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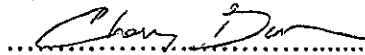
TEST REPORT

SR. No. TL51112

Issued By **High Voltage Division**

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Approved Signatory



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Test object description : Suspension-Type Porcelain Insulators, Class 52-4
Manufacturer : Fine Art Ceramic Company Limited
Sample number : สรธ.อ.354-37/1 ถึง 106 (52-4)
Sample quantity : 106 units
Date of receipt : 17 December 2008
Specimen condition : Normal
Client/Customer : Management System Certification Institute (Thailand)
1025 11th Floor Yakult Building, Phaholyothin Road, Samsennai,
Phayathai, Bangkok, Thailand 10400
Refer to : Letter No. 51/003-3, dated 9 December 2008
Purpose : Tests of electrical, mechanical and thermal characteristics
Date of test : 29 December 2008 to 9 April 2009
Place of test : High-voltage Laboratory, Faculty of Engineering
Chulalongkorn University.
Reference standard : 1) TIS 354-2528: Standard for Suspension-Type Porcelain Insulators.
2) ANSI C 29.1-1988: Test Methods for Electrical Power Insulators.
3) ANSI C 29.2-1992: Wet-Process Porcelain and Toughened Glass-
Suspension Type.
4) NEMA Standards Publication No. 107-1987 : Methods of
Measurement of Radio Influence Voltage (RIV) of High-Voltage
Apparatus.

Test items

1. Low-Frequency Dry Flashover Test
2. Low-Frequency Wet Flashover Test
3. Critical Impulse Flashover Tests
4. Radio-Influence Voltage Test (RIV)
5. Low-Frequency Puncture Voltage Test
6. Combined Mechanical- and Electrical- Strength Test
7. Residual Strength Test
8. Impact Test
9. Time-Loading Test
10. Thermal Shock Test
11. Average of Zn. Coating Thickness Test
12. Verification of Dimensions
13. Visual Inspection
14. Porosity Test

Distribution of samples

Test items	Sample No.	Quantity, units
1	1 - 3	3
2	4 - 6	3
3	7 - 12	6
4	18 - 22	5
5	13 - 17	5
6	31 - 40	10
7	41 - 65	25
8	23 - 25	3
9	26 - 30	5
10	66 - 70	5
11	74 - 78	5
12	71 - 73	3
13	1 - 78	78
14	Specimens from destroyed insulators	-

Tests

1. Low-Frequency Dry Flashover Test

Test procedure

A 50-Hz alternating test voltage was obtained from a 200-kV 10-kVA testing transformer. The measurement of the applied voltage was made by means of a 200-kV capacitor voltage divider with an accuracy of $\pm 1\%$. The test procedure was conducted in accordance with the paragraph 9.2.6.1 of TIS. 354-2528.

Quantity of sample : 3 units

Date of test : 3 January 2009

Atmospheric conditions

Barometric pressure, p	760.0	mmHg.
Temperature, T	27.0	°C
Relative humidity, h	55.0	%

Correction factors

The air density correction factor (k_d) and the humidity correction factor (k_h) based on standard conditions, i.e. $p = 760$ mm.Hg., $T = 25$ °C, and absolute humidity = 15g/m^3 , are:

$$k_d = 0.993$$

$$k_h = 1.004$$

Test results : Test results are shown in Table 1.

Table 1 The results of low-frequency dry flashover test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สรช.อ.354-37/1 ถึง 106 (52-4)

Sample No.	Flashover voltage, kV
1	89.7
2	86.9
3	86.0
Mean value	87.5
Standard value	80
Standard requirement	Mean value ≥ 76

Note: The given flashover voltages were the average values of five consecutive applied voltages.

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2. Low-Frequency Wet Flashover Test

Test procedure

A 50-Hz alternating test voltage was obtained from a 200-kV 10-kVA testing transformer. The measurement of the applied voltage was made by means of a 200-kV capacitor voltage divider with an accuracy of $\pm 1\%$. The test procedure was conducted in accordance with the paragraph 9.2.6.2 of TIS. 354-2528.

