied to the insulator as described in the definition of the cantilever load.
- After removal of the load:
  - Cut each insulator 90° to the axis of the core and about 50 mm from the base end fitting;
  - Cut the base end fitting longitudinally into two halves in the plane of the previously applied cantilever load;

Test Evaluation

- The test is regarded as passed if the threads of the base are reusable and each fiberglass rod has:
  - no delaminations, and
  - no cracks.

Test results: Satisfactory

See appendix A for test results and background information.

5.8 Tensile Load Test

Test Specimens

- Select three insulators for this test.

Test Procedure

- Test each insulator in accordance with Clauses 5.1.1 and 5.1.4.3 of ANSI Standard C29.1 for a tensile load of 12 kN.
- Increase the load until the insulator fails, and record the failure load.

Test Evaluation

- The test is regarded as passed if all three insulators have no failure at and below the tensile load of 12kN.

Test results: Satisfactory

See appendix A for test results and background information.

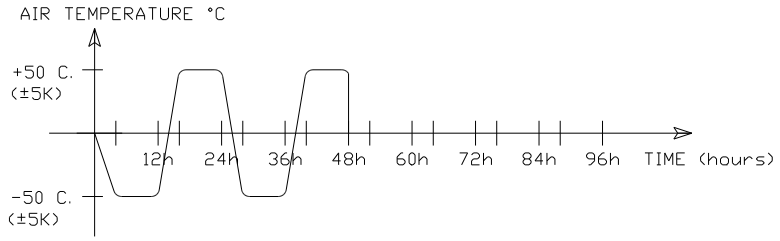
5.9 Thermal Mechanical Test

Test Specimens

- Select three insulators for this test.

Test Procedure

- Tension each insulator to 1 kN for 1 minute at ambient temperature.
- During this time, measure the length of each insulator. The measurement of the reference length shall be made to include the end fittings but exclude the couplings. The measurement accuracy shall be at least 0.5 mm. This is the reference length.
- Submit each insulator to thermal variations from -50°C ±5K to +50°C ±5K while under a permanent mechanical load of 6 kN for 48 hours. The time at each temperature shall be at least 8 hours per cycle. The thermal test cycles are shown below.



- At the end of thermal cycling, allow each insulator to reach the original ambient temperature and measure the length, using the same load as for the reference length.

Test Evaluation

- The test is regarded as passed if:
  - The increase in each insulator length is equal to or less than 2 mm, and
  - Each insulator passes the Moisture Penetration Test found in Clause 5.5 of this Specification.

Test results: Satisfactory

See appendix A for test results and background information.

5.10 Flammability Test

Test Procedure

- This test is intended to check the shed housing material for ignition and self-extinguishing properties. The test shall be performed according to IEC Publication 707, method FV.

Test Evaluation

- The test is passed if the test specimen belongs to category FV0 of IEC Publication 707.

Test results: Satisfactory

See appendix A for test results and background information.

Conclusions:

The samples of catalog number 80S046 Silicone Rubber Veri*Lite Line Post insulators meet all applicable requirements for a new design as outlined in ANSI C29.18 and LWIWG-02 standards for their stated Prototype and Design Tests, respectively.

APPENDIX A
CERTIFIED TEST REPORT

PROTOTYPE TEST REPORT PER ANSI C29.18 (2003)
DESIGN TEST REPORT PER LWIWG 02 (1996)
46 kV LINE POST COMPOSITE INSULATOR Cat # 80S046

Manufacturer's Design Test Report #: R06-06-03

Manufacturer ID:

Company: Hubbell Power Systems
Contact Person: Allen Bernstorf
Mailing Address: 8711 Wadsworth Road, Wadsworth OH 44281
Phone Number: 330-335-2361
FAX Number: 330-3347305
Test Location: Wadsworth OH

Manufacturers Composite Insulator Description:

Shed/Housing
- Material: Silicone Rubber
- Color: Gray
- Shed Diameter: End sheds 7.5" (190 mm), Intermediate Sheds 5.2" (132 mm)

Core:
- Material: Fibers: E-Glass Resin: Epoxy
  Youngs Modulus: $6x10^6$ psi (41369 MPa)
- Rod Diameter 1.75" (38.1 mm)

Metal Fittings:
- Base: 3/4" Stud
- HV End: Vertical ClampTop
- Material: Iron Type: Ductile
- Method of attachment to core: Crimp
- Working Cantilever Load (WCL): 1235 lbs (5.5 kN)
- Specified Tensile Load: 5000 lbs (22.2 kN)

Test Facilities

# 1	Company:	Hubbell Power Systems
	Test Location:	Wadsworth OH
	Contact Person:	Allen Bernstorf
	Mailing Address:	8711 Wadsworth Road Wadsworth OH 44281
	Phone Number:	330-335-2361 ext 209
	FAX Number:	330-334-7305
# 2	Company:	Hubbell Power Systems
	Test Location:	Aiken SC
	Contact Person:	David Ryan
	Mailing Address:	1850 Richland Ave East, Aiken SC 29801
	Phone Number:	803-648-8386 ext 148
	FAX Number:	803-642-2959

Certification:

This is to certify that the product, as described under "Manufacturer's Composite Insulator Description" was tested in accordance with referenced specifications, and complies with the particulars relating to such tests as set forth in the specifications.

