سامانه های نوین افرا
AFRA MODERN SYSTEMS

TEST REPORT

Sample: 24 kV Silicone Rubber Pin Insulator ($\frac{DP-280645}{W20M28+FM28/Al}$)

Manufacturer: Afra Modern Systems Company (Samanehaye Novine Afra)

Rated voltage: 24 kV

Number of sheds: 6

Creepage distance: 645 mm

Insulator material: Silicone Rubber

Test according to: IEC 62217 (2012), IEC 61952 (2008), ISO 868 (2003), IEC 60587 (2007), IEC 62073 (2016), IEC 60695-11-10 (2013), IEC 60383-1 (1993), IEC 60383-2 (1993), IEC 60060-1 (2010).

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1. General Information

1.1. Product Information

Equipment under test : Silicon rubber pin insulator

Manufacturer : Afra Modern Systems (Samanehaye Novine Afra)

Number of sheds : 6

Rated voltage : 24 kV

SCL :6 kN

Creepage distance : 645 mm

1.2. Performed Tests

No.	Test Title	Related Standard	Test Result
1	Hardness test	IEC 62217, ISO 868	Passed
2	Tracking and erosion test –Inclined Plane Test-	IEC 60587	Passed
3	Hydrophobicity test	IEC TS 62073	Passed
4	Horizontal Flammability test	IEC 62217, IEC 60695-11-10	Passed
5	Vertical Flammability test	IEC 62217, IEC 60695-11-10	Passed
6	Dye Penetration	IEC 62217	Passed
7	Water Diffusion	IEC 62217	Passed
8	Galvanizing Test	IEC 62217, IEC 60383-1	Passed
9	Dry Power Frequency Test	IEC 61952, IEC 60383-2, IEC 60060-1	Passed
10	Wet Power-Frequency Test	IEC 61952, IEC 60383-2, IEC 60060-1	Passed
11	Dry Lightning Impulse Test	IEC 61952, IEC 60383-2, IEC 60060-1	Passed
12	Verification of the SCL	IEC 61952	Passed

2. Performance and Results of Tests

2.1. Tests on shed and housing material

Housing of an insulator is external insulating part of a composite insulator providing the necessary creepage distance and protecting core from environment. To check the performance of the housing material the four following tests were carried out:

2.1.1. Hardness test

Two specimens of the insulator housing material with thickness of 4 mm were taken from the housing of two insulators. Hardness of the mentioned samples was measured with Shore A durometer at ambient temperature. After that, the samples were kept immersed in boiling water for 42 h. At the end of the boiling period, the samples were allowed to cool and, within 3 h, their hardness was measured again at the same temperature as that of the pre-boiling measurements ± 5 K.

Acceptance Criteria: The hardness of each specimen shall not change from the pre-boiled value by more than ± 20 %.

Result of Test: According to table 1, hardness test was passed.

Table 1: Hardness Results

Sample	Pre-Boiled Hardness	After-boiled Hardness	Difference of Change	Result
1	65	63	3.07%	Passed
2	67	66	1.49%	Passed

2.1.2. Tracking and erosion test –Inclined Plane Test-

This test was carried out at ambient temperature on sets of five specimens of insulator housing. The contaminant was flowed uniformly at rate of 0.6 ml/ min on samples' surface. After that the apparatuses was switched on and the voltage raised to 4.5 kV. The voltage was maintained constant for 6 h. The constant tracking voltage is the highest voltage withstood by all five specimens for 6 h without failure.

Acceptance Criteria: The test is passed if the value of the current in the high voltage circuit through the specimen does not exceeds 60 mA, ignition and puncturing of the sample do not occur.

Result of Test: According to table 2, all five specimens survive 6 h at 4.5 kV and no ignition or puncture occurred.

Table 2: Tracking and Erosion Results

Sample	Current (mA)	Erosion Depth (mm)
1	15	1.7
2	14	1.4
3	11	1.3
4	9	0.9
5	16	1.9

2.1.3. Hydrophobicity test

For determining the hydrophobicity of insulator, the mist was applied on the insulator housing from a distance of 25 cm ±10 cm, for a period of 20 s to 30 s. The measurements of the wettability were performed within 10 s after the spraying has been completed. The appearance on the insulator surface after mist exposure was identified with one of the seven wettability (hydrophobicity) classes (HC).

