

CHAPTER VI.

CONCLUSION and RECOMMENDATION.

1. For wet flashover voltage testing, the time after application of rain should be considered. From the results of investigation on the pin type and suspension type insulators shows that the test objects have to be sprayed between 1.5 minutes to 5 minutes before the voltage is applied, so that the surface of the test object is in a stabilized condition of wetting. However by varying the time of preraining, in order to get a stabilized flashover voltage level it was found that it depended upon the shape of insulator. The effect of time after application of rain had been carried out by S. Haraldsen at ASEA High Voltage Laboratory, on a support insulator, it was found that it took 24 minutes to obtain a stabilized flashover voltage.

Moreover the testing with a small size of rain drops gave the lower percentage different between the highest average and lowest average value of the flashover voltage than a larger size of rain drops. The maximum percentage different under large size of rain drops is about 57.3%, and the minimum percentage different under small size of rain drop is about 13.7 %.

2. A short period between consecutive flashover decreases a flashover voltage. It was found that the flashover voltage at the period of 12 seconds between

consecutive flashover was lower than that at the period of 60 seconds. The percentage different of flashover voltage between both periods are about 15.1 % for pin type and 9.8 % for suspension type. Therefore it is satisfied that the period between consecutive flashover shall be not less than 15 seconds according to the standard specification.

3. The size of rain drops has the effect on the flashover voltage of insulators. A larger size of rain drops causes a lower flashover voltage, because the larger size of rain drop splashes more than smaller size of rain drops when it impinges on the surface of insulator. In this investigation, when the rate of precipitation was kept to be constant at 4 mm./ min., the flashover voltages under smaller size of rain drops was higher than that under larger size of rain drops about 10.2 %.

4. Usually in practice the rate of precipitation of rain area about 3 mm. per min. in Europe and 5 mm. per min. in U.S.A. In this investigation, the rate of precipitation was about 4 mm. per min. However the effect of various rate of precipitation was also carried out. It was found that at lower rate of precipitation, the flashover voltage was high and decreased as the rate of precipitation increasing. The flashover voltage was nearly constant when the rate of precipitation was more than 3 mm. per min. It is therefore reasonable to use the rate of precipitation in range between 3mm. per min. for rain test.

5. When the rain falls at angle of 45 degrees to the vertical, the flashover voltage of pin insulator is highest at position of 60 degrees of inclination to the vertical in direction of spray (graph sheet No. 5.10 and 5.11). At the other positions the flashover voltage is lower because the surface of insulators is easily wetted and there are more splashes of water. The results of this test show that the position of insulator has to be considered in order to obtain a good design. However the position which has the lowest flashover voltage has also to be find out.

6. The resistivity of actual rain is high when it is compared with the under ground water. The artificial rain from the water supply has nearly the same resistivity as the actual rain. The resistance of water decreases as the temperature increases. The flashover voltage of insulator is greater, at high resistivity of water than at a lower resistivity. Therefore in designing the power transmission lines the condition of pollution has to be considered.

7. The flashover voltage across each unit of insulator decreases as the number of unit in a string increases. The potentials across the units near to the line are higher than those across units nearer to the supporting cross arm. For pin insulator connecting in parallel there is no

appreciable effect of the flashover voltage relation to the single unit.

It is suggested that further study for the electrical characteristics of insulators in a salt contamination and other pollutions areas should be carried out.

Note that the accuracy of all results depend on the accuracy of the measuring instruments. Most of meters for high voltage measurement were calibrated by the 12.5 cm. dia. sphere gap. In order to make sure that the results are exact another independent instrument should be used to check. In the future, if the standard or high accuracy equipments are available the standard test and many specifications due to the high voltage system will be specified as a standard for Thailand.

APPENDIX

Wet Flashover Voltage (Short time test) on
Pin insulator type P-2.1
Small size of rain drop
Artificial rain from under ground water

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	45.0	44.5	45.0	40.0	43.0	46.0
2	42.0	43.0	43.0	39.0	40.0	44.0
3	43.0	42.0	44.0	39.0	41.0	45.0
4	44.5	43.5	41.0	40.0	40.5	44.5
5	44.5	43.0	42.0	40.5	43.0	45.0
6	43.0	43.0	42.0	41.0	42.0	45.0
7	44.0	42.0	42.0	40.0	42.5	45.0
8	43.5	42.0	44.0	42.0	42.5	42.0
9	43.5	43.5	43.5	40.5	43.0	45.0
10	43.5	42.0	43.0	39.0	42.0	44.5
11	44.5	42.0	43.5	39.0	42.0	42.0
12	42.0	41.0	43.5	40.0	40.0	45.0
13	43.0	44.0	42.0	42.0	39.0	45.0
14	44.0	43.0	44.0	40.0	39.0	40.0
15	43.0	43.0	44.0	41.0	40.0	43.0
Average KV.	43.5	42.7	43.0	40.2	41.3	44.0

Final average = 42.5 KV.

