National Electric Energy Testing, Research & Applications Center

NETRAC

A Research Center of the Georgia Institute of Technology

Thermal and temperature cycling tests on solid dielectric switches, interrupters, and reclosers

Reclosers and Other Distribution Equipment Subcommittee Meeting

September 21, 2004

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Georgia Institute of Technology

Members 2004-05

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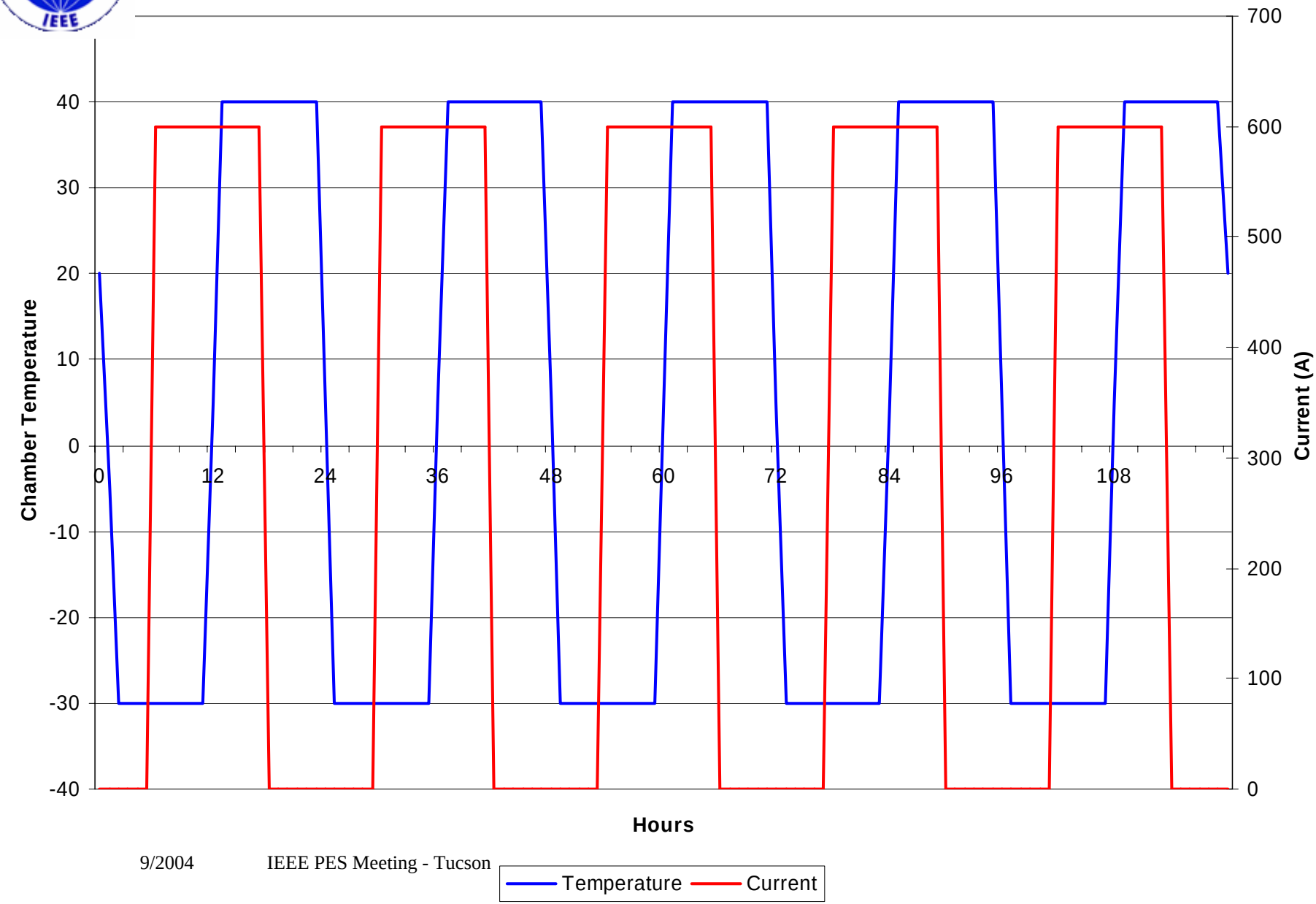
Introduction

- NEETRAC has recently completed an initial testing program to investigate possible issues with thermal cycling on solid dielectric switches.
- The testing procedure was developed by the NEETRAC membership and based on IEC 60575, “Thermal mechanical performance test on string insulators”.