Quantity of sample : 3 units

Date of test : 3 January 2009

Atmospheric conditions

Barometric pressure, p	760.0	mmHg.
Temperature, T	27.0	°C
Relative humidity, h	55.0	%

Correction factors

The air density correction factor (k_d) based on standard conditions, i.e. $p = 760$ mm.Hg., $T = 25$ °C is:

$$k_d = 0.993$$

Test results : Test results are shown in Table 2.

Table 2 The results of low-frequency wet flashover test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สรท.อ.354-37/1 ถึง 106 (52-4)

Sample No.	Flashover voltage, kV
4	53.4
5	52.1
6	50.0
Mean value	51.8
Standard value	50
Standard requirement	Mean value ≥ 45

Note: The given flashover voltages were the average values of five consecutive applied voltages.

1001
1001

3. Critical Impulse Flashover Tests

Test procedure

A standard lightning impulse voltage, i.e. 1.2/50 μ s waveform, was generated by an impulse generator rated for 400 kV 20 kJ. The waveforms were shown in figure 1. The measurement of the applied voltage was made by means of a 400-kV capacitor voltage divider and a peak voltmeter which has an accuracy of ± 3 %.

Three insulators were tested by impulses with both positive and negative polarities. The test procedure was performed in accordance with the paragraph 9.2.6.3 of TIS. 354-2528. The critical dry impulse flashover voltages were determined by the up-down method.

<i>Polarity :</i>	<u>Positive</u>	<u>Negative</u>	
<i>Quantity of sample :</i>	3	3	units
<i>Date of test :</i>	30 December 2008	30 December 2008	

Atmospheric conditions

Barometric pressure, p	762.0	762.0	mm.Hg.
Temperature, T	27.5	26.7	$^{\circ}$ C
Relative humidity, h	65.0	67.0	%

Correction factors

The air density correction factor (k_d) and the humidity correction factor (k_h) based on standard conditions, i.e. $p = 760$ mm.Hg., $T = 25$ $^{\circ}$ C, and absolute humidity = 15g/m^3 , are:

k_d	0.994	0.997
k_h	0.982	0.985

Test results : Test results are shown in Table 3.

Table 3 The results of critical impulse flashover test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สร๑.๑.354-37/1 ถึง 106 (52-4)

Sample No.	Flashover voltage, kV	
	Positive polarity	Negative polarity
7	118.2	-
8	117.6	-
9	119.9	-
10	-	121.1
11	-	123.8
12	-	121.6
Mean value	118.6	122.2
Standard value	125	130
Standard requirement	Mean ≥ 115	Mean ≥ 119.6

4. Radio-influence voltage test (RIV)

Test procedure

The test procedure was conducted in accordance with paragraph 9.2.6.4 of TIS. 354-2528. The test circuit, shown in figure 2, was applied in accordance with the recommendation of NEMA 107-1987. It was calibrated with an external calibrating signal from the PD Calibrator type 451 of Haefely.

The 50-Hz alternating voltages were applied sequentially at different levels and the values of RIV were measured at a frequency of about 1 MHz by using an EMI/Field Intensity Meter model NM-25T of Carnel Labs.

Quantity of sample : 5 units

Date of test : 7 January 2009

Atmospheric conditions

Barometric pressure, p	764.0	mmHg.
Temperature, T	25.0	°C
Relative humidity, h	56.0	%

The circuit RIV factor and background interference

The circuit RIV factor, k_r , is 0.8 and the background interference is less than 1.3 μV .

Test results

The results show that the test specimens generated RIV less than 2.6 μV at the specified test voltage of 10 kV, as shown in Table 4.