Wet Flashover Voltage (Short time test) on
 Pin insulator type P-2.1
 Medium size of rain drop
 Artificial rain from water supply

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	52.0	49.0	50.0	51.0	52.0	50.0
2	49.5	48.0	48.0	50.0	50.0	49.0
3	50.0	49.5	48.0	48.0	49.5	49.5
4	50.5	50.5	49.0	49.0	49.5	49.5
5	51.0	50.5	49.0	50.0	51.0	49.0
6	50.5	48.0	50.0	49.0	50.5	50.0
7	50.0	47.0	49.0	49.0	49.0	49.5
8	49.5	50.0	51.0	50.0	49.5	49.5
9	50.0	49.0	48.0	51.0	50.0	49.0
10	49.0	50.0	48.0	50.0	49.0	49.0
11	49.0	49.0	49.0	50.0	49.0	50.0
12	50.0	49.0	50.0	49.0	49.0	50.0
13	49.0	49.0	51.0	49.5	48.0	49.5
14	49.0	50.0	49.0	49.5	51.0	49.0
15	49.0	51.0	49.0	50.0	50.0	49.5
Average KV.	49.9	49.2	49.2	49.6	49.7	49.4

Final average = 49.5 KV.

Wet Flashover Voltage (Short time test) on

Pin insulators type P-2.1

Artificial rain from water supply

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	60.0	56.0	54.0	55.0	58.0	56.0
2	55.0	55.0	53.5	53.0	55.0	54.0
3	52.0	55.0	52.5	51.5	54.5	52.0
4	53.5	54.0	50.5	52.0	53.0	52.0
5	52.5	54.0	50.0	53.0	54.0	51.0
6	53.0	52.5	49.0	54.0	54.0	50.0
7	55.0	50.0	50.0	49.0	56.0	51.0
8	55.0	50.0	50.0	49.0	56.0	51.0
9	55.0	50.5	50.5	50.0	55.0	51.5
10	55.0	50.0	49.0	49.5	55.0	52.0
11	49.5	51.5	50.0	50.0	56.0	54.0
12	50.5	52.5	50.0	52.0	55.0	55.0
13	50.0	52.0	49.5	54.0	54.0	54.5
14	50.5	53.0	49.0	56.0	52.0	53.0
15	53.0	52.0	50.5	53.5	51.0	56.0
Average KV.	53.2	52.7	50.5	52.4	54.4	52.7

Final average = 53.2 KV.

Wet Flashover Voltage (Short time test) on
Pin insulators type P-2
Large size of rain drop
Artificial rain from under ground water

No. of reading	Flashover KV.			
	1	2	3	4
1	36.0	35.5	35.5	36.0
2	36.5	36.0	36.5	35.5
3	37.5	35.5	36.0	35.0
4	37.0	35.5	35.5	35.0
5	37.5	36.0	36.5	35.0
6	37.5	36.5	36.5	35.5
7	37.0	35.0	36.0	35.0
8	36.5	36.0	36.0	35.0
9	36.5	36.0	35.5	35.0
10	37.0	35.0	36.0	35.5
Average KV.	36.9	35.7	36.0	35.3

Final average = 36.0 KV.

Wet Flashover Voltage (Short time test) on
 Pin insulators type P-3
 Large size of rain drop
 Artificial rain from under ground water

No. of reading	Flashover KV.					
	1	2	3	4	5	6
1	32.0	29.0	30.0	31.0	30.0	31.0
2	30.5	30.5	31.0	30.5	30.5	30.0
3	30.5	30.0	29.5	30.5	30.0	30.5
4	30.0	29.0	30.0	30.0	30.0	30.5
5	30.5	30.0	30.0	30.5	30.5	30.0
6	30.0	30.0	30.5	31.0	29.0	30.5
7	31.0	30.0	31.0	29.5	30.5	30.0
8	30.5	30.5	30.5	30.0	30.0	31.0
9	30.5	30.0	30.0	30.0	29.0	30.0
10	30.0	29.0	30.0	30.5	30.5	30.5
Average KV.	30.6	29.8	30.3	30.4	30.0	30.4

Final average = 30.2 KV.