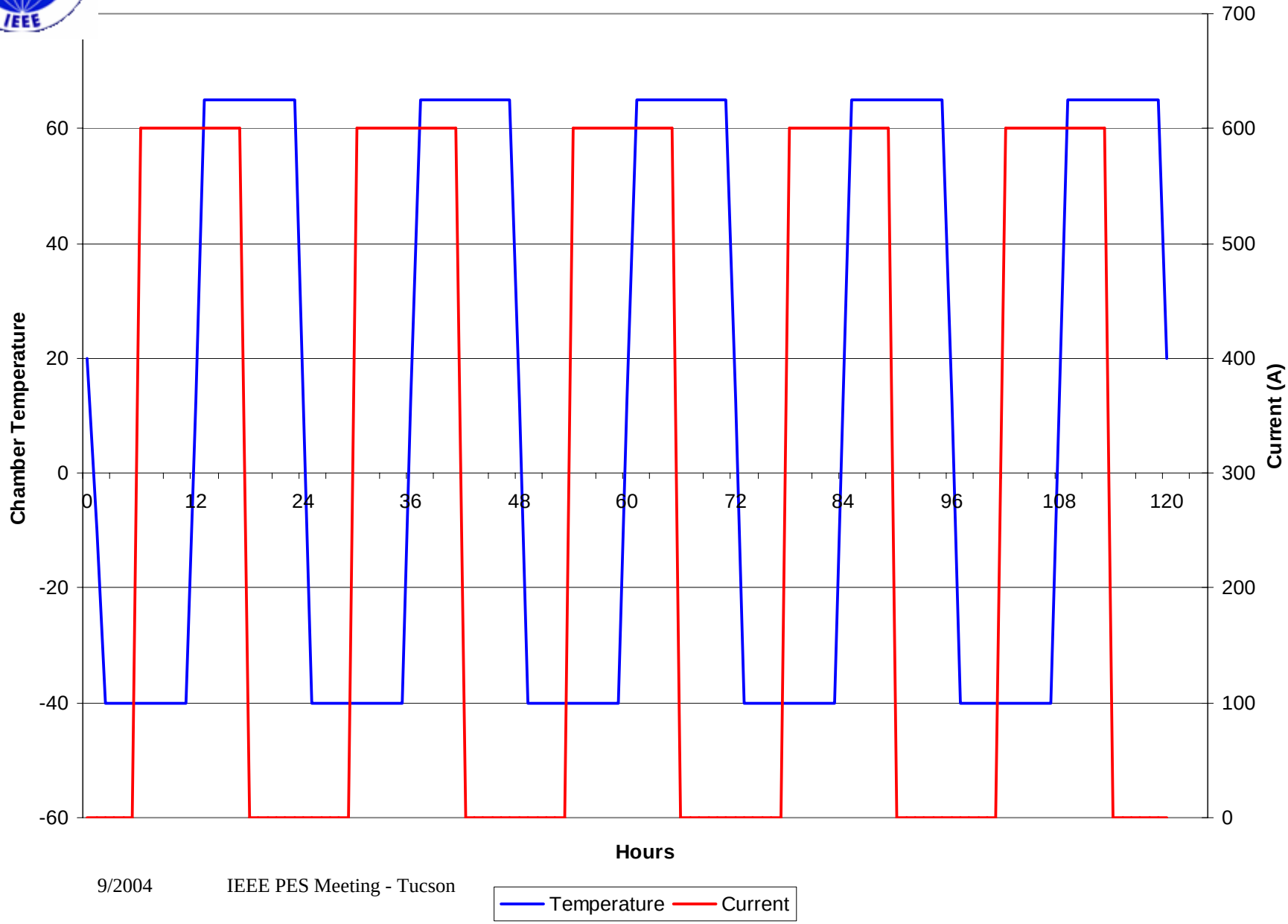
Test Procedure

- Initial benchmark tests (partial discharge and BIL) were performed on all switches.
- Switches were then exposed to temperature cycling in an environmental chamber from -30°C to 40°C and current cycling from 0 to 600A for 5 days.
- Benchmark tests (partial discharge and BIL) were repeated.
- Switches were then exposed to temperature cycling in an environmental chamber from -40°C to 65°C and current cycling from 0 to 600A for 5 days.
- Benchmark tests (partial discharge and BIL) were repeated.