Certified by

Name: R. Allen Bernstorf

Position: Principal Engineer Date: 2/22/07

Signature:

PROTOTYPE TESTS ANSI C29.18 (2003)
DESIGN TESTS LWIWG 02 (1996)

1.0 WATER PENETRATION TEST (CEA LWIWG-02 Clause 5.1)

Insulator Class: 69 kV (LP69) Cat No.: 80S046-0210 Dwg #:026428-00
Test Dates: 01/05/07 to 01/10/07 Insulator Manufacturing Date: 01/05/07
Test Facility #: 1

1.1 Shore A Hardness Measurements

a). Post boiling visual inspection: Comments

Pass

Insulator # 1:	Yes	No signs of cracks, dissolving or crumbling
Insulator # 2:	Yes	No signs of cracks, dissolving or crumbling
Insulator # 3:	Yes	No Signs of cracks, dissolving or crumbling

b). Shore A Hardness

	Before Boiling	After Boiling	Pass
Insulator 1 Shed # 1	75	77	Yes
Insulator 1 Shed # 2	75	74	Yes
Insulator 2 Shed # 1	75	76	Yes
Insulator 2 Shed # 2	75	75	Yes
Insulator 3 Shed # 1	76	77	Yes
Insulator 3 Shed # 2	76	76	Yes

1.2 Steep-Front Impulse Voltage Test

a). Wave Generation Method:
Marx Type Generator with low ohmic series resistance

b). Evaluation: Pass

Insulator # 1:	Yes
Insulator # 2:	Yes
Insulator # 3:	Yes

1.3 Power Frequency (60 Hz) Dry Voltage Test

a). Atmospheric Conditions:

i) Dry Bulb Temperature (°C): 21.8, 21.1, 21.8
ii) Wet Bulb Temp (°C) or Rel Humidity (%): 12.2%, 12.1%, 13.1%
iii) Barometric Pressure (mm Hg): 742, 743, 742

b). Average Dry (60 Hz) Flashover Voltage (kV)

	Uncorrected	Corrected
Insulator # 1	141.4 kV rms	174.6 kV rms
Insulator # 2	142.0 kV rms	175.1 kV rms
Insulator # 3	142.5 kV rms	175.4 kV rms
Additional or Benchmark Insulator	141.6 kV rms	174.9 kV rms

c). Evaluation of 60 Hz Flashover Voltage Test: Pass

Insulator # 1	Yes
Insulator # 2	Yes
Insulator # 3	Yes

d). 60 Hz withstand test (30 min) at 80% of section 1.3 (b):

Insulator # 1:	Pass	Yes
Pre-test Shank Temp (°C)	23.0	
Post-test Shank Temp (°C)	23.0	
Insulator # 2:	Pass	Yes
Pre-test Shank Temp (°C)	22.0	
Post-test Shank Temp (°C)	21.1	
Insulator # 3:	Pass	Yes
Pre-test Shank Temp (°C)	21.6	
Post-test Shank Temp (°C)	22.1	

2.0 AGING OR ACCELERATED WEATHERING TEST (CEA LWIWG-02 Clause 5.2)

Test Dates: 04/22/05 to 06/24/05 Test Facility #: 2

a) Test Method:

Fluorescent UV Test Standard: ASTM G53

c) Evaluation:

ID marking	Pass	Cracks and Blisters	Pass
Specimen # 1:	Yes	Specimen # 1:	Yes
Specimen # 2:	Yes	Specimen # 2:	Yes
Specimen # 3:	Yes	Specimen # 3:	Yes

3.0 DYE PENETRATION TEST (CEA LWIWG-02 Clause 5.3)

Insulator Class : 46 kV (LP46)
Cat No.: 80S046-0209
Dwg No.: 026428-00

Test Dates:02/09/06 to 02/09/06 Insulator Manufacturing Date: 11/08/05

Test Facility #: 1

Evaluation:	Pass	Time to Full Capillarity Penetration
Insulator # 1 samples:	Yes	No Penetration after 15 min
Insulator # 2 samples:	Yes	No Penetration after 15 min
Insulator # 3 samples:	Yes	No Penetration after 15 min