Table 4 The results of RIV test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สรธ.อ.354-37/1 ถึง 106 (52-4)

Test voltage, kV	RIV of sample No., μV				
	18	19	20	21	22
7	1.3	1.3	1.3	1.3	1.3
8	1.3	1.3	1.3	1.3	1.3
9	1.3	1.3	1.3	1.3	1.3
10	1.3	2.5	1.3	2.5	2.5
11	6.3	3.8	2.5	12.5	18.8
12	12.5	8.8	6.3	18.8	37.5
11	2.5	2.5	1.3	3.8	15.0
10	1.3	1.3	1.3	2.5	1.3
9	1.3	1.3	1.3	1.3	1.3
8	1.3	1.3	1.3	1.3	1.3
7	1.3	1.3	1.3	1.3	1.3
Standard requirement	RIV at 10 kV must be less than 50 μV				

5. Low-Frequency Puncture Voltage Test

Test procedure

A 50-Hz alternating test voltage was obtained from a 500 kV 250 kVA testing transformer. The measurement of the applied voltage was made by means of a 600 kV capacitor voltage divider having an accuracy of $\pm 3\%$. The test procedure was conducted in accordance with the paragraph 9.2.6.5 of TIS. 354-2528. The test was performed while each test specimen was immersed in transformer oil.

Quantity of sample : 5 units

Date of test : 19 February 2009

Atmospheric conditions

Barometric pressure, p	762.7	mmHg.
Temperature, T	27.4	°C
Relative humidity, h	56.0	%

Test result : Test results are shown in Table 5.

Table 5 The results of puncture test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สรธ.อ.354-37/1 ถึง 106 (52-4)

Sample No.	Puncture voltage, kV
13	143.0
14	132.0
15	118.8
16	123.2
17	136.4
Mean value, \bar{x}	130.7

175
175

6. Combined Mechanical and Electrical Strength Test

Test procedure

The test procedure was conducted in accordance with paragraph 9.2.5.1 of TIS. 354-2528. Load was applied to the test specimen, while it was suppressed with an alternating voltage of 60 kV, until the test specimen was broken or punctured.

Quantity of sample : 10 units

Date of test : 6 March 2009

Atmospheric conditions

Barometric pressure, p	753.4	mmHg.
Temperature, T	31.3	°C
Relative humidity, h	60.0	%

Test results : Test results are shown in Table 6.

Table 6 The results of combined mechanical and electrical strength test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สรจ.อ.354-37/1 ถึง 106 (52-4)

Sample No.	Failing load of the insulators, kN
31	72.8
32	66.0
33	80.0
34	71.4
35	83.6
36	78.7
37	76.7
38	84.6
39	83.6
40	83.5
Mean value, \bar{X}	78.1
Standard deviation, S	6.3
Standard value	66.72

7. Residual-Strength Test

Test procedure

The shells of the test specimens were broken off. These specimens, without any shells, were subjected to a mechanical strength test. The test procedure was conducted in accordance with the paragraph 9.2.5.5 of TIS 354-2528.

Quantity of sample : 25 units

Date of test : 6 March 2009

Test results : Test results are shown in Table 7.

Table 7 The results of residual-strength test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สร๑.๑.354-37/1 ถึง 106 (52-4)

Sample No.	Failing load of the insulators, kN
41	72.7
42	77.2
43	79.7
44	74.9
45	70.0
46	74.9
47	68.7
48	72.2
49	69.1
50	69.1
51	85.4
52	69.5
53	68.7
54	66.7
55	65.5
56	67.7
57	61.4
58	24.4
59	74.9
60	74.7
61	67.7
62	67.2
63	66.9
64	64.6
65	71.4
Mean value, \bar{X}_R	69.0
Standard deviation, S_R	10.6
Standard requirement	$\bar{X}_R \geq 1.2 \times 33.36 + 1.645 S_R = 57.47 \text{ kN}$

8. Impact Test

Test procedure

The test specimen was mounted on the testing machine (see Fig.10 in ANSI C29.2-1992) under a tensile load of 8.9 kN. The test procedure was conducted in accordance with the paragraph 9.2.5.2 of TIS 354-2528. After receiving the specified impact, the specimen was tested for electrical soundness by being subjected to momentary flashover.