Acceptance Criteria: HC is a value between 1 (the most hydrophobic) and 7 (the least hydrophobic).

Result of Test: According to figure 1, only discrete droplets were formed which are practically circular, so hydrophobicity class is **HC1**.

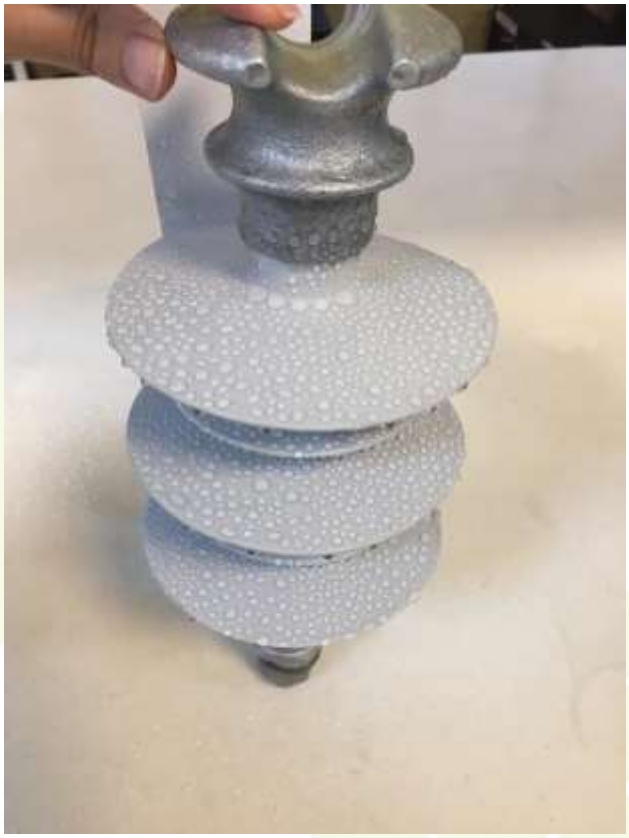

Figure 1: Hydrophobicity of the Insulator

2.1.4. Flammability test

This test can be conducted in two ways as following:

In two variations of this test, a rectangular bar-shaped test specimen is supported horizontally or vertically by one end and the free end is exposed to a specified test flame. The burning behavior of the horizontally supported bar under specific test conditions is assessed by measuring the linear burning rate. The burning behavior of the vertically supported bar under specific test conditions is assessed by measuring the afterflame and afterglow times (observing whether the materials self-extinguish), the extent of burning and the dripping of flaming particles.

2.1.4.1. Horizontal Flammability test

Three bar specimens with the dimensions of 125 mm ± 5 mm long by 13,0 mm ± 0,5 mm wide, and 3 mm thickness were tested. Each test specimen was marked with two lines perpendicular to the longitudinal axis of the bar, 25 mm ± 1 mm and 100 mm ± 1 mm from the end that was exposed to the test flame. The test specimen was clamped at the end furthest from the 25 mm mark, with its longitudinal axis approximately horizontal and its transverse axis inclined at 45° ± 2°.

The test flame was applied without changing its position for 30 s ± 1 s or was removed as soon as the flame front on the test specimen reaches the 25 mm mark if within less than 30 s. The timing device was restarted when the flame front reaches the 25 mm mark.

Acceptance Criteria: The materials were classified HB, HB40 or HB75 (HB = horizontal burning) in accordance with IEC 60695-11-10, with the following sub-classes:

a) If it does not burn with a flame after the ignition source is removed;
b) If the test specimens continue to burn with a flame after removal of the ignition source, and the flame front does not pass the 100 mm mark;
c) If the flame front passes the 100 mm mark and it does not have a linear burning rate exceeding 40 mm/min.

Result of Test: Three specimens did not burn after the ignition source was removed, so this material can be classified as **HB 40** (clause A).

