CHAPTER V.

DATA and RESULTS.

5.1 Dry Flashover Voltage.

The dry flashover voltage values were shown in tables 5.1 - 5.5. Each unit of sampled insulators was read repeatedly about 15 readings, and the average values were determined which showed in the lowest row. The lowest flashover voltage value of each type was assumed to be the mean of six average values.

A dry flashover testing on the suspension insulator type S - 3 and the pin insulator type P - 3 could not be made owing to the capacity of A.C. voltage was not available.

For the pin insulator type P - 1 has a flashover voltage by average about 66 KV; type P - 2.1 about 94.2 KV, type P - 2 about 120.7 KV. and for the suspension insulator type S - 1 about 80.8 KV. and 83.6 KV. for type S - 2.

TABLE 5.1

Dry Flashover Voltage on Pin insulator type P-1

Temperature 24.5 °C

	Flashover Voltage KV.					
	1	2	3	4	5	6
1	68.5	66	66.5	68.5	67	64
2	66	63	66	66	66	65
3	66	63.5	66	67.5	66	65
4	67.5	65	65.5	66.5	67	66
5	67	65.5	66	66.5	67	64
6	66	66	64.5	67	66	64
7	65.5	65.5	65	67.5	66	66
8	67.5	65.5	65.5	67.5	67	65
9	65.5	65.5	65.5	66	67	66
10	65	66	66.5	67	67	66
11	66.5	65.5	66	67	66	66
12	66	64	67	67.5	65	67
13	66	67	65.5	67	66	65
14	67	66.5	66	66	66	65
15	65.5	65.5	66	67.5	65	65
Average KV.	66.4	65.5	65.8	67	66.3	65.2

Final average = 66.0 KV.

TABLE 5.2

Dry Flashover Voltage on Pin insulator type P-2.1

Temperature 22.5°C

	Flashover Voltage KV.					
1	1	2	3	4	5	6
1	98	94	91	98	97	92
2	96	94	93	98	96	94
3	95	96	92	98.5	98	90
4	98	96	89	98	97	91
5	96	95	89	98	96	90
6	96	96	88	98.5	96	90
7	96	96.5	84	96	96	95
8	96	94	89	97	97	93
9	97	95	89	96.5	95	94
10	98	94	88	96.5	96	94
11	96	93.5	87	96	96	93
12	93	95	88.5	97	95	92
13	94	95	88	98	97	92
14	94	95	88	96.5	95	92
15	95	96	89	97	96	91
Average KV.	95.8	95	88.9	97.2	96.3	92.3

Final average = 94.2 KV.

TABLE 5.3

Dry Flashover Voltage (Short time test) on Pin insulator type P-2. Temperature 22 °C

	Flashover Voltage KV.					
	1	2	3	4	5	6
1	114.0	124.0	125.5	123.0	115.0	120.0
2	116.0	125.0	124.0	123.0	115.0	121.0
3	116.0	125.0	125.5	121.0	117.0	121.0
4	114.0	125.0	125.5	120.0	116.0	123.0
5	118.0	125.0	125.5	122.0	118.0	121.0
6	117.0	124.0	125.0	122.0	115.0	120.0
7	117.0	124.5	125.0	122.0	116.0	121.0
8	117.5	124.5	125.0	119.0	116.0	122.0
9	116.0	125.0	124.5	118.0	116.0	121.0
10	117.0	124.5	125.0	122.0	117.0	121.0
11	116.0	124.0	124.0	121.0	116.0	121.0
12	116.0	125.0	124.0	121.0	116.0	120.0
13	116.0	124.0	124.0	121.0	116.0	122.0
14	117.0	124.0	124.0	120.0	116.0	121.0
15	118.0	124.0	125.0	122.0	118.0	121.0
Average KV.	116.1	124.5	124.7	121.1	116.1	121.0

Final average = 120.7 KV.

TABLE 5.4

Dry Flashover Voltage (KV) on Suspension insulators type S-1. Temperature 21.5 °C

	Flashover Voltage KV.					
	1	2	3	4	5	6
1	82.0	73.0	80.0	79.0	81.0	80.0
2	83.0	83.0	80.0	80.0	79.0	80.0
3	80.0	81.0	80.5	81.0	80.0	80.0
4	83.0	82.0	81.0	81.0	80.0	79.00
5	82.0	73.0	81.0	80.0	80.0	79.5
6	82.0	82.0	81.0	79.0	78.0	80.0
7	81.5	83.0	83.0	78.0	79.0	79.5
8	82.5	82.0	81.5	81.0	81.0	79.5
9	82.0	82.0	81.0	80.0	80.0	80.0
10	83.0	82.0	82.0	80.0	80.0	80.0
11	82.5	81.5	81.0	80.0	79.0	80.0
12	82.0	81.0	81.5	79.0	80.0	79.0
13	82.0	81.0	81.5	81.0	80.0	80.0
14	81.0	81.0	82.0	80.0	80.0	80.0
15	81.0	82.0	83.0	81.0	81.0	79.5
Average KV.	81.8	80.5	81.3	80.0	79.8	81.0

Final average = 80.8 KV.

TABLE 5.5

Dry Flashover Voltage(KV) on Suspension insulators type S-2. Temperature 21.5 °C.

	Flashover Voltage KV.					
	1	2	3	4	5	6
1	88.0	78.0	84.0	85.0	80.0	83.0
2	83.0	82.0	85.0	85.0	81.0	82.0
3	80.0	82.0	85.0	84.0	81.0	84.0
4	88.0	83.0	84.0	85.0	82.0	83.0
5	86.0	81.0	86.0	86.0	81.0	83.0
6	88.0	83.0	82.0	85.0	83.0	83.0
7	88.0	82.0	83.0	85.0	82.0	83.0
8	87.0	82.0	84.0	84.0	82.0	81.0
9	88.0	83.0	85.0	83.0	82.0	83.0
10	88.0	81.0	85.0	86.0	81.0	82.0
11	88.0	83.0	83.0	85.0	80.0	82.0
12	88.0	81.0	87.0	85.0	81.0	82.0
13	87.0	83.0	86.0	84.0	82.0	83.0
14	85.0	83.0	86.0	83.0	82.0	83.0
15	86.0	82.0	85.0	86.0	81.0	83.0
Average KV.	85.9	82.0	84.7	84.8	81.5	82.8

Final average = 83.6 KV.

5.2 Effect of Preraining.

The time of preraining is a problem which one who makes a rain test have to consider. Generally according to the specification in the standard a minimum time of preraining on the test object is between 1 and 5 minutes in order to ensure that the test object become a stabilized condition of wetting.

The wet flashover voltage (short time test) as a function of time preraining were shown in table 5.6 to table 5.12. As the flashover of insulators in rain test is dependent upon the wet condition of surface, a constant flashover voltage cannot be expected, so that the values may be represented by the mean of at least four samples at the same conditions. The variation of flashover voltage on insulators with time are shown clearly in graphs corresponding to each type of samples.

The variation of flashover voltage with time on pin insulators type P - 1 shown in graph sheet No. 5.1 has the highest mean value = 41.1 KV. at 0.5 minute and the lowest mean value = 31.3 KV; hence the difference between both values = 28.3 %. The maximum average value of flashover voltage being about 41.1 KV. at t = 0.5 , has decreased to 33.0 KV. after 14 minutes of raining.

For the pin insulators type P - 2, the variation of flashover voltage with time as shown in graph sheet No. 5.2. has the highest average value about 60.8 KV. at t = 0.5 min.

and decrease to 37.5 KV. after 11 minutes of raining. The difference between the highest average value and the lowest average value is about 57.3 % . It was seen that the percentage different, highest and lowest value of pin insulator type P - 2 is more than type P - 1. Moreover the rate of decreasing flashover voltage on type P - 2 is faster than on type P - 1 at a few minute after raining .

The variation of flashover voltage with time on the pin insulators type P - 2.1, which has the shape and feature like to the pin insulator type P - 1 is shown in graph sheet Nol 5.3 . The percentage different between the highest average value and the lowest average value is about 34.9%. The maximum average value of flashover voltage is about 53.4KV. at t = 0.5 minute and decrease to 39.8 KV. after 4.5 minutes of raining.

From the table 5.9 the variation of flashover voltage on the pin insulators type P - 3 with time is plotted as shown in graph sheet No. 5.4 . It is seen that after 3 minutes of raining the flashover voltage decrease to nearly constant value. The maximum average value is about 75.8 KV. and has the percentage different between highest average and lowest average value about 30.4%.

The other sample of insulators in this testing are suspension type . The relation of flashover voltage and time is shown in graph sheet No 55. The maximum average value is about 94.3 KV. which is different to the lowest average value about 13.8%. It takes about 3 minutes after

raining for a constant flashover voltage is obtained.

However, the flashover voltage which mention above are carried out under medium size of rain drops. The variation of flashover voltages with time under small size of rain drop are also investigated on the pin - insulator type P - 2 and P - 3; as shown clearly in graph sheet No.5.6 and 5.7. For the pin insulator has the percentage different between highest average and lowest average value about 19.5%, for type P - 2 and 13.7 % for P - 3. It is shown that the percentage different on P - 2 is more than on P - 3 which corresponds to the effect of time preraining under medium size of rain drops.

It may be stated that the suspension type S - 3 has very little of its surface covered against the rain and also having a simple shape, so that the surface of insulator may be easy and rapidly in wetting, and thereafter nothing more happens; so that it causes a small percentage different between highest average value and lowest average value. The other insulator is more complicated, such as pin insulator type P - 2. Owing to its shape, it takes a long time for raining in order to make the underside of the insulator has been wetted; by this reason the variation of flashover voltage is caused so much.