Quantity of sample : 3 units

Date of test : 19 February 2009 and 4 March 2009

Test results

The test specimens showed electrical soundness, when passed the momentary flashover, after the impact test.

9. Time-Loading Test

Test procedure

The specified load of 44.48 kN was applied smoothly and maintained for a period of 24 hr to the test specimens. After the load has been removed, the specimens were checked for electrical soundness by being subjected to momentary flashover. The test procedure was conducted in accordance with paragraph 9.2.5.4 of TIS 354-2528.

Quantity of sample : 5 units

Date of test : 20 January 2009 and 23 January 2009

Test results

The test specimens showed electrical soundness, when passed the momentary flashover, after the time-loading test.

10. Thermal Shock Test

Test procedure

The insulators were tested for ten complete cycles in accordance with paragraph 5.5 of ANSI C29.1-1988. The temperature of the hot water and cold water baths were approximately 96°C and 4°C respectively. After the thermal shock test cycles, the specimens were tested for electrical soundness by being subjected to momentary flashover. The test procedure was conducted in accordance with paragraph 9.2.4 of TIS. 354-2528.

Quantity of sample : 5 units

Date of test : 20 January 2009 and 4 March 2009

Atmospheric conditions

Barometric pressure, p	762.0	mmHg.
Temperature, T	34	°C
Relative humidity, h	60	%

Test results

The test specimens showed electrical soundness, when passed the momentary flashover, after the thermal shock test.

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11. Average of Zn. Coating Thickness Test

Test procedure

The test procedure was conducted in accordance with the paragraph 9.2.3 of TIS.384-2528. The test equipment was a coating thickness meter model EBAN 2000(F) with an accuracy of $\pm 1\%$.

Quantity of sample : 5 units

Date of test : 6 January 2009

Test results : Test results are shown in Table 8

Table 8 The test results of the average of Zn. coating thickness test of Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สร๑.๑.354-37/1 ถึง 106 (52-4)

Part	Thickness, μm .						Average of individual specimen
	Sample No.	Position					
		1	2	3	4	5	
CAP	74	98	120	219	135	128	140.0
	75	86	103	115	260	91	131.0
	76	88	101	125	97	136	109.4
	77	115	179	92	113	201	140.0
	78	88	94	117	147	89	107.0
	Average of all samples						125.5
COTTER BOLT	74	130	164	200	162	191	169.4
	75	122	99	92	100	144	111.4
	76	145	151	141	138	165	148.0
	77	114	152	116	140	202	144.8
	78	118	121	137	113	118	121.4
	Average of all samples						139.0
EYE BOLT	74	167	138	146	147	125	144.6
	75	126	100	135	147	132	128.0
	76	127	132	162	135	108	132.8
	77	132	98	94	96	101	104.2
	78	131	186	115	102	131	133.0
	Average of all samples						128.5

Standard requirement, μm		
Hardware	Individual specimen	Average of entire specimens
Hardware (except nuts/bolts)	79	86
Nuts/bolts	43	53