2.1.4.2. Vertical Flammability test

Five bar specimens with the dimensions of 125 mm ± 5 mm long by 13,0 mm ± 0,5 mm wide, and 3 mm thickness were tested. The test specimen was clamped using the upper 6 mm of its length with the longitudinal axis vertical. The lower end of the test specimen was 300 mm ± 10 mm above the horizontal cotton pad.

The central axis of the burner tube was maintained in the vertical position, approached the test specimen horizontally towards the wide face. The flame was applied centrally to the middle point of the bottom edge of the test specimen so that the top of the burner was 10 mm ± 1 mm below that point. The burner was maintained at that distance for 10 s ± 0,5 s and moved in the vertical plane in response to any changes in the length or position of the test specimen.

After that, the burner was withdrawn immediately and the timing device was used to commence measurement of the afterflame time t_1. After that the flame was applied again and the afterflame time t_2, and the afterglow time t_3 of the test specimen were recorded. This procedure was repeated for all of the five specimens.

Acceptance Criteria: The specimens can be classified according the following table:

Criteria	Materials Classification		
	V-0	V-1	V-2
Individual test specimen afterflame times (t_1, t_2)	≤ 10 s	≤ 30 s	≤ 30 s
Total afterflame time t_f for any conditioned set of five specimens	≤ 50 s	≤ 250 s	≤ 250 s
Individual test specimen afterflame time plus afterglow time after the second flame application ($t_2 + t_3$)	≤ 30 s	≤ 60 s	≤ 60 s
Afterflame and/or afterglow of any specimen burned to the holding clamp	No	No	No
Cotton indicator pad ignited by flaming particles or drops	No	No	Yes

Result of Test: Regarding table 3, specimens were classified as **FV-0:**

Table 3: Vertical Flammability Results

Sample	t_1	t_2	t_3	t_2+t_3	Result
1	1	1	0	1	Passed
2	0	1	0	1	Passed
3	1	1	0	1	Passed
4	0	2	1	3	Passed
5	0	0	0	0	Passed

2.2. Tests on the core material

Core is central insulating part of an insulator which provides the mechanical characteristics. To check the performance of core material against water penetration, the two following tests were carried out:

2.2.1. Dye Penetration

Ten samples, with the length of 10 mm ± 0.5 mm, were cut from the insulator with a diamond-coated circular saw blade under running cold water. The cut surfaces were smoothed by means of fine abrasive cloth (grain size 180).

The specimens were placed on a layer of steel balls of same diameter in a tray. A solution of 1 % (by weight) of Astrazon BR 200 in methanol was poured into the tray, its level being 2 mm or 3 mm higher than the level of the balls. The specimens were observed for 15 minutes.

Acceptance Criteria: No dye shall rise through the specimens before the 15 minutes have elapsed.

Result of Test: according to figure 2, no dye rise through the specimens before the 15 minutes have elapsed.

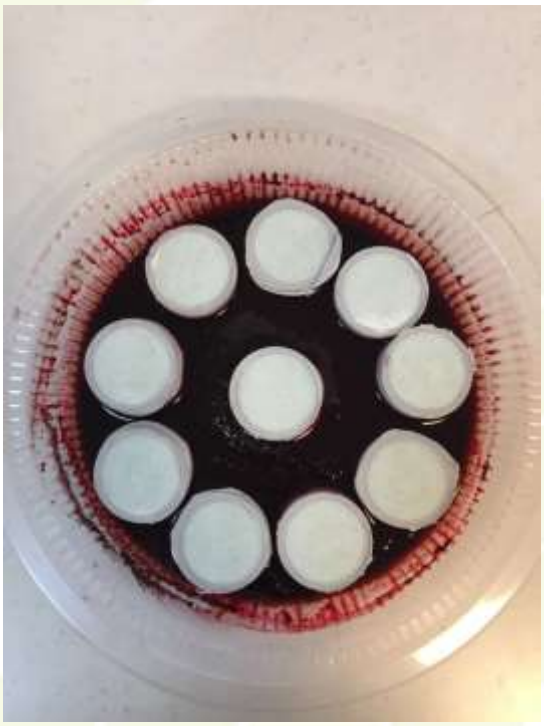

Figure 2: Schematic View of Dye Penetration Test

2.2.2. Water Diffusion

Three cylindrical samples with 30 mm ± 0.5 mm height was cut from the insulator making the cut approximately 90° to the long axis of the insulator. The specimens were boiled in a suitable container for 100 h ± 0.5 h in deionized water with 0.1 % by weight of NaCl.