TABLE 5.6

Wet Flashover Voltage (KV) on Pin insulator type P-1
as a function of time
Medium Size of rain drop

Time Preraining min	Flashover KV					Average
	1	2	3	4	5	
0.5	44.0	41.5	40.5	39.0	40.5	41.1
1.0	36.0	39.0	40.0	35.0	37.0	37.1
1.5	38.0	36.0	36.0	31.0	33.0	34.8
2.0	35.0	38.0	37.0	32.0	33.0	35.0
2.5	36.0	37.0	36.0	32.0	33.5	34.9
3.0	36.5	36.5	36.5	33.0	35.0	35.5
3.5	35.5	33.0	36.5	31.0	33.0	33.8
4.0	35.0	36.0	34.0	34.0	34.0	34.6
4.5	38.0	35.0	31.0	32.0	34.0	34.0
5.0	37.0	35.0	34.0	34.0	33.0	34.6
6	36.5	34.0	38.0	38.0	35.0	36.3
7	35.5	37.0	33.0	34.0	34.5	34.8
8	36.5	31.0	31.0	38.0	34.0	34.1
9	33.0	34.0	33.0	33.5	33.0	33.4
10	34.2	34.0	32.0	34.0	33.5	33.6
11	34.0	35.0	33.0	33.0	32.5	33.5
12	33.0	33.0	32.5	33.0	32.5	32.8
13	32.5	33.0	33.0	34.0	33.0	33.1
14	33.0	34.0	32.0	34.0	32.0	33.0
15	34.0	33.0	33.0	34.0	33.0	33.2

Final average = 34.3 KV.

The difference between highest and lowest = 28.3 %

SHEET No. 5.1

FLASHOVER VOLTAGE (SHORT TIME TEST)

on Insulators type P-1 as a function of time.

(Medium size of rain drops)

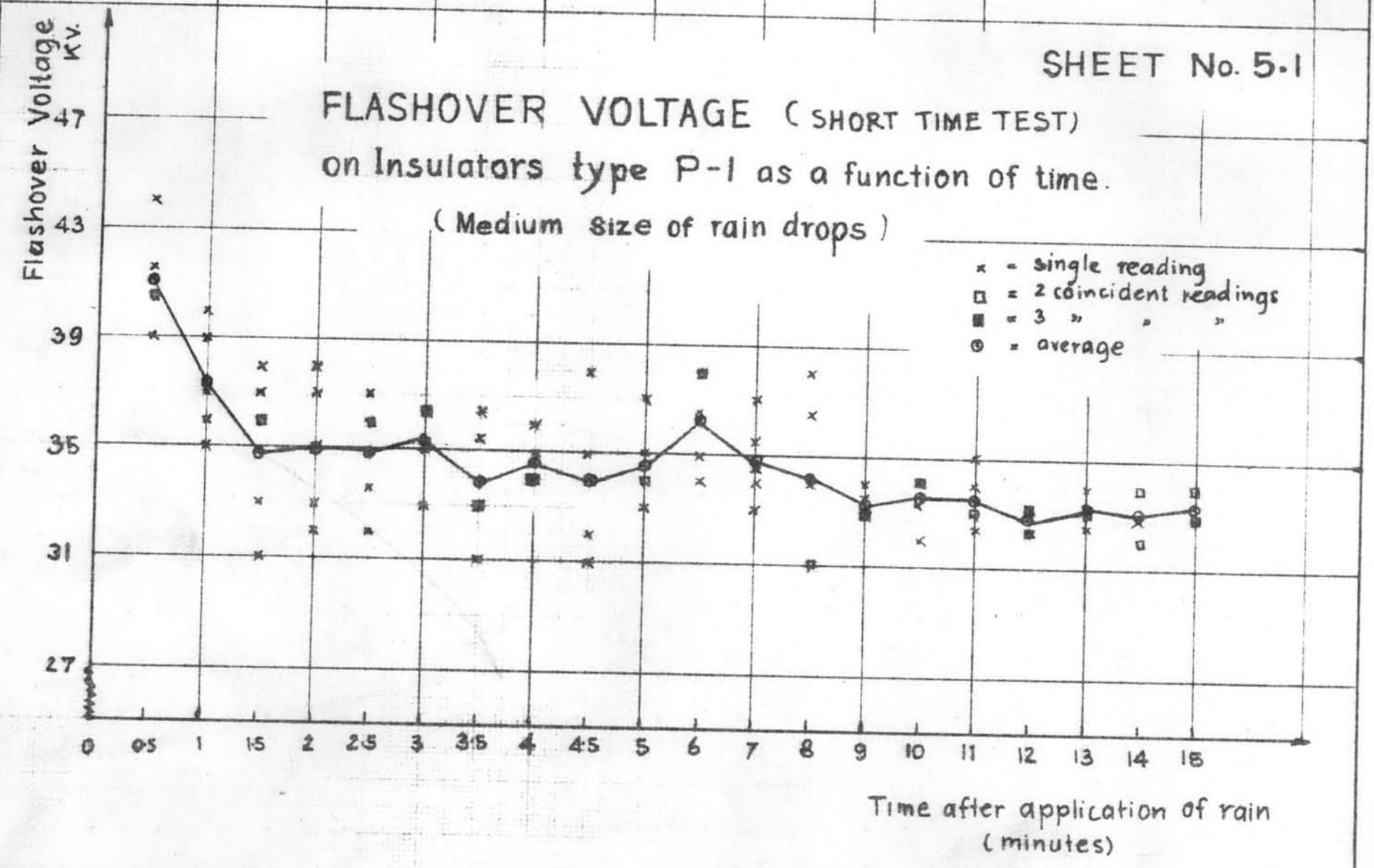


TABLE 5.7

Wet Flashover voltage (Kv) (short time test) on Pin insulator type P-2 as a function of time

Medium of size of rain drop

Time Preraining (min)	Flashover Kv				Average
	1	2	3	4	
0.5	61.0	60.5	60.0	61.5	60.8
1.0	54.8	58.0	48.0	54.0	53.8
1.5	47.0	46.2	43.2	46.8	45.9
2.0	44.5	43.2	42.0	45.0	43.7
2.5	43.2	42.0	41.5	44.0	43.4
3.0	41.5	41.0	40.5	42.8	41.4
3.5	40.5	41.5	40.0	42.8	41.2
4.0	41.0	40.5	38.5	43.2	40.8
4.5	38.5	39.2	38.0	39.2	38.7
5	40.0	41.0	37.5	42.0	40.7
6	38.0	39.2	38.5	40.0	39.0
7	37.5	38.5	38.0	38.5	38.2
8	38.0	38.5	40.5	39.2	39.1
9	37.5	37.5	39.5	38.0	38.0
10	37.5	38.0	37.5	37.5	38.0
11	37.5	37.5	37.5	37.5	37.5
12	37.5	37.5	37.5	37.5	37.5
13	37.0	37.0	37.0	37.0	37.0
14	37.0	38.0	38.0	37.0	37.5
15	38.0	37.0	38.0	37.0	37.5

Final average = 41.6 Kv.

The difference between highest and lowest value 57.3 %

SHEET No. 5·2

FLASHOVER VOLTAGE (Short Time Test)

on Insulators type P-2 as a function of time.

(Medium size of rain drops)

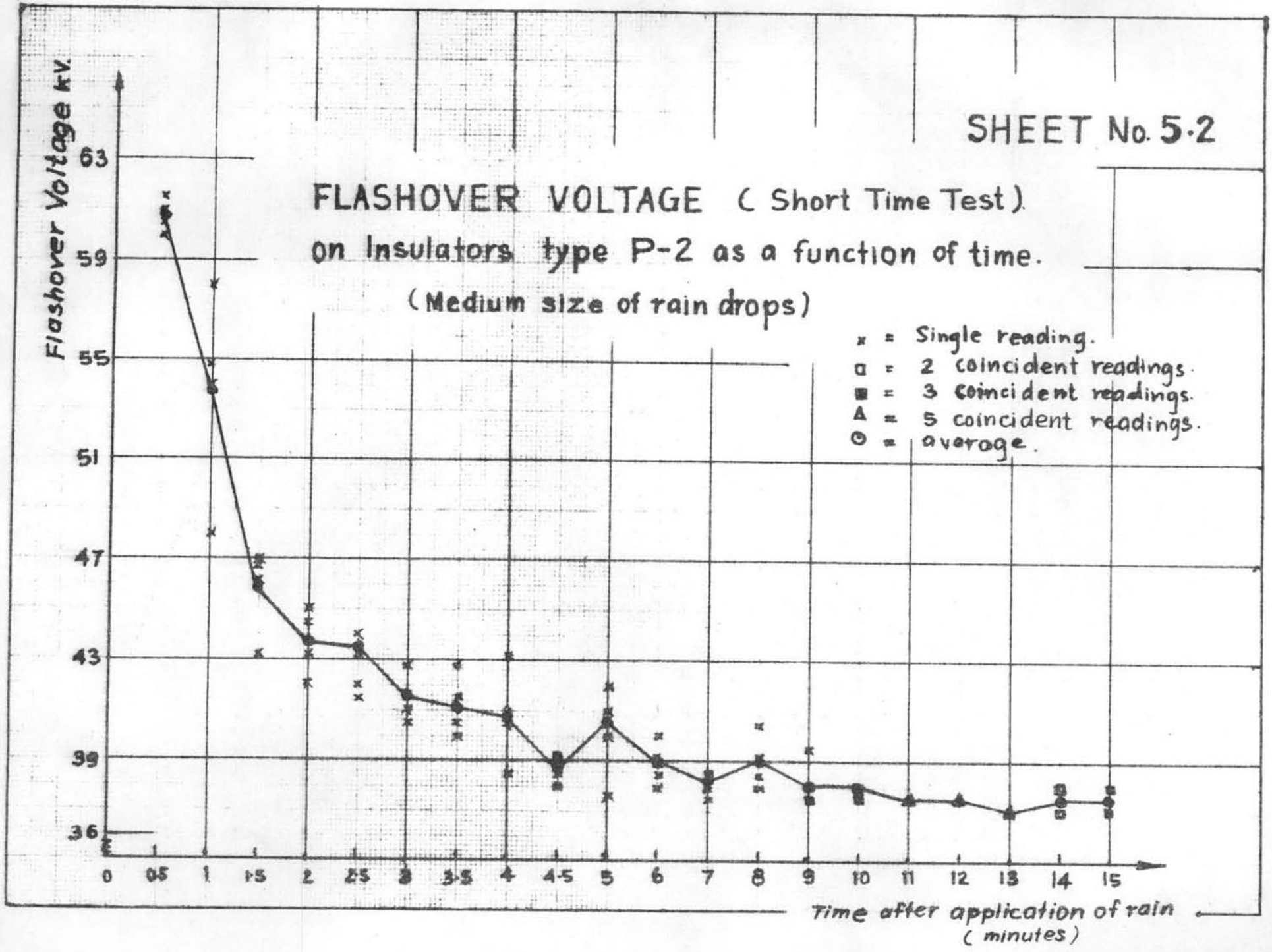


TABLE 5.8

Wet Flashover Voltage (KV) (Short time test) on Pin insulator type P-2.1 as a function of time