12. Verification of Dimensions

Test procedure

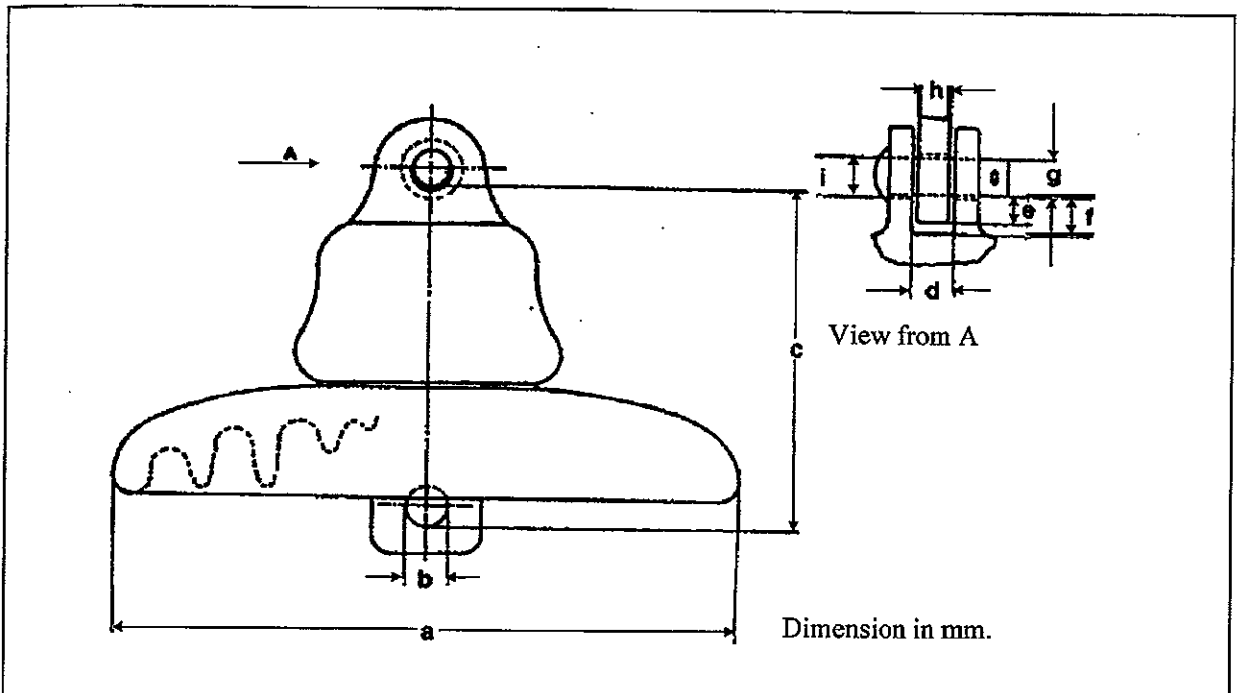
The test procedure was conducted in accordance with the paragraph 9.2.1.2 of TIS. 354-2528.

Quantity of sample : 3 units

Date of test : 9 April 2009

Test results : Test results are shown in Table 9.

Table 9 The results of dimensional test on Suspension-Type Porcelain Insulators, Class 52-4, Sample No. สรธ.อ.354-37/1 ถึง 106 (52-4)



	Requirement	No.71	No.72	No.73		Requirement	No.71	No.72	No.73
a	≤ 273	253	255.5	254	F	≥ 17.5	18	18.5	19
b	16.5-18.5	18	18	18	G	15.5-16.5	16	16	16
c	143-149	144	144	144	H	12.5-14.5	14	13.5	13
d	≥ 17.5	20.2	20	20	I	16.5-18.5	18	18	18
e	13.5-14.5	14	14	14	Leakage distance		319	327	321

13. Visual Inspection

Test procedure

The test procedure was conducted in accordance with the paragraph 9.2.1.1 of TIS. 354-2528.

Quantity of sample : 78 units

Date of test : 29 December 2008

Test results

The entire surfaces of test specimens were relatively smooth and free from imperfection.

14. Porosity Test

Test procedure

The test procedure was conducted in accordance with the paragraph 9.2.2 of TIS. 384-2528.

