Polymer Cutout Evaluation NEETRAC

Frank C. Lambert
Georgia Tech / NEETRAC

High Voltage Fuses Subcommittee
Calgary, Alberta
October 14, 2008

NEETRAC Members 2008 - 2009

1. 3M
2. ABB
3. ACA Conductor Accessories
4. Ameren Services
5. American Electric Power
6. Baltimore Gas & Electric
7. Borealis Compounds LLC
8. Con Edison
9. Cooper Power Systems
10. Dominion Virginia Power
11. Dow Chemical Company
12. Duke Energy
13. Entergy
14. Exelon
15. Florida Power & Light
16. First Energy
17. GRESCO Utility Supply
18. Hubbell
19. NRECA
20. NSTAR
21. PacifiCorp
22. Prysmian Cables & Systems
23. Public Service Electric & Gas
24. South Carolina Electric & Gas
25. Southern California Edison
26. Southern Company
27. Southern States
28. Southwire
29. Thomas and Betts
30. TVA
31. tyco / Raychem
32. Zenergy Power

Introduction

- NEETRAC has recently completed an initial test program to investigate the performance of 15 kV Polymer Cutouts.
- The testing procedure was developed by the NEETRAC membership and based on ANSI C29.13-2000, “American National Standard for Insulators – Composite Distribution Deadend Type”.
- Generic results from these tests are presented to the HVF Subcommittee for consideration in the next version of IEEE Std. C37.41.

Samples Tested

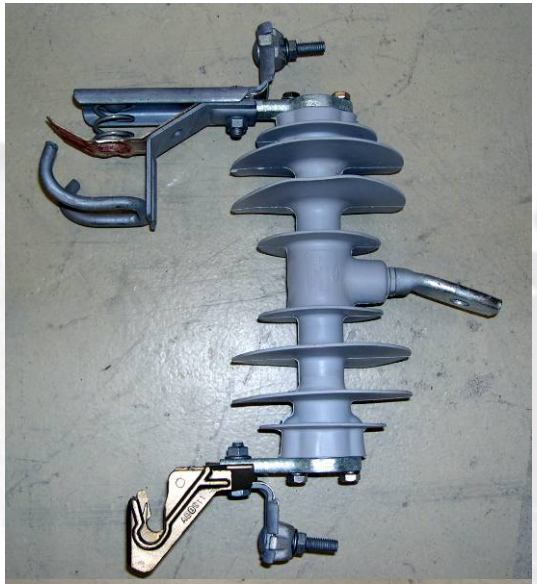
S&C Electric Company

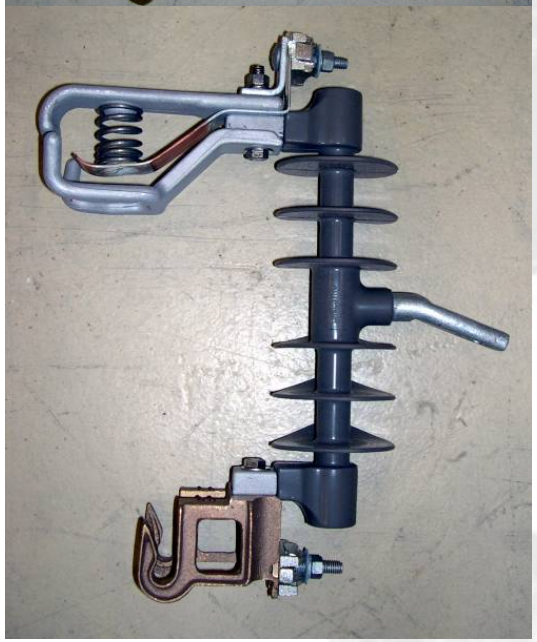
Model: 89021R10-PD

Hubbell Power Systems

Model: CP710-112PB

Samples Tested





ABB

Model: X1JCNNAM11

Indústria Eletromecânica
Balestro Ltda.