Medium size of rain drop

Time Preraining (min)	Flashover KV						Average
	1	2	3	4	5	6	
0.5	51.0	49.0	55.0	54.8	55.5	54.8	53.4
1.0	43.0	48.0	52.0	48.0	49.0	46.0	47.6
1.5	38.8	44.5	49.0	45.6	47.0	45.0	44.9
2.0	44.0	43.0	44.5	43.0	43.0	43.0	43.3
2.5	43.0	42.0	43.0	42.0	42.0	42.0	42.4
3.0	43.0	42.0	41.5	41.5	41.0	41.5	41.8
3.5	42.0	41.0	41.0	41.0	41.0	41.0	41.2
4.0	41.5	40.5	40.5	40.5	40.5	40.0	40.6
4.5	41.0	39.0	39.0	39.0	41.0	40.0	39.8
5	38.8	39.0	40.0	49.2	40.5	39.2	41.2
6	38.8	40.0	41.0	41.5	43.0	40.5	40.8
7	37.5	40.0	40.5	40.5	40.5	40.5	39.9
8	40.5	40.0	40.0	40.5	40.5	40.5	40.4
9	42.0	40.0	40.0	40.5	40.0	40.5	40.5
10	40.5	40.0	40.0	40.0	40.0	40.0	40.1
11	39.2	40.0	39.0	41.0	40.0	40.0	39.8
12	40.0	39.0	40.0	40.0	39.0	40.0	39.7
13	39.0	39.0	40.0	40.0	40.0	40.0	39.7
14	40.0	40.0	49.0	39.0	40.0	39.0	39.5
15	39.0	39.0	40.0	40.0	39.0	40.0	39.5

Final average = 41.8 KV.

The difference between highest and lowest value = 34.9 %

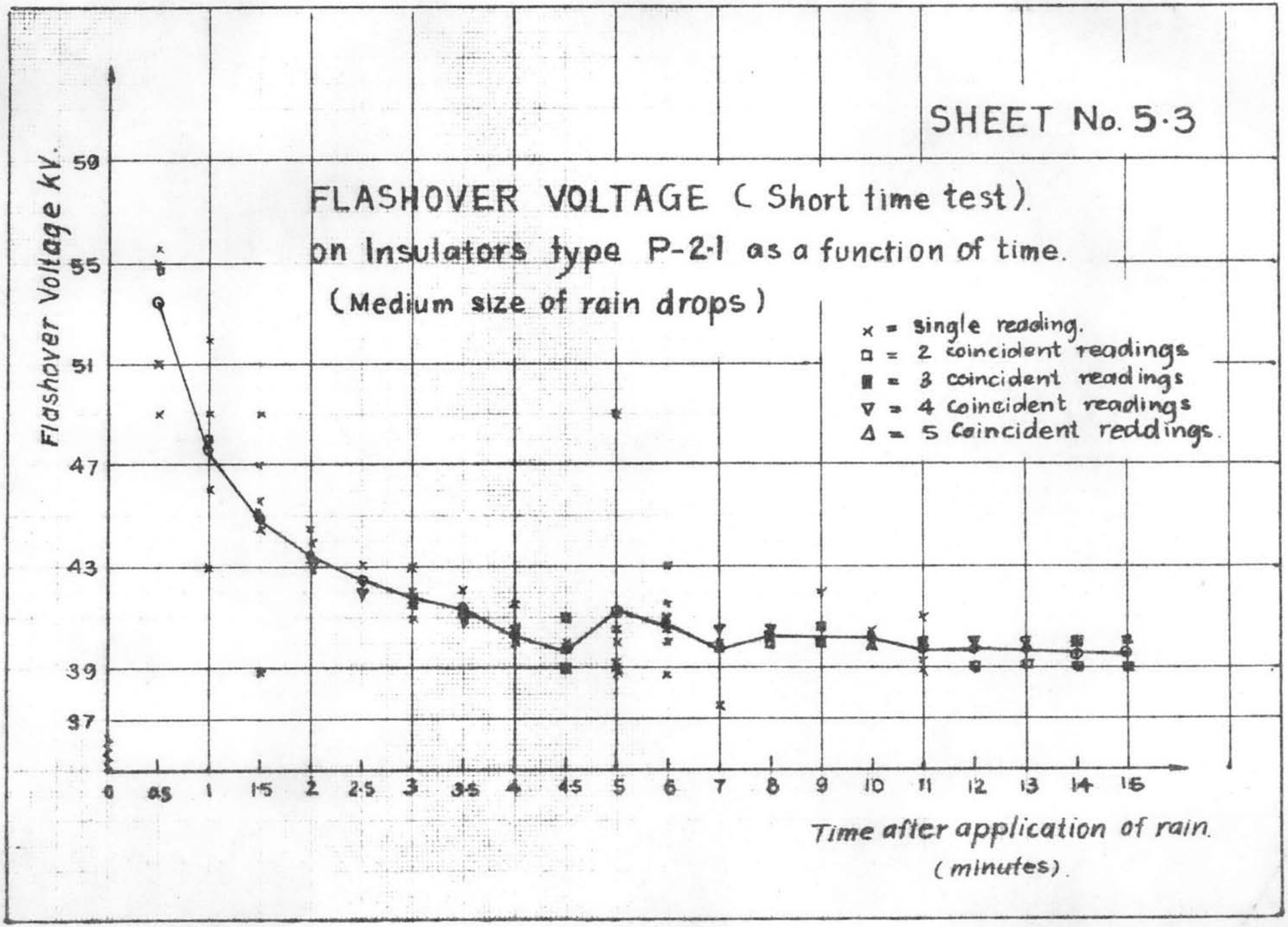

SHEET No. 5·3
FLASHOVER VOLTAGE (Short time test).
on Insulators type P-2-1 as a function of time.
(Medium size of rain drops)
× = single reading.
□ = 2 coincident readings
■ = 3 coincident readings
▽ = 4 coincident readings
Δ = 5 coincident reddings.
Flashover Voltage KV.
50
55
51
47
43
39
37
0
0.5
1
1·5
2
2·5
3
3·5
4
4·5
5
6
7
8
9
10
11
12
13
14
15
Time after application of rain.
(minutes).

TABLE 5.9

Wet Flashover Voltage (KV) on Pin insulator type P-3
as a function of time
Medium size of rain drop

Time Preraining (min)	Flashover KV.						Average
	1	2	3	4	5	6	
0.5	85.5	72.5	72.5	79.5	73.0	71.5	75.8
1.0	71.5	69.3	69.0	72.5	70.0	60.5	69.1
1.5	69.0	62.0	61.5	65.0	67.0	60.0	64.2
2.0	65.6	60.0	63.0	60.5	64.5	60.5	61.9
2.5	68.0	59.4	60.0	60.5	62.6	59.2	61.5
3.0	63.6	60.0	60.5	61.0	63.6	57.5	61.1
3.5	63.0	61.5	59.2	60.0	63.0	54.6	60.2
4.0	63.0	60.0	59.2	58.0	63.0	56.3	60.0
4.5	65.0	60.5	58.6	58.6	63.6	54.6	60.1
5	63.0	58.6	58.6	58.0	63.0	56.5	60.0
6	63.6	58.6	61.0	59.2	62.0	54.6	59.9
7	62.6	57.5	57.5	59.2	64.5	54.6	59.2
8	62.6	58.0	59.2	60.0	66.0	54.0	59.9
9	63.0	59.2	58.6	59.2	61.5	55.0	59.4
10	62.0	59.2	59.2	58.6	62.0	57.0	59.7
11	62.0	60.0	59.0	58.0	61.0	54.0	60.1
12	60.5	59.2	60.0	59.0	61.0	55.0	59.2
13	57.5	59.2	60.0	59.5	60.0	54.0	58.4
14	58.0	59.2	59.0	59.0	61.5	55.0	58.6
15	60.0	59.0	59.5	59.0	60.0	55.0	58.5

Final average = 60.5 KV.

The difference between highest and lowest value = 30.4 %

SHEET No. 5·4

FLASHOVER VOLTAGE (Short time test).

on Insulators type P-3 as a function of time.