4.0 WATER DIFFUSION TEST (CEA LWIWG-02 Clause 5.4)

Insulator Class : 46 kV (LP46)
Cat No: 80S046-0209
Dwg No.: 026428-00

Test Dates: 01/26/06 to 01/30/06 Insulator Manufacturing Date: 11/18/05

Test Facility #: 1

Evaluation: Pass

Insulator # 1 samples: Yes
Insulator # 2 samples: Yes
Insulator # 3 samples: Yes

5.0 POWER ARC TEST (CEA LWIWG-02 Clause 5.5)

Insulator Class : 69 kV (LP69)
Cat No.:80S046-0210
Dwg No.:026428-00

Test Dates: 01/08/06 to 01/09/06 Insulator Manufacturing Date: 11/08/05

Test Facility #: 1

5.1 Power Arc Test: (60 Hz)

Post Power Arc Visual Evaluation:

Insulator # 1:	Pass	Yes
Test duration (cycles):		16
Test current magnitude (kA):		9929
Insulator # 2:	Pass	Yes
Test duration (cycles):		16
Test current magnitude (kA):		10042
Insulator # 3:	Pass	Yes

Test duration (cycles): 16
Test current magnitude (kA): 10127

5.2 Moisture Penetration Test: Pass

Insulator # 1: Yes
Insulator # 2: Yes
Insulator # 3: Yes

6.0 TRACKING AND EROSION TEST (CEA LWIWG-02 Clause 5.6)

Insulator Class : 46 kV (LP46)
Cat No.: 80S046-0209
Dwg No.:026428-00

Test Dates: 11/23/05 to 02/02/06 Insulator Manufacturing Date: 11/27/05

Test Facility #: 1

6.1 Tracking Test:

a) Tracking Test Method 2.

b) Test Voltage: Visual Examination
Pass

Insulator # 1:	30.5 kV rms	Yes
Insulator # 2:	30.5 kV rms	Yes
Insulator # 3:	30.5 kV rms	Yes

6.2 Steep Front Impulse Voltage Test

a) Waveform Generation Method:
Marx Type Generator with low ohmic Series Resistance

b) Evaluation: Pass

Insulator # 1: Yes
Insulator # 2: Yes
Insulator # 3: Yes

6.3 Power Frequency Dry (60Hz) Voltage Test

a) Atmospheric Conditions:

i) Dry Bulb Temperature (°C): 22.8, 23.5, 23.7
ii) Wet Bulb Temperature (°C) or Relative Humidity (%): 23.9%, 23.5%, 23.2%
iii) Barometric Pressure (mm Hg): 727, 727, 727

b) Average dry 60 Hz flashover voltage (kV):

	Uncorrected	Corrected
Insulator # 1	137.9 kV rms	167.7 kV rms
Insulator # 2	139.4 kV rms	169.6 kV rms
Insulator # 3	137.8 kV rms	167.9 kV rms
Additional or Benchmark Insulator	140 kV rms	171.0 kV rms

c). Evaluation of 60 Hz Flashover Voltage Test: Pass

Insulator # 1: Yes
Insulator # 2: Yes
Insulator # 3: Yes

d). 60 Hz withstand test (30 min) at 80% of section 1.3 (b):

Insulator # 1: Pass Yes
Pre-test Shank Temp (°C: 23.0
Post-test Shank Temp (°C): 23.7

Insulator # 2: Pass Yes
Pre-test Shank Temp (°C): 23.5
Post-test Shank Temp (°C): 24.9

Insulator # 3: Pass Yes
Pre-test Shank Temp (°C): 23.5
Post-test Shank Temp (°C): 23.8

7.0 WORKING CANTILEVER LOAD TEST (CEA LWIWG-02 Clause 5.7)

Insulator Class : 46 kV (LP46)
Cat No.: 80S046-0209
Dwg No.: 026428-00

Test Date: 01/27/06 to 01/27/06
Working Cantilever Load (WCL): 1235 lbs (5.5 kN)

Insulator Manufacturing Date: 11/18/05 Test Facility #: 1

Evaluation:	Pass	Comments
Insulator # 1:	Yes	No cracks or delaminations
Insulator # 2:	Yes	No cracks or delaminations
Insulator # 3:	Yes	No cracks or delaminations

8.0 TENSILE LOAD TEST (CEA LWIWG-02 Clause 5.8)

Insulator Class : 46 kV (LP46)
Cat No.: 80S046-0209
Dwg No.: 026428-00

Test Dates: 10/19/05 to 10/20/05 Insulator Manufacturing Date: 11/15/05

Test Facility #: 1

Evaluation:	Pass	Failure Load:
Insulator # 1:	Yes	Insulator # 1: 13500 lbs (60.1 kN)
Insulator # 2:	Yes	Insulator # 2: 14200 lbs (63.2 kN)
Insulator # 3:	Yes	Insulator # 3: 14400 lbs (65.1 kN)