Model: CHBP 01

Water Penetration - ANSI C29.13, Clause 7.1

Test Description	Pass/Fail Criteria
Hardness test – ASTM D2240	N/A
100 hour boiling water test - in water having 0.1% by weight of NaCl	N/A
Hardness test – ASTM D2240	Hardness must not change from the pre-boiled specimen by more than 20%
Steep-front impulse voltage test (10 positive & 10 negative)	All impulses must cause external flashover. Punctures must not occur.
Low-frequency flashover test	Shall equal or exceed 90% of baseline flashover value
Elevated AC withstand test	No puncture shall occur. The temperature rise of the shank of each sample insulator shall be no more than 20 °C above ambient.

Once the samples are removed from the boiling water, all remaining tests on each sample must be performed in a forty-eight hour period.

Water Penetration

Hardness test – ASTM D2240 after 100 hour boiling

- Requirement – hardness must not change from the pre-boil specimen by more than 20%
- Maximum % change observed was +10.1% and -9.4%
- No visible signs of cracks, dissolving or crumbling were found upon visible inspection after the boil period.
- All units passed.

Water Penetration

Steep-front Impulse Voltage Test after 100 hour boiling

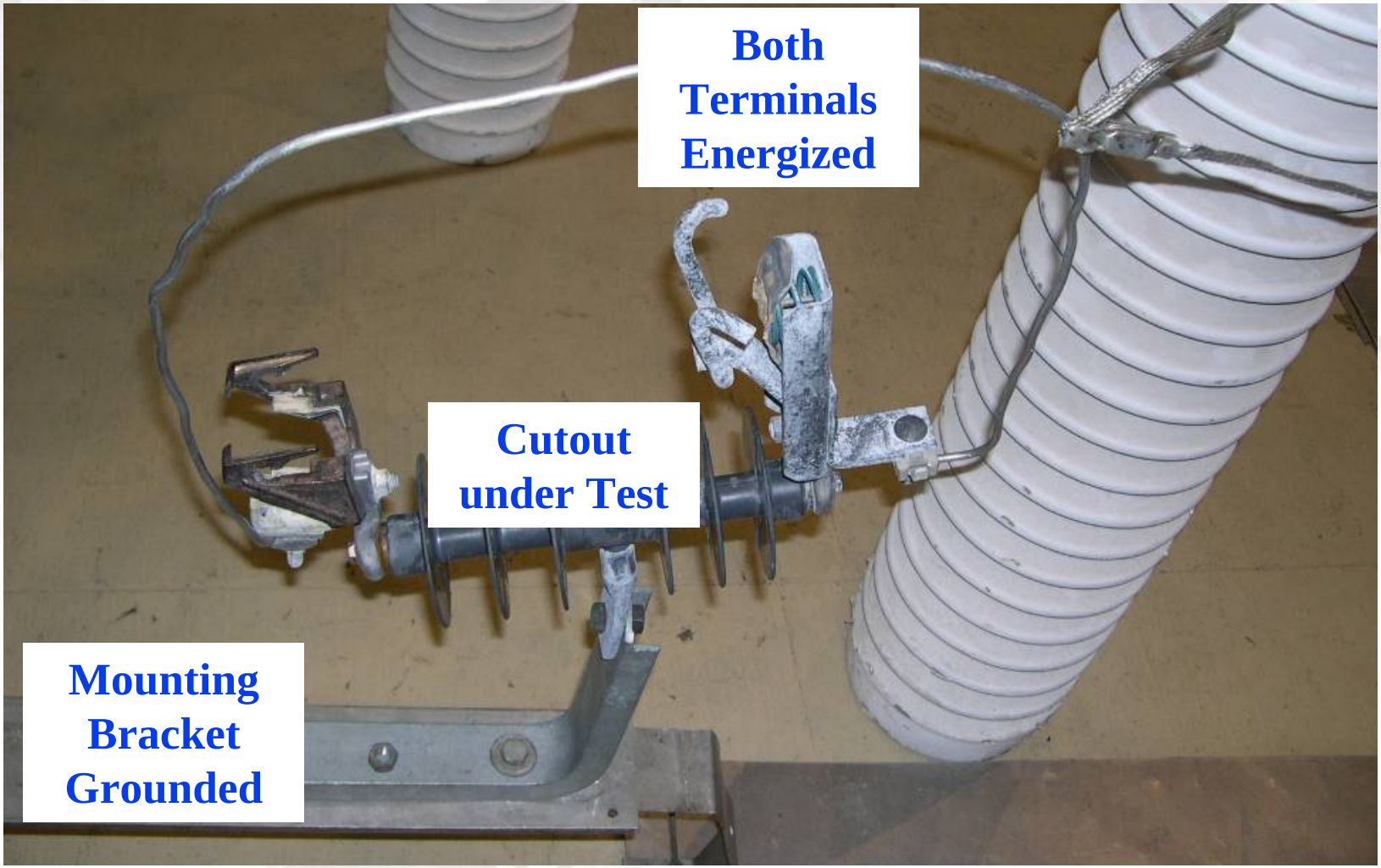
- 10 positive and 10 negative impulse waves with a voltage steepness of at least 1000 kV/µs per IEEE Std 4-1995, Section 7.2.7.
- The test is considered successful if all impulse applications result in an external flashover of the insulator samples and NO PUNCTURES are observed.