(Medium size of rain drops)

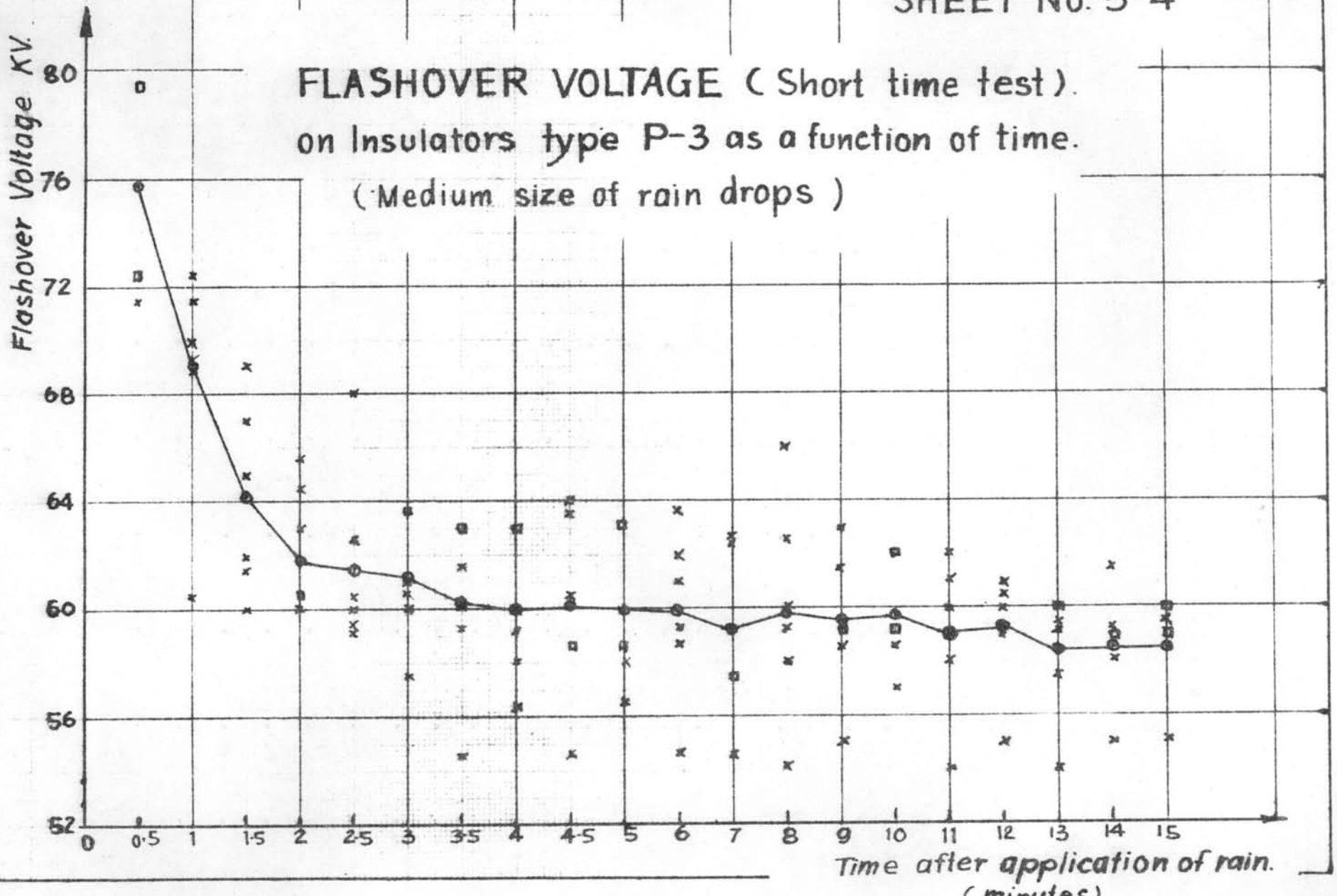


TABLE 5.10

Wet Flashover Voltage (KV) on String (2 units) of Suspension Insulator type S-3 as a function of time

Medium size of rain drop

Time Preraining (min)	Flashover KV				Average
	1	2	3	4	
0.5	100.0	97.0	89.2	91.0	94.3
1.0	92.5	93.5	85.0	89.2	92.3
1.5	89.2	91.0	89.6	87.0	89.2
2.0	94.7	89.8	90.0	81.0	88.9
2.5	92.5	90.0	87.0	82.5	88.0
3.0	89.8	89.2	82.0	81.0	85.5
3.5	89.8	92.5	84.0	81.0	86.8
4.0	91.0	91.4	82.5	82.5	86.8
4.5	85.2	89.6	83.0	81.0	85.7
5	100.0	87.0	83.0	82.5	85.7
6	94.7	89.2	81.0	80.0	86.3
7	89.2	89.8	82.5	81.0	85.7
8	91.4	95.0	77.0	82.0	85.7
9	93.5	87.0	83.0	79.6	85.9
10	89.2	89.2	80.0	82.5	85.3
11	89.2	89.2	87.0	82.0	86.8
12	89.8	89.8	79.6	80.0	84.7
13	89.2	89.2	78.0	79.6	84.2
14	89.6	89.8	79.6	80.5	84.8

Final average = 87.1 KV

The difference between highest and lowest value = 13.8 %

SHEET No. 5·5

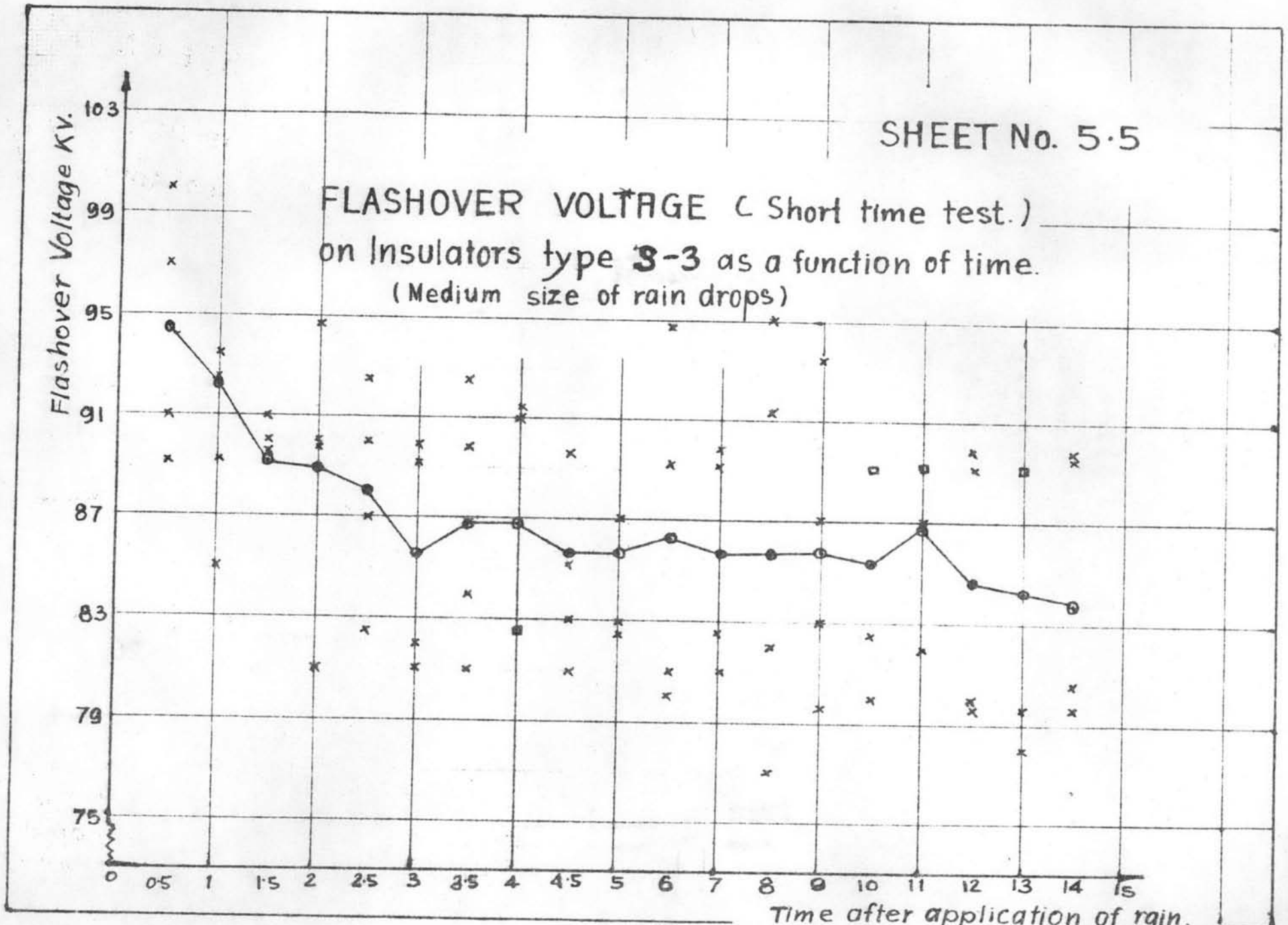

FLASHOVER VOLTAGE (Short time test.)
on Insulators type S-3 as a function of time.
(Medium size of rain drops)
Flashover Voltage KV.
103
99
95
91
87
83
79
75
0
0·5
1
1·5
2
2·5
3
3·5
4
4·5
5
6
7
8
9
10
11
12
13
14
15
Time after application of rain.
(minutes)

TABLE 5.11

Wet Flashover Voltage (KV.) on Pin Insulators type P-2
as a function of time
Small size of rain frop

Time Preraining (min)	Flashover KV.				Average
	1	2	3	4	
0.5	46.6	46.0	46.0	47.0	46.4
1.0	43.3	42.6	45.0	44.0	43.7
1.5	43.5	43.5	40.2	43.0	42.6
2.0	41.5	40.2	38.5	41.0	40.3
2.5	41.0	40.0	38.5	42.0	40.4
3.0	42.0	43.2	39.0	40.0	41.1
3.5	41.5	40.2	38.0	39.0	39.7
4.0	41.5	40.0	38.5	37.0	39.2
4.5	42.0	41.0	38.0	39.0	40.0
5	43.2	42.0	38.0	39.0	40.6
6	40.2	40.2	38.0	37.0	38.8
7	41.5	41.0	38.5	38.0	39.8
8	41.0	42.0	38.0	39.0	40.0
9	43.0	41.5	38.5	39.0	40.5
10	41.5	40.2	39.0	38.0	39.7
11	41.0	41.0	37.0	38.5	39.4
12	41.0	41.5	39.0	37.0	39.4
13	40.5	40.5	39.0	37.5	39.4
14	41.0	41.0	38.0	37.0	39.2
15	40.0	42.0	37.0	37.0	39.0

Final average = 40.4 KV.