Wet Flashover Voltage (Short time test) on String

(2 units) of suspension insulators type S-3

Small size of rain drop

Artificial rain from under ground water

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	98.0	93.5	103	98	108	104
2	93.5	94.0	99	94	99	102
3	95.5	93.0	106	99	100	105
4	97.5	89.0	108	101	103	107
5	101.0	87.0	107	100	103	99
6	92.5	93.5	116	101	104	101
7	88.0	93.5	91	99	101	100
8	89.0	103.0	100	100	95	99
9	88.5	90.0	100	101	97	104
10	103.0	96.0	103	98	97	96
11	100.0	88.0	88	98	100	99
12	98.0	90.0	90	100	98	99
13	99.0	91.0	92	102	99	101
14	102.0	91.0	92	97	102	102
15	100.0	92.0	100	96	100	100
Average KV.	96.3	92.2	99.7	98.9	100.0	100.1

Final average = 98.5 KV.

Wet Flashover Voltage (Short time test) on String of
Suspension insulators type S-3
Large size of drop
Artificial rain from under ground water

No. of reading	Flashover KV.			
	1	2	3	4
1	80	82.0	82.0	81
2	78	81.0	81.0	81
3	78	83.0	81.0	80
4	79	82.5	80.0	80
5	79	81.0	82.5	79
6	78	82.0	81.0	81
7	79	82.5	82.0	80
8	80	83.0	80.0	81
9	79	81.0	81.0	80
10	80	80.0	82.5	79
11	80	82.0	82.0	79
12	80	81.0	81.0	81
13	80	80.0	80.0	80
14	81	81.0	82.0	80
15	79	80.0	82.5	79
16	80	82.0	82.0	80
17	81	82.5	81.0	81
18	80	82.0	81.0	81
19	80	80.0	80.0	79
20	79	81.0	80.0	80
Average KV.	79.5	81.4	81.2	80.2

Final average = 80.6 KV.

Wet Flashover Voltage (Short time test) on
Pin Insulators type P-3
Small size of drop
Artificial rain from under ground water

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	72.0	69.0	72.0	68.0	70	73.0
2	71.5	66.0	67.0	63.0	70	71.5
3	70.0	67.0	71.5	67.5	68	71.0
4	71.0	66.5	65.0	62.0	69	71.0
5	68.0	66.0	66.5	66.0	70	69.0
6	69.5	67.0	66.5	66.5	67	69.5
7	70.0	66.5	66.0	63.0	68.0	67.5
8	66.5	66.5	67.0	65.5	68	68.0
9	68.0	68.0	67.0	67.0	65	68.0
10	67.0	68.0	63.0	67.0	70	70.0
11	69.0	65.5	64.0	63.0	69	71.0
12	68.0	66.0	65.0	64.0	69	69.0
13	69.0	68.0	66.0	65.0	67	70.0
14	70.0	68.0	66.0	66.0	66	69.5
15	68.0	65.0	69.0	67.0	67	67.0
Average KV.	69.0	67.0	67.0	65.4	68.0	69.7

Final average = 67.1 KV.

Wet Flashover Voltage (Short time test) on
Pin Insulators type P-3
Large size of rain drop
Artificial rain from under ground water

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	53	52	53	50	53	53
2	50	51	52	52	53	50
3	52	51	51	52	54	48
4	52	52	50	52	52	49
5	51	53	51	52	52	50
6	51	50	52	49	54	51
7	51	53	52	52	54	50
8	52	53	49	52	53	49
9	50	50	48	51	53	48
10	50	52	51	52	52	47
11	51	52	50	53	53	47
12	51	51	48	52	51	48
13	50	52	50	51	52	49
14	51	51	49	52	51	46
15	51	51	48	50	52	45
16	52	51	49	53	52	45
17	49	52	48	51	52	45
18	51	52	48	52	51	44
19	51	51	49	52	51	43
20	51	51	49	51	50	44
Average KV.	51.3	51.5	49.9	51.5	52.3	47.5

Final average = 50.7 KV.

Wet Flashover Voltage (Short time test) on
Pin Insulators type P-3
medium size of drop
Artificial rain from water supply

No. of reading	Flashover Voltage KV.					
	1	2	3	4	5	6
1	66.0	65	63	66.0	64.0	67.0
2	65.5	63	64	64.0	64.0	63.0
3	66.0	65	66	64.5	63.5	63.0
4	66.5	63	63	65.0	62.0	64.0
5	63.0	62	65	64.0	63.5	64.5
6	67.0	60	66	64.0	64.0	65.0
7	65.0	62	65	64.5	63.0	63.0
8	65.0	63.	64	63.0	63.0	66.0
9	67.0	62	65	64.0	63.0	66.0
10	64.0	61	64	64.0	64.0	65.0
11	66.0	61	64	62.0	64.5	66.0
12	65.0	62	64	64.0	63.0	64.0
13	63.0	62.0	63	65.0	62.0	62.0
14	64.0	62	66	64.5	66.0	65.0
15	64.0	63	65	64.0	65.0	63.0
Average KV.	65.1	62.4	62.5	64.2	63.6	64.4

Final average = 63.7 KV.