Water Penetration

Steep-front Impulse Voltage Test

Water Penetration

Steep-front Impulse Voltage Test



Water Penetration

Steep-front Impulse Voltage Test Results

Manufacturer	Positive Impulses Completed	Negative Impulses Completed
A	4	-
A	10	5
A	10	5
B	5	-
B	2	-
B	2	-
C	10	6
C	10	10
C	5	-
D	10	10
D	10	10
D	10	10
Porcelain	10	10

Water Penetration

Steep-front Impulse Voltage Test Results

- One sample from Manufacturer C and all three samples from Manufacturer D successfully passed the Steep-front Impulse Voltage tests.
- A new porcelain cutout also passed the test for comparison purposes.

Water Penetration

Low Frequency Flashover Test

- A low-frequency dry flashover test was performed on one new sample and any boiled samples that passed the steep-front test in accordance with Clause 7.1.6.3 of ANSI C29.11.
- The average flashover voltage for each test sample must be at least 90 % of the value of the reference insulator (the new sample) to pass this test.

Water Penetration

Low Frequency Flashover Test Results

Sample	Low-Frequency Dry Flashover (kV)	90% of Dry Flashover	Pass/Fail (≥90%)
C	79	75	PASS
D	71	68	PASS
D	72		
D	74		
Porcelain	67	67	PASS

Water Penetration

Low Frequency Withstand Test

- An elevated low-frequency dry withstand test was performed at 80 % of the average flashover value of the reference insulator for 30 minutes on the samples.
- The samples pass this test if no puncture occurs and if the temperature rise of the shank of the insulator is no more than 20 ºC above ambient.

Water Penetration

Low Frequency Withstand Test Results

Sample	Applied Test Voltage (kV)	Temperature (°C)			
		Ambient	Measured	Rise	
C	64.4	22.3	24.3	+2.0	PASS
D	58	25.7	31.1	+5.4	PASS
D			33.3	+7.6	PASS
D			33.5	+7.8	PASS
Porcelain	57	25.0	25.5	+0.5	PASS
	Requirement			<20°C Rise	

UV Aging

Two samples of each insulator design were placed in an environmental aging chamber and aged for 1,000 hours using UVA-340 bulbs and the following cycle:

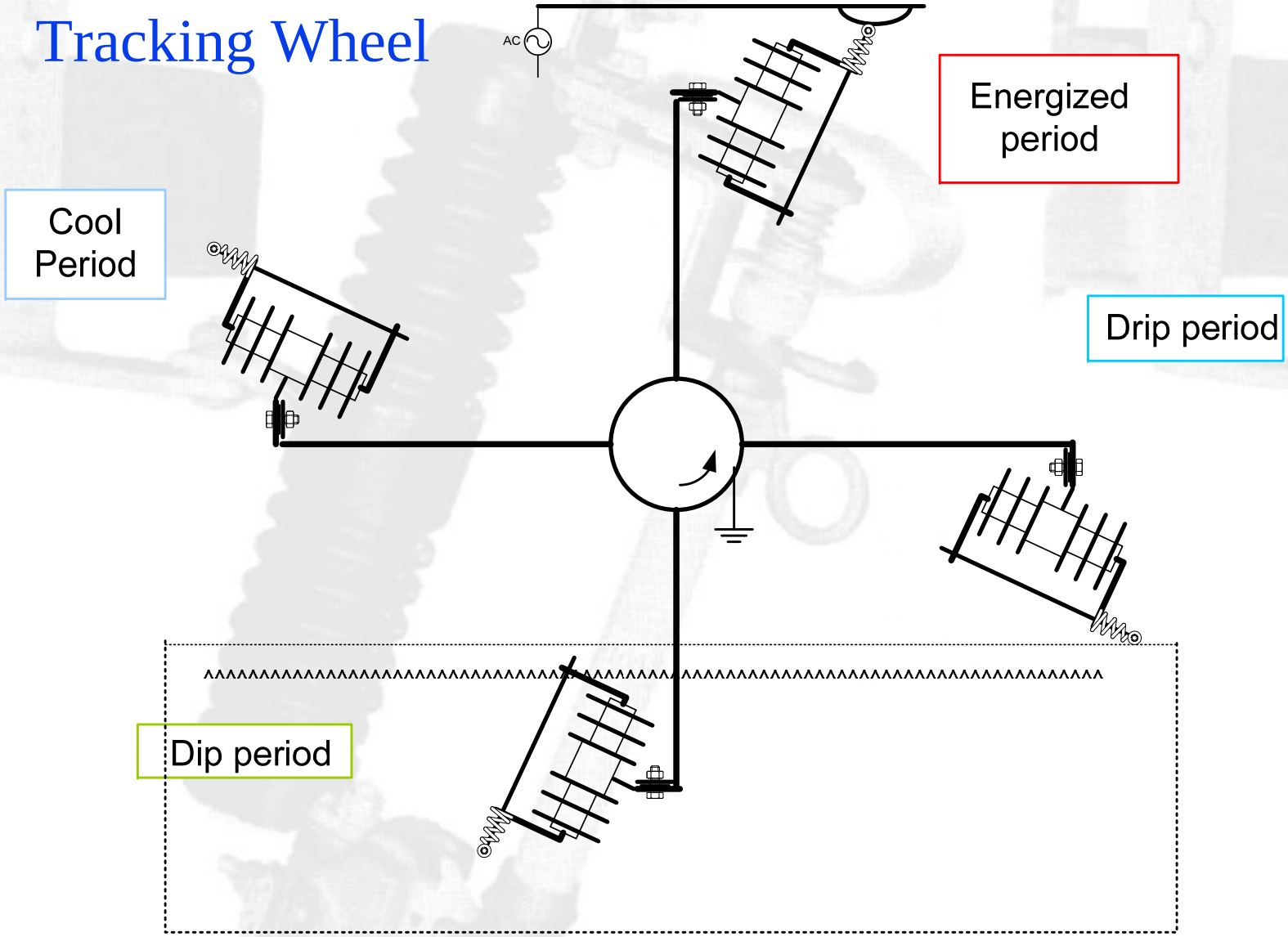
- 8 h UV at 60 (± 3) °C Black Panel Temperature;
- 0.25 h water spray (no light), temperature not controlled; and
- 3.75 h condensation at 50 (± 3) °C Black Panel Temperature.
- All samples successfully completed the test with only one manufacturer showing some slight discoloration at the end of the aging period.

Tracking & Erosion

- Each sample must complete 30,000 cycles lasting 200 seconds ± 25 seconds each with the samples stationary no less than 80 % of the cycle time.
- Each cycle consists of the sample going through the four positions with approximately an equal period of time at each position.
- The saline solution in the tank consisted of de-ionized water with 1.40 ± 0.06 g/l of NaCl.
- After every four days of testing, the samples were given a 24 hour recovery period. During this period, the test procedure was the same except the dip tank was empty.

Tracking & Erosion

Tracking Wheel



Tracking & Erosion

- The applied voltage during the energized period was 12.4 kV, 150% of the maximum single phase-to-ground value listed for 15 kV designs in Table 2, Col 2 of C37.42.