The percentage different between highest and lowest value = 19.5 %

SHEET No. 5-6

FLASHOVER VOLTAGE (Short time test)
on Insulators type P-2 as a function of time

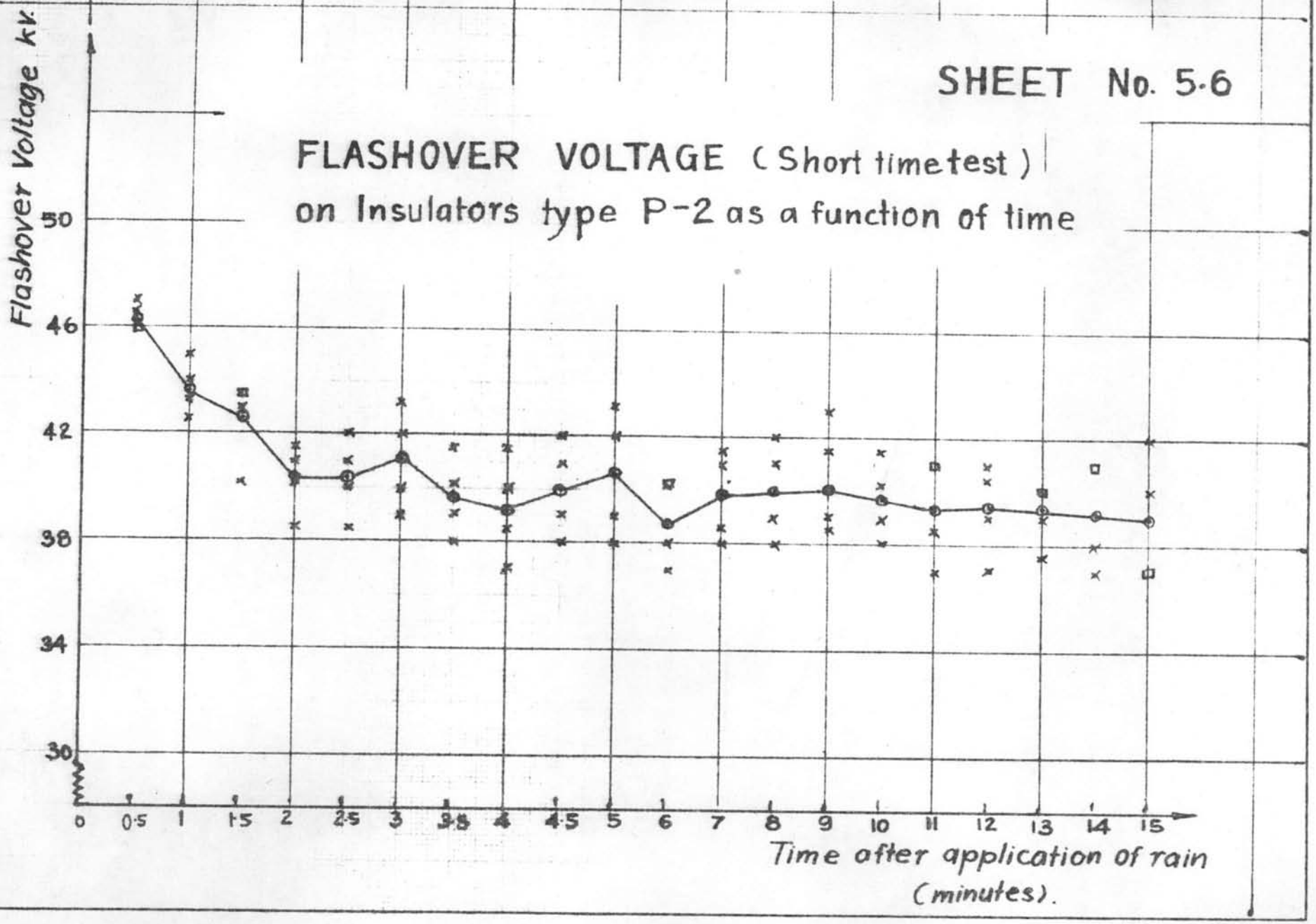


TABLE 5.12

Wet Flashover Voltage (KV) on Pin Insulators type P-3

as a function of time

Small size of rain drop

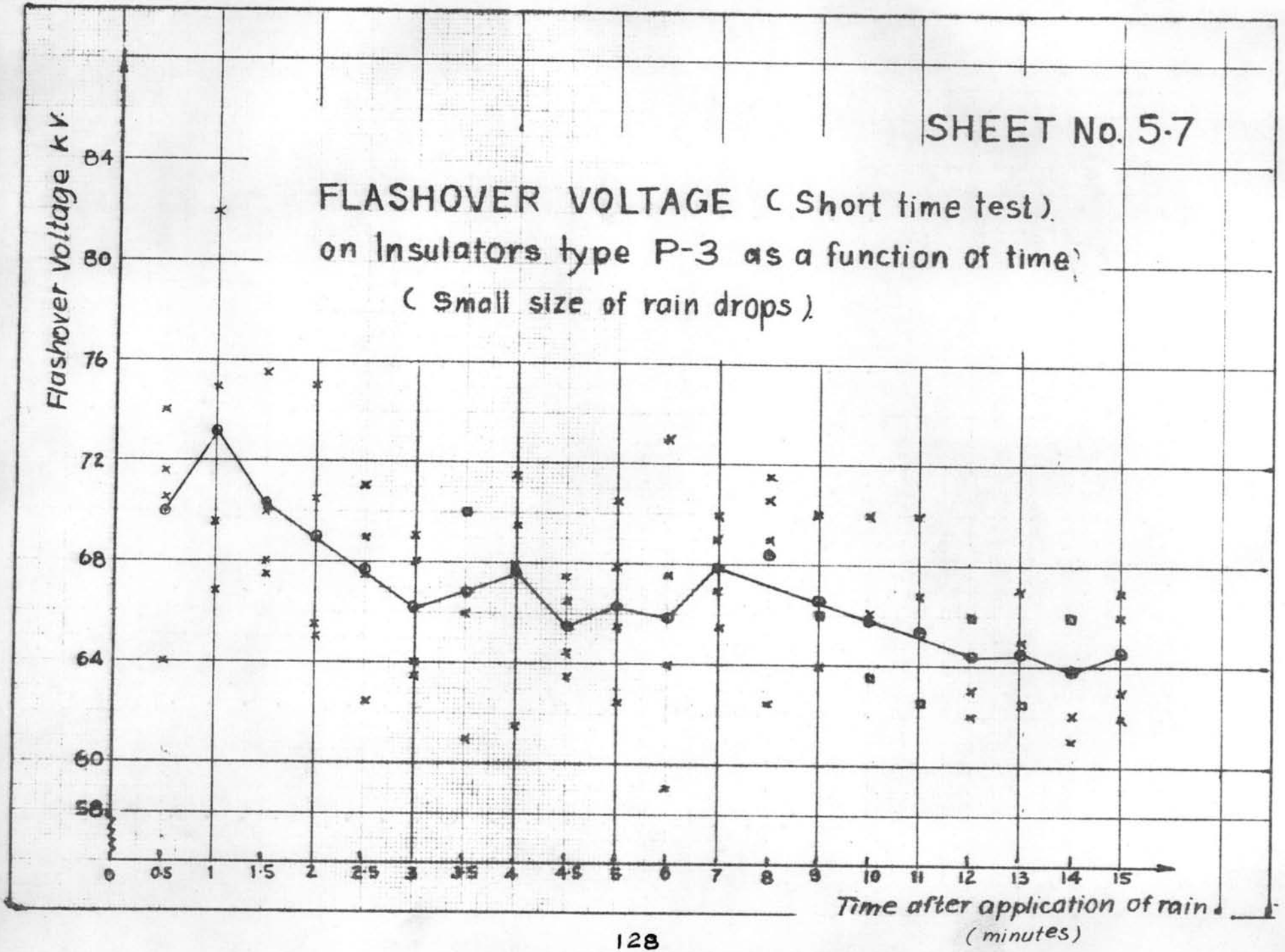
Time Preraining (min)	Flashover voltage Kv.				Average
	1	2	3	4	
0.5	64.0	74.0	70.5	71.5	70.0
1.0	66.8	75.0	69.5	82.0	73.2
1.5	68.0	75.5	67.5	70.0	70;3
2.0	65.0	75.0	65.5	70.5	69.0
2.5	62.5	71.0	67.5	69.0	67.6
3.0	63.5	69.0	64.0	68.0	66.2
3.5	66.0	70.0	61.0	70.0	66.8
4.0	71.5	69.5	61.5	68.0	67.1
4.5	66.5	63.5	64.5	67.5	65.5
5	61.5	70.5	65.5	67.8	66.3
6	59.0	73.0	64.0	67.5	65.8
7	65.5	69.0	70.0	67.0	67.9
8	62.5	70.5	69.0	71.5	68.4
9	64.0	70.0	66.0	66.0	66.5
10	63.5	66.0	63.5	70.0	65.9
11	62.5	66.8	62.5	70.0	65.4
12	62.0	66.0	63.0	66.0	64.3
13	62.5	65.0	62.5	67.0	64.3
14	61.0	66.0	62.0	66.0	63.8
15	62.0	66.0	63.0	67.0	64.6

Final average = 67.0 KV.

The difference between highest and lowest value = 13.7 %

SHEET No. 5-7

FLASHOVER VOLTAGE (Short time test)
on Insulators type P-3 as a function of time
(Small size of rain drops)



5.3 Effect of Period between Consecutive Flashovers.

The specification of ASA, usually the period between consecutive flashovers shall be not less than 15 seconds nor more than 5 minutes. In order to investigate this effect the pin insulator type P - 2 and the suspension insulator type S-3 are carried out under small size of rain drops. The flashover voltage corresponding the period of 12 seconds and 60 seconds on both types are shown in table 5.13. The flashover voltage values under period 12 seconds are less than the value under period of 60 seconds. The different percentage between the average under period of 12 seconds and the average under period of 60 seconds on both sample of insulators are about 15.1% for pin type and 9.8% for suspension type.