Week 1


Chamber Temperature
Current (A)
Hours
40
30
20
10
0
-10
-20
-30
-40
700
600
500
400
300
200
100
0
0
12
24
36
48
60
72
84
96
108
Temperature
Current

Week 2


Chamber Temperature
Current (A)
Hours
60
40
20
0
-20
-40
-60
700
600
500
400
300
200
100
0
0
12
24
36
48
60
72
84
96
108
120
Temperature
Current

8 Samples in Test Program from 4 Manufacturers for both OH and UG Applications

Sample Number	Rated Voltage	Rated Current	Rated BIL
A	27 kV	600 A	125 kV
B	27 kV	600 A	125 kV
C	15 kV	600 A	110 kV
D	15kV	630 A	110 kV
E	27 kV	630 A	125 kV
F	38 kV	800 A	170 kV
G	15 kV	630 A	110 kV
H	27 kV	800 A	125 kV

PD Test Procedure

- PD tests were conducted according to Section 6.7 of IEEE Standard C37.60-2003.
- The interrupter was verified in the closed position prior to performing each PD test.
- Corona rings or balls were applied as necessary to each sample to minimize the effects of surface-to-air discharges during application of high voltage for the PD tests.
- The phases not being tested on each unit were connected to ground during the PD test.

PD Test Procedure

- 110% of the rated line-to-ground voltage was initially applied to each unit to initiate partial discharges within a unit.
- The voltage was immediately reduced to 105% of the rated voltage.
- After one minute at the reduced voltage, PD data was recorded.

Partial Discharge in pC by Phase

Sample Number	Background Noise Floor (pC)			Partial Discharge (pC) by Phase and Test Week								
				Phase-A			Phase-B			Phase-C		
	Initial	W-1	W-2	Initial	W-1	W-2	Initial	W-1	W-2	Initial	W-1	W-2
1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
2	<1	<1	<1	1	<1	1	1	2	1	1	4	1
3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
4	1	<1	<1	114	135	158	3	**	**	128	175	242
5	1	<1	<1	55	69	**	1	**	**	1	<1	24
6	1	<1	<1	1	<1	<1	1	<1	<1	1	<1	<1
7	1	<1	<1	1	<1	<1	3	1	<1	1	5	1
8	*	<1	<1	*	<1	<1	*	<1	<1	*	<1	<1

* New Sample added after first week of aging. W-1 (Week 1) tests for this sample are the initial tests for this sample.

** Sample previously failed during BIL.

Impulse Failure

BIL Test Procedure

- BIL tests were performed according to Section 6.2.1.1 of IEEE Standard C37.60-2003 using a standard 1.2 x 50 µS voltage impulse.
- The interrupter contacts remained in the closed position for these tests.
- The two phases not under test were grounded.
- Three positive and three negative full wave impulses were applied to the device for each BIL test. Reduced wave impulses were used when changing polarity.

BIL Test Procedure

- If flashover occurred on only one test of a consecutive group of three, nine more impulses of the same polarity were applied to the device.
- If the unit withstood all nine of the additional impulses, the unit is considered to have passed the BIL test for that polarity.
- Each BIL test was begun with impulses of an arbitrary polarity.

BIL Test Results

Sample Number	BIL Test Results (Pass/Fail) by Phase and Test Week								
	Phase-A			Phase-B			Phase-C		
	Initial	W-1	W-2	Initial	W-1	W-2	Initial	W-1	W-2
1	P	P	P	P	P	P	P	P	Fail
2	P	P	Fail	P	P	Fail	P	P	Fail
3	P	P	P	P	P	P	P	P	P
4	P	P	P	Fail	-	-	P	P	P
5	P	Fail	-	Fail	-	-	P	P	P
6	P	P	P	P	P	P	P	P	P
7	P	P	P	P	P	Fail	P	P	P
8	*	P	P	*	P	P	*	P	Fail

* New Sample added after first week of aging. W-1 (Week 1) tests for this sample are the initial tests for this sample.

Several designs included heating elements in the compartments. These elements were not energized during the testing program.

Observations

- 2 of 8 switches exhibited increased PD levels with thermal cycling. Both of these designs incorporated silicone grease in the interface.
- 6 of 8 switches experienced BIL failure on at least one phase during the entire test program.
- 2 of 8 switches experienced BIL failure on one phase during the initial benchmark tests.
- 1 of 8 switches experienced BIL failure on one phase after the first week (-30°C to 40°C).

Observations

- 4 of 8 switches experienced BIL failure on at least one phase after the second week (-40°C to 65°C).
- 4 of the 6 BIL switch failures involved problems in the operating well.
- 1 of the 6 BIL switch failures involved problems in the vacuum bottle interface.
- 1 of the 6 BIL switch failures involved a crack in the solid dielectric material. No increase in PD was detected.

Recommendations

- A design test should be developed and incorporated within C37.60 to insure the dielectric integrity of solid dielectric switches over their expected lifetime.
- -30°C to 40°C should be the minimum temperature range.
- Benchmark tests should include PD, BIL, and/or ac Withstand as appropriate to evaluate the particular dielectric system.