Flashover Distance	Leakage Distance	Voltage Stress
140 mm	380 mm	32.9 V/mm
165 mm	319 mm	39.2 V/mm
180 mm	300 mm	41.7 V/mm
178 mm	216 mm	57.9 V/mm

Tracking & Erosion

Tracking Wheel Results

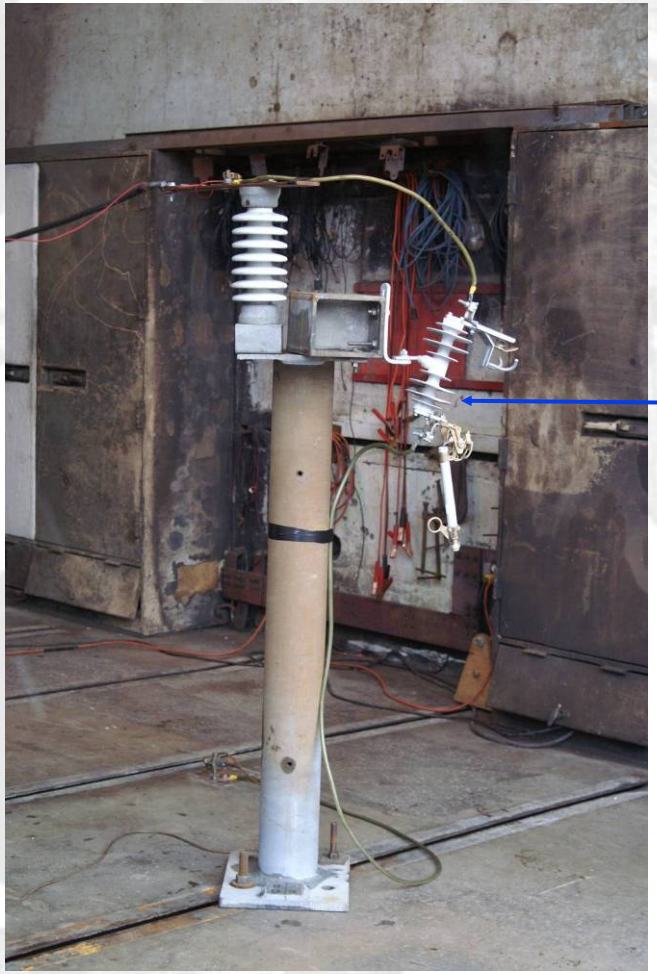
Manufacturer	New Units	UV Aged
A	3 of 3 passed	2 of 2 passed
B	3 of 3 passed	2 of 2 passed
C	0 of 3 passed	0 of 2 passed
D	3 of 3 passed	2 of 2 passed

Mechanical / Pre-conditioning

- Cap was engaged in the first thread to simulate a cross threaded condition.
- Distance from the top of the cap to the top of the pivot contact on the lower barrel was measured on all of the units. The distance ranged from 11.930 to 12.002 inches.
- Fuse barrels were then installed in each cutout and the units were placed in an environmental chamber and exposed to the thermal cycle from ANSI C29.13-2000, Figure 4, 96 hours, time at each temperature 8 hours.
- The temperature range was reduced to -30 °C to +40 °C to comply with the service conditions in ANSI/IEEE C37.40 as requested by the manufacturers.

Mechanical / Interruption Tests

- Units were then subjected to Interruption Tests as required in C37.41, Section 6.4, Test Series 1 and Test Series 5.



Cutout
Under Test

Mechanical / Interruption Tests

Interruption Test Results

- There was no apparent correlation between mechanical pre-conditioning and failure in the interruption tests.

Manufacturer	Series 1 (Min)	Series 1 (Max)	Series 5
A	Pass	Pass	Fail
B	Fail	Pass	Pass
C	Pass	Pass	Pass
D	Fail	Pass	Pass

Recommendations for IEEE C37.41

- Add requirements for Water Penetration Test
- Add requirements for UV Weathering and Tracking and Erosion
- Consider Mechanical Pre-conditioning prior to performance of the Interruption tests.

Contact Info

Frank C. Lambert
Georgia Tech / NEETRAC
404-675-1855
frank.lambert@neetrac.gatech.edu