5.4 Effect of Size of Rain Drops.

The rain reaching the sample of insulator should have the form of drops not jets. The different size of drops are determined by observation which has been described clearly in Chapter IV article 4.2.

The size of the actual rain drops has the effect on the flashover voltage . The investigation for this purpose was carried out on the three types of insulator including the type P - 2.1, P - 3 and S - 3. The results of flashover voltage according to the different size of rain drops were

TABLE 5.13

Wet Flashover Voltage in difference of time interval applied (12 sec and 60 sec) on Insulator

Small size of drop

No.of reading	Medium Pin type		Large Suspension type	
	12 sec.	60 sec.	12 sec.	60 sec.
1	60	69	85	94
2	61	70	82	89
3	62	67	81	87
4	59	73	87	88
5	58	73	88	96
6	60	70	85	103
7	62	72	85	93
8	59	66	83	89
9	61	68	85	94
10	60	67	83	100
11	62	70	85	99
12	63	72	83	94
13	58	69	81	93
14	57	70	85	93
15	57	73	83	89
16	59	72	86	95
17	56	70	82	87
18	57	72	80	97
19	61	71	84	103
20	60	68	86	88
Average KV.	59.7	70.3	84.0	93.2
% difference	15.1		9.8	

shown in the table 5.13.(a). It is seen that the larger size of drops cause the insulators have lower flashover voltage. In the otherwords the flashover voltage of insulator under large size of rain drops is less than under small size of rain drops. For example the flashover voltage of the pin insulator type P - 3 under the small, medium and large size of drops are 67.7, 58.5 and 50.7 KV. respectively. The results may be discussed that the larger size of rain drops has the splashes more than the smaller size of rain drops when it reaches on the surface of insulator. The rain falls down on the lower surface of insulator then splashes up to the underside of the upper surface that causes an arcing distance to become shorter and yields a low flashover voltage. occur.

It is more distinguishable the effect of size of rain drops on the flashover voltage in function of time between the small and larger size of drops are compared in graph sheet No. 5.8. The comparison graph shows that the smaller drop condition gives the average flashover voltage higher than the average values at larger drops. The difference between both conditions are about 10. 2%.

TABLE 5.13 (a)

Average Wet Flashover Voltage (KV.) on High Voltage Insulator at Different size of Rain drop

Artificial rain from under ground water

Precipitation 4 mm/min.

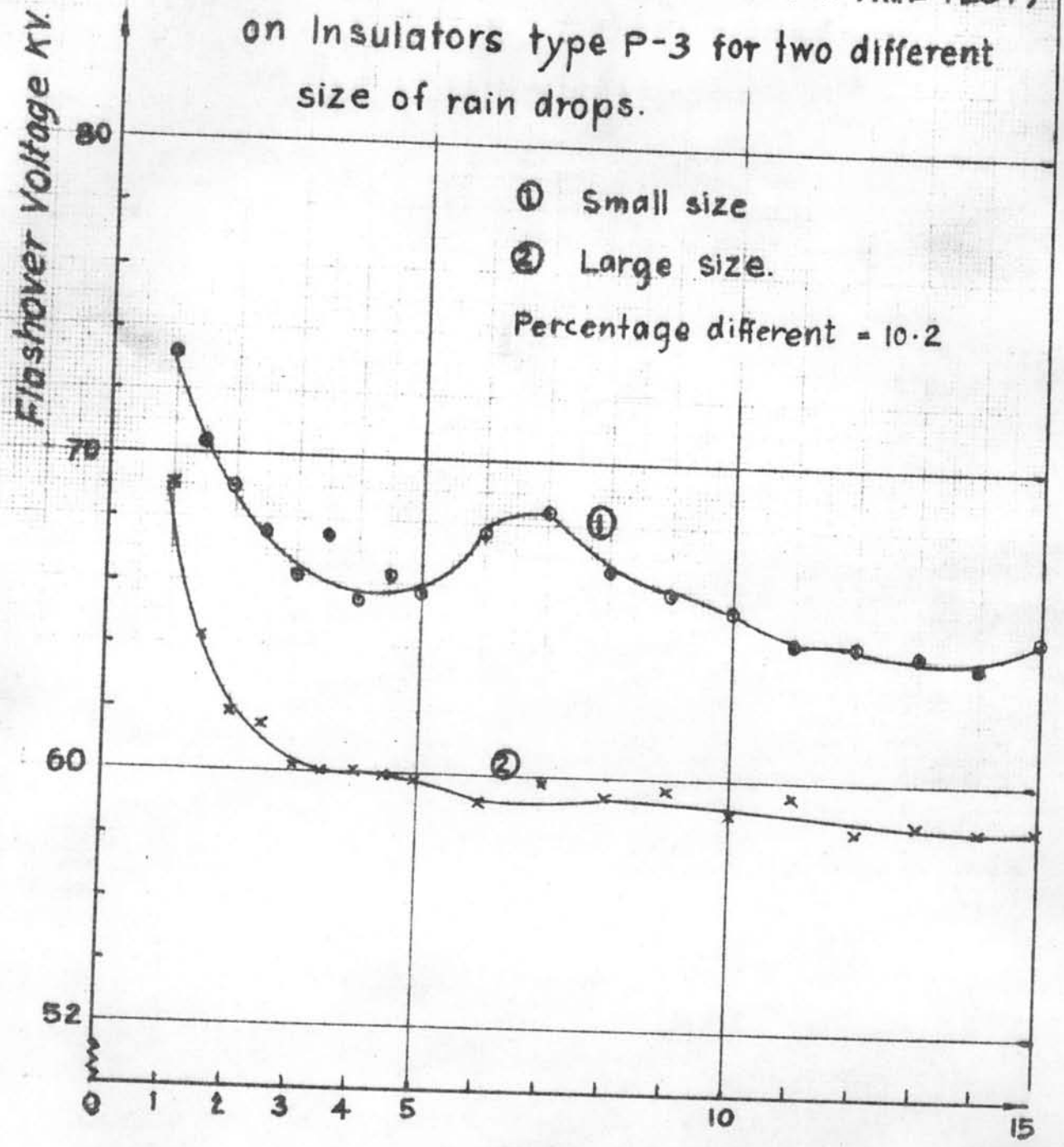
Type of Insulators	Pin type P-2.1			Pin type P-3			Suspension type S-3		
Size drop	Small	Med.	Large	Small	Med.	Large	Small	Med.	Large
	43.5	40	30.6	69.0	60.0	51.3	96.3	89.8	79.5
	42.7	39	29.8	67.0	59.0	51.5	92.2	89.2	81.4
	43.0	39	30.3	67.0	59.5	49.9	99.7	82.5	81.2
	40.2	40	30.4	65.4	59.0	51.5	98.9	87.0	80.2
	41.3	39	30.0	68.0	60.0	52.3	100.0	83.0	79.6
	44.0	40	30.4	69.7	55.0	47.5	100.1	85.0	78.0
Average KV.	42.5	39.5	30.2	67.7	58.5	50.7	98.5	86.1	79.7

Note that these figures are the average values which have been taken from the data in the appendix

SHEET No. 5-8

FLASHOVER VOLTAGE (SHORT TIME TEST)

on Insulators type P-3 for two different size of rain drops.



5.5 Effect of Rate of Precipitation.

The specification of rate precipitation is explained clearly in chapter IV, article 4.2, and practical testing has been shown in chapter I, article 1.5. The results of variation flashover voltage according to the different of rate precipitations are indicated in table 5.14(a),(b) and (c). The relation between the flashover voltages and the rate of precipitation are shown in graph sheet No. 5.9. It is seen from the curve that at a small rate of precipitation the flashover voltage is so high and decreases as the increasing of rate precipitation. It is also showed that at rate of precipitation is varied. At the rate of precipitation more than 3 mm. per minute the flashover voltage decreases a little as the rate of precipitation increases. For this testing the flashover voltage is about 89.2 KV. at 1 mm.per minute and decreases to 63,8 KV. at 3 mm. per minute and 62.3 KV. at 5 mm.per minute. It is therefore resonable to specify a rate of precipitation between 3 mm. per minute to 5 mm. per minute, because in this range a flashover voltage is nearly.constant.

It may be discussed that at greater rate of precipitation the flashover voltage is lower than at a very small rate of precipitation, because the former causes the more of wetting on surface than the later condition. The other reason is the more density of rain may increase the conduction.