After boiling, the specimens were removed from the boiling container and placed in another container filled with tap water at ambient temperature for 15 min. Immediately before the voltage test, the specimens were removed from the container and their surfaces dried with filter paper.

For voltage test, each specimen was put between the electrodes. The test voltage was increased at approximately 1 kV per second up to 12 kV. The voltage was kept constant at 12 kV for 1 min and then decreased to zero.

Acceptance Criteria: During the test no puncture or surface flashover shall occur. The current during the whole test shall not exceed 1 mA (r.m.s.).

Result of Test: According to table 4, all specimens passed the test.

Table 4: Water Diffusion Test Results

Sample	Duration (min)	Voltage (kV)	Ultimate current (µA)	Result
1	1	12.0	10	Passed
2	1	12.1	14	Passed
3	1	12.1	22	Passed

2.3. Tests on the end fitting

End fitting is the integral component or formed part of an insulator intended to connect it to a supporting structure, or to a conductor, or to an item of equipment, or to another insulator. Galvanizing test is a suitable test for determination of fittings' coating thickness which was conducted as following.

2.3.1. Galvanizing Test

The coating thickness of the ferrous fittings of insulator was determined by coating thickness instrument (Elcometer). On the test sample, three to ten randomly distributed measurements were carried out according its dimensions.

Acceptance Criteria: The coating shall be continuous, as uniform and as smooth as possible and free from anything that is determined to the stated use of the coated object. The mean coating thickness of specimen shall be not less than 85 µm.

Result of Test: Mean coating thickness of top fitting was 89 µm

2.4. Electrical and Mechanical tests

Three following electrical tests and a mechanical test (verification of SCL) were carried out to investigate the insulator's general performance.

2.4.1. Dry Power Frequency Test

The insulator was cleaned and put in high potential circuit and test voltage was applied between fittings. The test voltage was linearly raised to the withstand value and maintained for 1 min. Then the voltage was increased additionally which arcing of the insulator occurred.

It should be noted that the test voltage was corrected according to the atmosphere correction factor. According to the following ambient conditions, the atmosphere correction factor was 0.800.

Pressure: 855 hPa

Ambient temperature: 27.7°C

Relative humidity: 26%

Acceptance Criteria: The insulator shall be considered to have passed the test if no flashover or puncture occurs. Additionally, regarding 24kV insulator, the dry power frequency withstand voltage should be equal or higher than 70 kV.

Result of Test: Corrected withstand and breakdown voltage (V_{actual}) of the insulator were measured as following which demonstrate that the insulator has passed the test.

Withstand voltage: 81.25 kV

Breakdown voltage: 93.75 kV

2.4.2. Wet Power-Frequency Test

The wet test procedure was intended to simulate the effect of natural rain on external insulation. The insulator was sprayed with water falling on it as droplets and directed so that the vertical and horizontal components of the spray intensity were approximately equal. The insulator was pre-wetted initially for at least 15 min. then, the insulator was put in high potential circuit and test voltage was applied between fittings. The test voltage was linearly raised to the withstand value and maintained for 1 min. Then the voltage was increased additionally which arcing of the insulator occurred.

It should be noted that the test voltage was corrected according to the atmosphere correction factor. According to the following ambient conditions, the atmosphere correction factor was 0.822.

Pressure: 855 hPa

Ambient temperature: 27.7 °C

Acceptance Criteria: The insulator shall be considered to have passed the test if no flashover or puncture occurs. Additionally, regarding 24kV insulator, the wet power frequency withstand voltage should be equal or higher than 50 kV.

Result of Test: Corrected withstand and breakdown voltage (V_{actual}) of the insulator were measured as following which demonstrate that the insulator has passed the test.