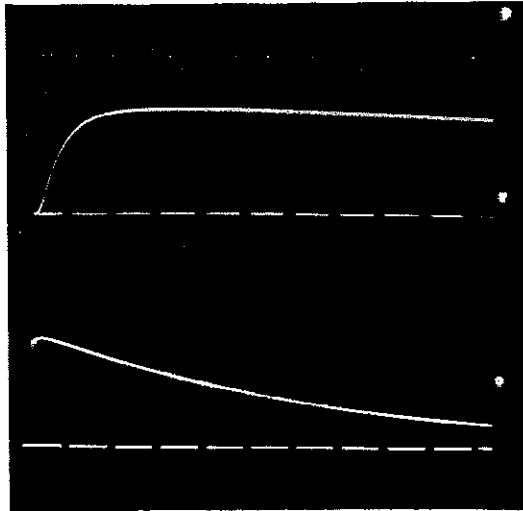
Quantity of sample : Specimens from destroyed insulators

Date of test : 16 February 2009

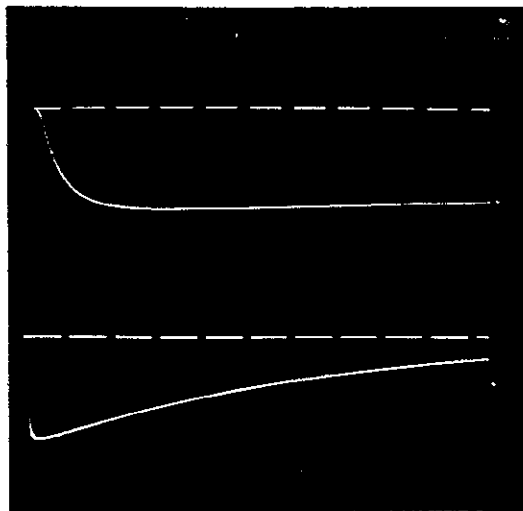
Test results

There was no visible penetration of dye into the porcelain on any of the fragments tested.

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Positive polarity

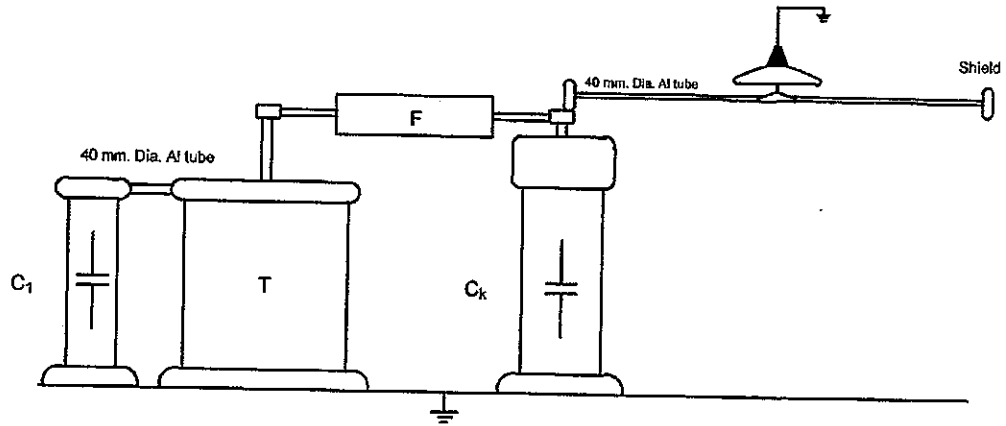


Negative polarity

Time scale: Upper trace 1 μ s/div.; Lower trace 10 μ s/div.

Figure 1 Waveforms of impulse voltages

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M



- T = 20 kVA, 50 kV, 50 Hz testing transformer
- C₁, C₂ = 100 pF 100 kV capacitor voltage divider
- F = 3.7 mH inductor (Filter)
- C_k = 1000 pF 100 kV Coupling capacitor

Figure 2 RIV test circuit

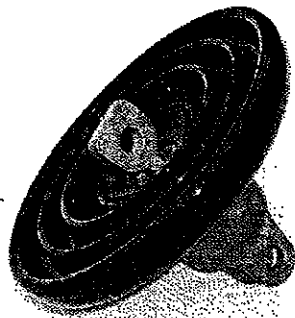


Figure 3 Suspension-Type Porcelain Insulators, Class 52-4,
Sample No. สรธ.อ.354-37/1 ถึง 106 (52-4)