TABLE 5.14 (a)

Wet Flashover Voltage (Short time test) on Pin Insulators type P-3 at various rate of precipitations

(Medium size of rain drop)

Artificial rain from under ground water

Precipitation	1 mm/min.			2 mm/min.			3 mm/min.		
Sample	1	2	3	1	2	3	1	2	3
	94	93	90	73	70	74	64	65	63
	82	90	86	71	69	69	62	64	62
	92	91	88	69	69	70	64	67	64
	93	90	91	68	73	72	63	65	62
	92	88	89	72	76	72	63	64	62
	82	85	89	69	70	70	62	63	65
	90	87	89	75	72	74	64	64	64
	93	87	90	74	75	75	65	63	64
	88	91	87	76	74	74	66	64	66
	94	88	87	74	75	69	63	62	66
	88	88	92	76	70	70	64	66	65
	88	90	85	74	69	70	62	66	63
	89	89	86	73	73	72	61	65	65
	90	87	87	74	75	73	64	64	64
	93	90	87	75	74	74	64	67	67
Average KV.	89.8	89.0	88.3	73.0	72.3	71.8	63.4	63.4	64.0
	89.2			72.4			63.8		

TABLE 5.14 (b)

Wet Flashover Voltage on Pin Insulators type P-3

at Various rate of precipitations

(Medium size of rain drop)

Artificial rain from under ground water

Precipitation	5 mm/min.			7.5 mm/min.		
Sample	1	2	3	1	2	3
	61.5	62.0	61.0	61.0	59.0	59.0
	61.0	61.5	62.0	60.5	58.5	60.5
	62.5	63.0	61.5	60.0	58.0	60.0
	61.5	63.5	61.5	59.0	58.5	58.5
	60.5	62.0	62.5	60.5	58.5	58.5
	63.0	60.5	63.5	60.0	58.5	58.5
	63.5	61.0	60.5	59.0	58.0	60.5
	63.5	61.5	63.0	59.0	59.0	58.5
	63.5	62.5	62.0	60.0	59.0	59.0
	62.0	63.0	63.5	58.5	58.0	58.0
	61.5	63.5	60.5	60.0	59.0	58.5
	63.5	63.0	63.5	58.0	60.0	58.5
	63.0	63.0	61.0	58.5	58.5	58.5
	60.5	64.0	63.5	59.0	59.0	59.0
	64.5	64.0	62.0	58.0	58.5	59.0
Average KV.	62.3	62.6	62.0	59.4	58.7	59.0
	62.3			59.0		

TABLE 5.14 (c)

Wet Flashover Voltage on Pin Insulators type P-3

at Various rate of precipitations

(Medium size of rain drop)

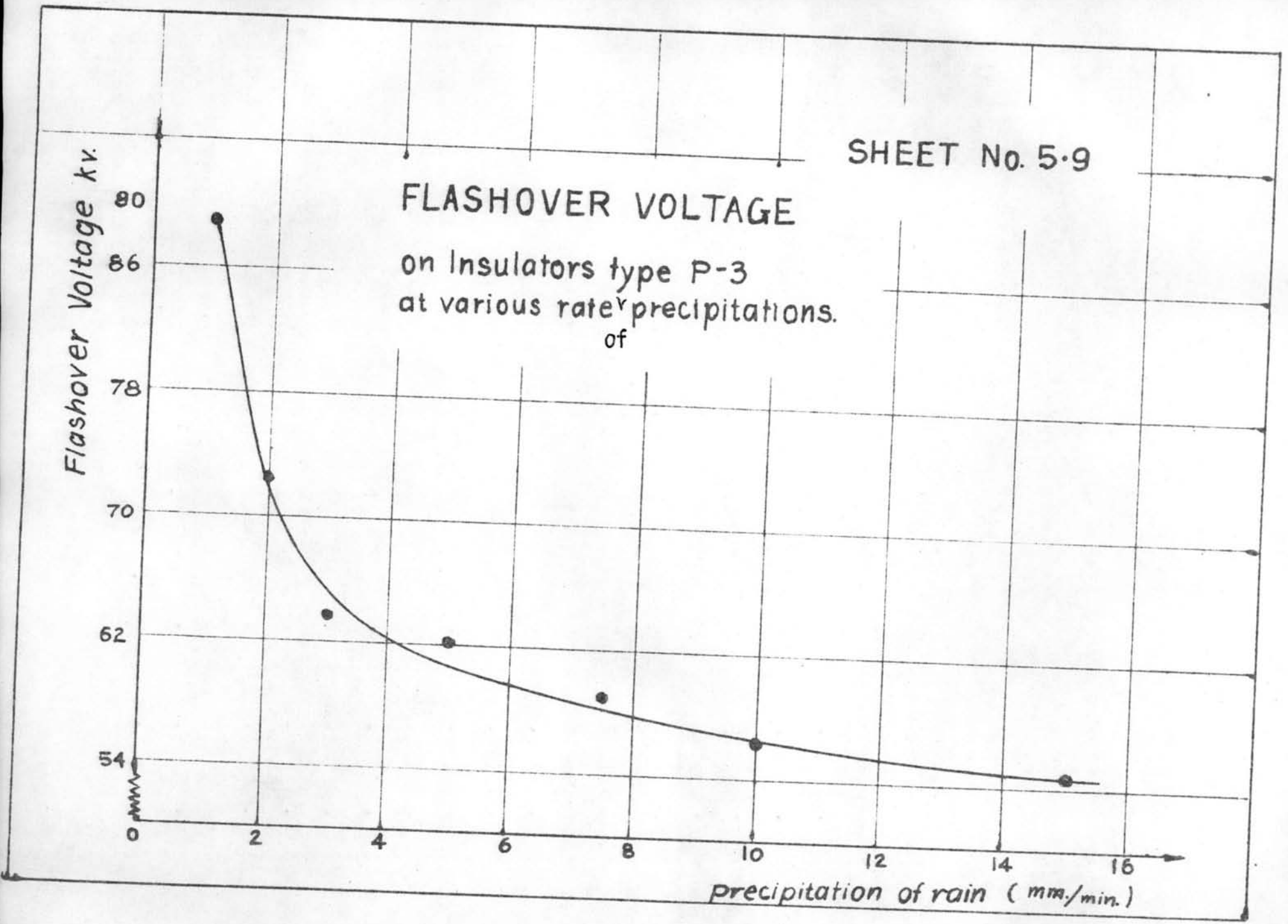
Artificial rain from under ground water

Precipitation	10 mm/min.			15 mm/min.		
Sample	1	2	3	1	2	3
	58	58	57	54.5	55.0	53.5
	56	58	56	55.0	54.0	55.0
	56	54	56	54.0	54.0	54.5
	57	55	56	55.0	55.0	54.5
	55	56	55	54.5	54.5	55.0
	57	56	56	56.0	54.5	54.5
	56	56	56	55.0	55.0	55.0
	56	57	55	55.0	54.0	55.0
	55	56	56	55.0	54.5	54.5
	57	57	55	54.5	54.5	54.0
	57	57	57	55.0	54.5	54.5
	57	56	57	54.5	54.5	55.0
	56	54	56	54.5	54.5	55.0
	59	55	57	55.0	55.0	55.0
	57	56	57	53.5	54.5	54.5
Average KV.	56.5	56.1	56.3	54.3	54.3	54.6
	56.3			54.5		

SHEET No. 5·9

FLASHOVER VOLTAGE

on Insulators type P-3
at various rates of precipitations.



The otherhands the water become a conductor yields the flash-over voltages are lower at the greater rate of precipitation.

5.6 Effect of Angle of Incidence of Rain.

In practical rain test, usually the rain falls about 45 degree angle on the test object. There are many directions of the actual rain falling, therefore the effect of various angles inclination were carried out. It is convenient to keep the direction of rain to be constant and then rotates the sample of insulator to obtain a certain position.

The results of variation flashover at various positions are shown in table 5.15 and 5.16. The average values for each position is plotted in graph sheet No. 5.10 and 5.11. The pin insulator type p - 3 is tested under small size and medium size of rain drops at positions of 90,60,45,30 and zero degree angle with the vertical. Under both conditions of rain drops the maximum flashover voltage occur at position of 60 degree angle; and decreases at the other position (see the curves) which have the angles greater and less. It may be observed that at the position nearly 60 degree, the splashes of water on the surface of insulator are less than the other position, especially at position of insulator's flanges are parallel with the direction of rain. In the later position, the more surfaces of insulator are easy in wetting that cause a flashover at low voltage.

TABLE 5.15

Wet Flashover Voltage on Pin Insulator rype P-3

In function of angle of inclination

Small size of rain drop

	Angle of inclination in degree						
	+90	+60	+45	+30	0	-30	-45
	80.0	94.0	88.5	74	63.0	66	45.0
	77.0	82.5	90.0	72	62.0	65	43.0
	77.0	93.0	85.5	70	62.0	58	43.0
	78.0	94.5	82.5	69	60.5	61	44.5
	77.5	93.0	86.0	73	57.5	62	43.5
	80.0	82.5	86.5	69	58.0	61	41.5
	80.5	91.0	85.5	77	60.0	74	42.0
	81.0	95.0	83.0	76	61.0	66	41.0
	80.0	94.5	85.0	77	60.5	64	43.0
	81.0	88.5	86.5	75	59.5	61	43.0
	79.0	95.0	87.0	73	59.5	60	43.0
	79.5	88.5	85.0	78	59.0	61	41.0
	80.0	88.5	87.0	75	58.0	62	42.5
	80.0	89.0	88.0	75	57.0	60	43.0
	78.0	91.0	82.5	78	55.0	62	42.0
Average	79.1	90.8	85.8	74.1	59.5	62.8	42.7

TABLE 5.16

Wet Flashover Voltage (Short time test) on Pin Insulator type P-3 in function of angle of inclination