Withstand voltage: 62 kV

Breakdown voltage: 72 kV

2.4.3. Dry Lightning Impulse Test

The standard 1.2µs/50µs lightning-impulse voltage with a front time less than 20 s was used. 15 impulses of positive and 15 impulses of negative polarity were applied to the sample. Minimum time interval between pulses was 3 s. The insulator should withstand 15 impulses and then the voltage was increased additionally which arcing of the insulator occurred.

It should be noted that the test voltage was corrected according to the atmosphere correction factor. According to the following ambient conditions, the atmosphere correction factor was 0.800.

Pressure: 855 hPa

Ambient temperature: 27.7 °C

Relative humidity: 26%

Acceptance Criteria: The insulator shall be considered to have passed the test if no flashover or puncture occurs. Additionally, regarding 24kV insulator, the dry lightning impulse withstand voltage should be equal or higher than 125 kV in both positive and negative polarities.

Result of Test: Corrected withstand and breakdown voltage (V_{actual}) of the insulator were measured as following which demonstrate that the insulator has passed the test.

Positive Withstand voltage: 145 kV	***Negative Withstand voltage:*** 150 kV
Positive Breakdown voltage: 156 kV	***Negative Breakdown voltage:*** 170 kV

2.4.4. Verification of the SCL

For verification of specified cantilever load (SCL), the insulator was subjected to a cantilever (bending) load, at the conductor position, in the direction foreseen in service. The bending load was increased rapidly but smoothly from zero to approximately 75 % of the SCL and then gradually increased to the SCL in a time between 30 s to 90 s.

Acceptance Criteria: The insulators have passed this test if the SCL can be maintained for the required time.

Result of Test: The insulator tolerates 6 kN effectively and the test was passed.