9.0 THERMAL MECHANICAL TEST (CEA LWIWG-02 Clause 5.9):

Insulator Class : 46 kV (LP46)
Cat No.: 80S046-0209
Dwg No.: 026428-00

Test Dates: 12/27/05 to 01/03/06

Test Facility #: 1 Insulator Manufacturing Date: 11/08/05

9.1 Thermal Mechanical Cycling Reference Length Measurements:

	Pre-Cycling	Post-Cycling	Pass
Insulator # 1 (mm)	11.822	11.835	Yes
Insulator # 2 (mm)	11.830	11.830	Yes
Insulator # 3 (mm)	11.816	11.817	Yes

9.2 Moisture Penetration Test:

Pass

Insulator # 1: Pass
Insulator # 2: Pass
Insulator # 3: Pass

10.0 FLAMMABILITY TEST (CEA LWIWG-02 Clause 5.10)

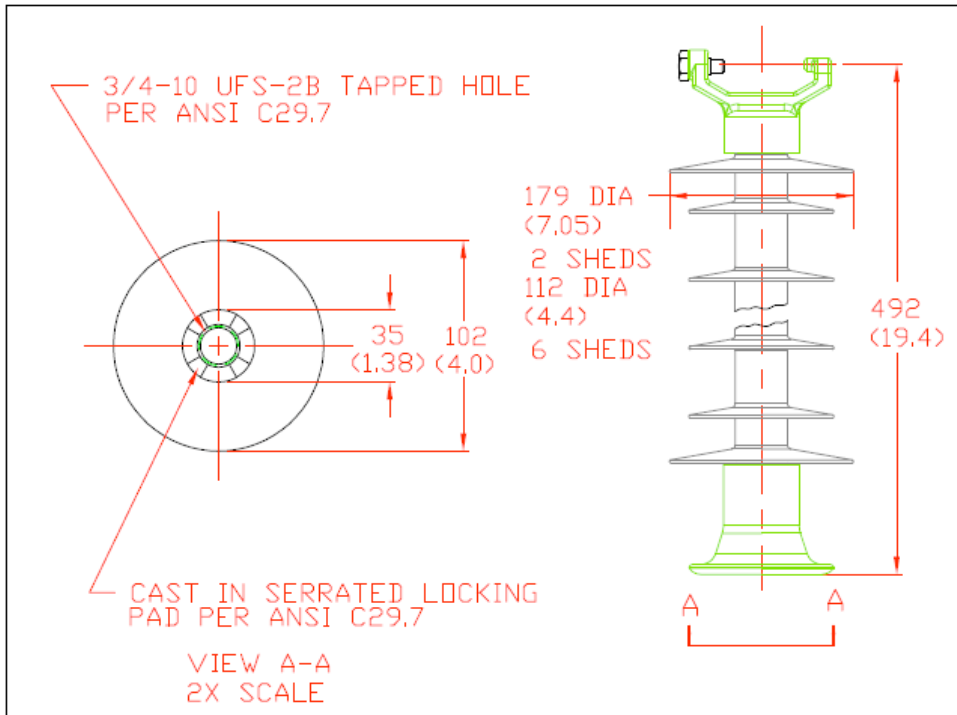
Insulator Class : 46 kV (LP646)
Cat No.: 80S046-0209
Dwg No.: 026428-00

Test Date: 05/18/05 Insulator Manufacturing Date: 04/22/05

Test Facility #: 1

Evaluation Pass Comment:

Specimen: Yes Specimen meets category FVO



DRY ARCING DISTANCE	390 MM (14.4 IN)
LEAKAGE DISTANCE	872 MM (34.3 IN)
60 Hz DRY FLASHOVER	160 kV
60 Hz WET FLASHOVER	100 kV
IMPULSE POS. CRITICAL: FLASHOVER	240 kV
IMPULSE POS. WITHSTAND	225 kV
SCL	12.5 kN (2800 LB.)
RCL	5.5 kN (1235 LB.)
NET WEIGHT	4.54 KG (10.0 LB.)

PROTOTYPE
APPROVED FOR TOOLING

OHIO BRASS®
TOLERANCE CHART

HUBBELL® POWER SYSTEMS

TITLE
VERI LITE
46 KV LINE POST

SIZE	DWG NO.	CAT / PART / ASSY NO.	REV
S	026428-00	80S046-0209	2

REV DATE	DO NOT SCALE THIS DRAWING	DRN BY	DATE	SHEET
08/01/05		JVR	05/06/04	1 OF 1

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