3. Apparatus Figures

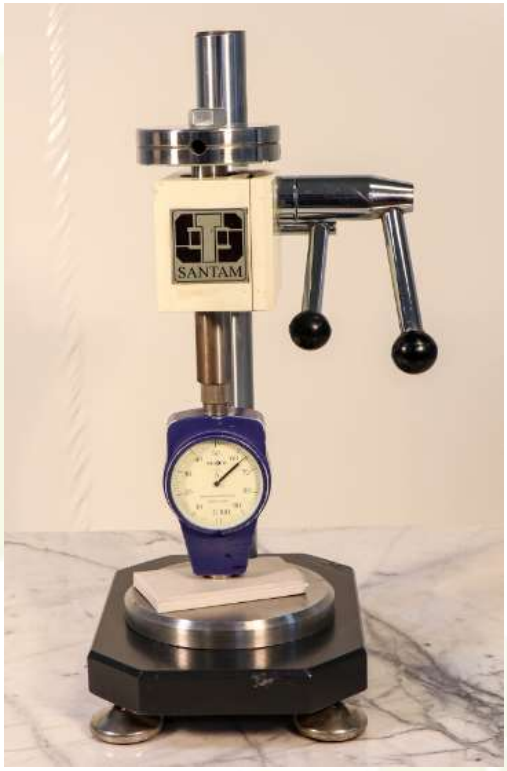

Figure 3: Shore A Durometer

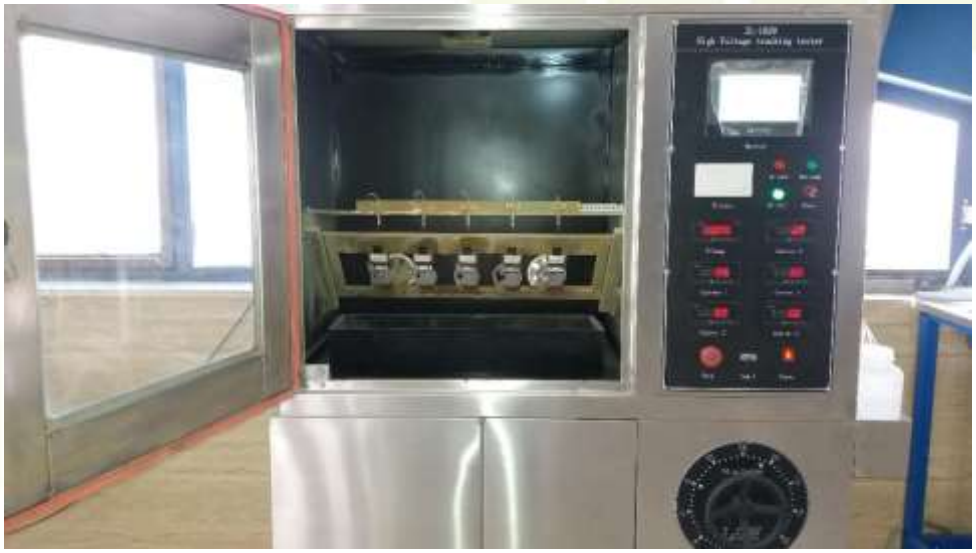

Figure 4: Tracking Machine Tester

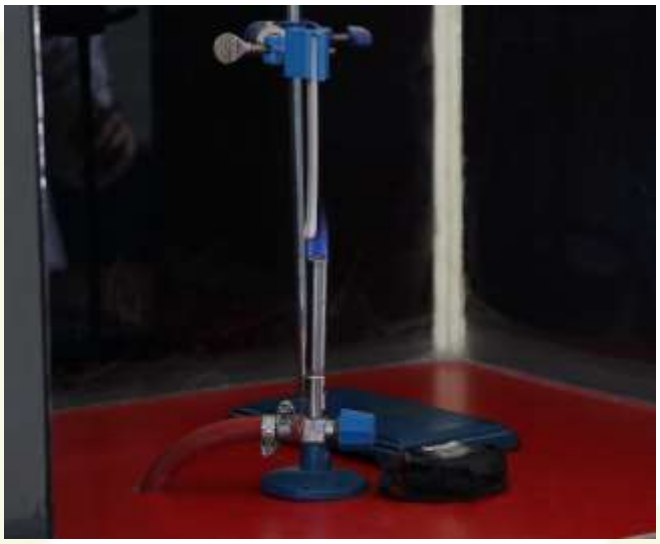

Figure 5: Equipment of Flammability Test

Figure 6: Brass Electrodes Used in Water Diffusion Test

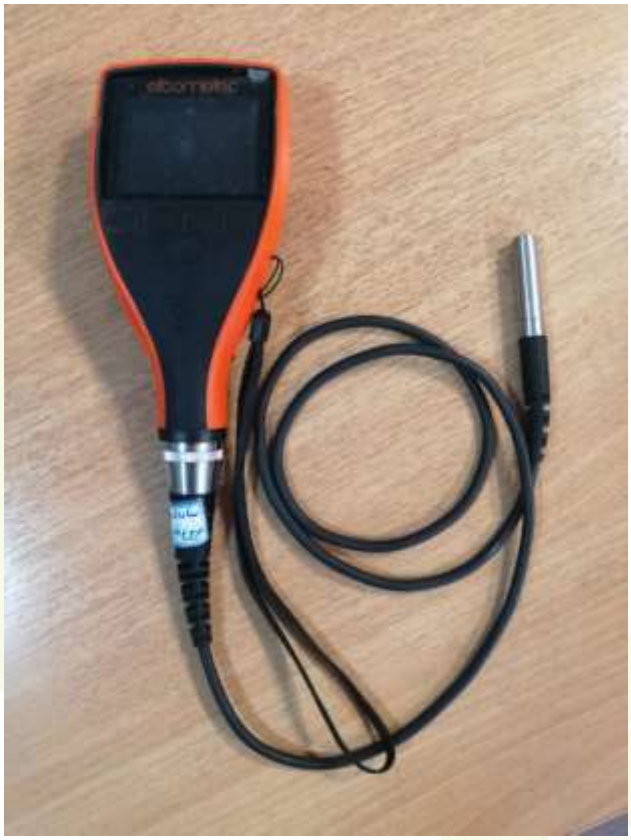

Figure 7: Equipment Used for Coating Thickness Measurement

Figure 8: Equipment of Lightening Impulse Voltage Test

Figure 9: Wet Power Frequency Voltage Test Chamber

Figure 10: Cantilever/ Bending Test Machine

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