Medium size of rain drop

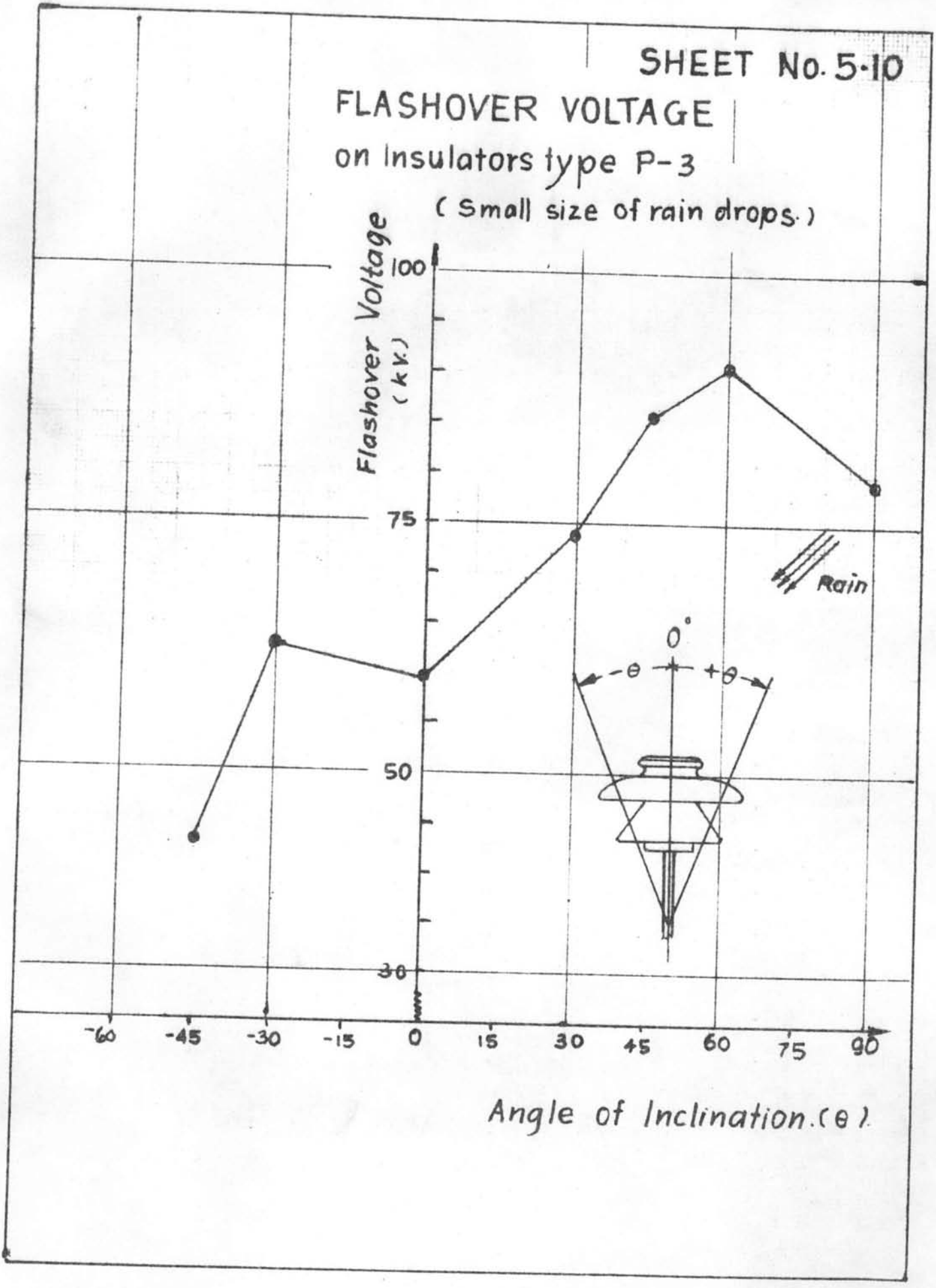
No.of reading	Angle of inclination in degree						
	+90	+60	+45	+30	-45	-30	0
1	43.0	82.0	76	70	55.0	56	57
2	43.0	79.5	72	70	55.0	54	56
3	43.0	77.0	70	68	54.5	54	56
4	42.0	79.5	74	67	54.5	56	56
5	41.0	80.0	73	65	55.0	55	56
6	41.5	77.0	72	66	53.0	55	55
7	44.0	74.0	73	66	54.0	54	57
8	43.0	79.0	73	68	54.0	55	56
9	43.0	79.0	73	68	54.0	55	56
10	41.0	77.0	71	67	53.0	54	55
11	41.5	79.0	72	68	55.0	54	55
12	43.0	78.0	72	64	54.0	54	55
13	42.0	79.0	73	67	54.0	54	56
14	43.0	78.0	71	70	54.0	55	56
15	42.0	78.0	73	70	53.0	55	56
Average KV.	42.4	78.3	72.4	67.4	54.1	54.6	55.9

SHEET No. 5-10

FLASHOVER VOLTAGE

on Insulators type P-3

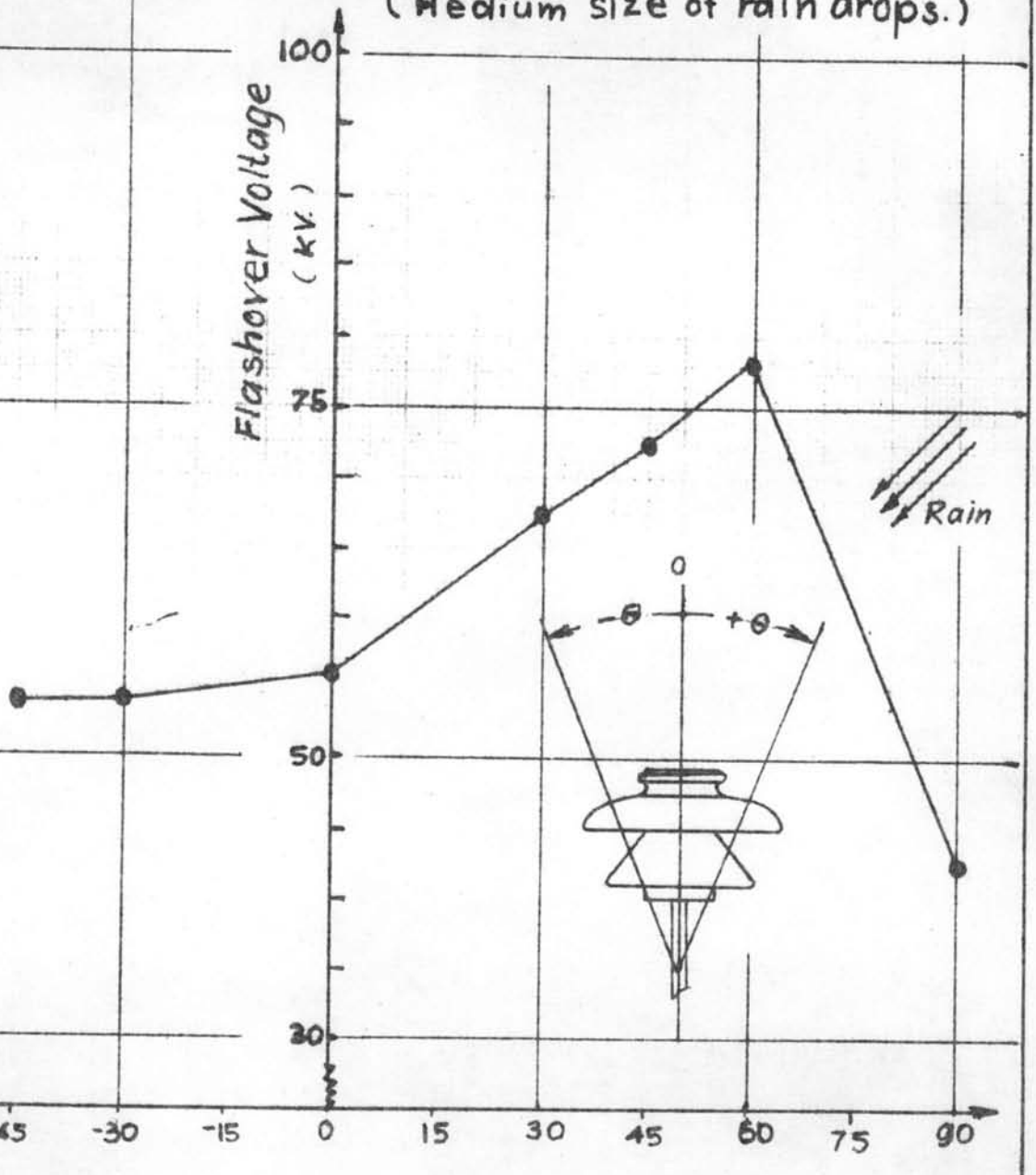
(Small size of rain drops.)



SHEET No. 5·11

FLASHOVER VOLTAGE on Insulators type P-3

(Medium size of rain drops.)



5.7 Effect of Resistivity of Water.

In fact the actual rain has a high resistivity. The comparable resistivity of water which changes according to the temperature are shown in the graph sheet No.4.1 In order to investigate the effect of different resistivity on flash-over voltage, the two kinds of water, underground water and the water from the water supply are used. The properties of the both kinds of water are explained clearly in chapter IV.

The string of suspension insulators type S - 1, S- 2 and S - 3 are the sample for this testing. The results are shown in table 5.17, 5.18 and 5.19 . By this testing the potential gradient or potential distribution and the efficiency of a string can be determined.

From the table 5.17 - 5.19, it is seen that a high resistivity of water gives a higher flashover voltage than a lower resistivity . It may be stated that the underground water has a more conductivity, so that the resistance between the conductor to ground become lower.

5.8 Potential Distribution.

5.8.1 A String of Suspension Insulators.

The string of suspension insulators were tested in the vertical position. The results are shown in table 5.17-5.20. The maximum number of units are 4 units in a string. It is seen that the flashover voltage across each unit of

TABLE 5.17

Wet Flashover Voltage (Short time test) on Suspension Insulators type S-3 at different resistivity of water

Medium size of rain drop

Artificial rain from under ground water and water supply

Number of Unit	Under ground water			Water supply	
	1	2	3	1	2
	48	90.0	126	51.0	94.0
	46	88.0	124	49.0	92.0
	47	87.5	124	48.5	92.0
	47	88.0	124	49.0	88.0
	48	88.0	122	49.5	87.5
	46	88.0	125	48.5	91.0
	46	89.0	125	48.0	90.0
	46	87.5	126	48.5	90.0
	47	86.0	125	49.0	90.0
	47	87.5	124	49.0	93.5
	46	88.0	126	48.5	87.5
	48	86.0	123	49.0	87.0
	49	85.0	125	48.0	93.5
	48	88.0	124	48.0	91.5
	49	87.0	124	48.0	91.5
Average KV.	47.2	87.5	124.2	48.8	90.4
Efficiency %		92.7	87.5		92.6

TABLE 5.18

Wet Flashover Voltage (Short time test) on Suspension Insulators type S-1 at different resistivity of water

Medium size of drop

Artificial rain from under ground water and water supply

Number of Unit	Under ground water			Water supply		
	1	2	3	1	2	3
	27.5	50.0	75.0	30.5	58.0	81.0
	27.0	49.0	72.5	30.5	56.0	80.5
	27.0	48.5	73.0	30.0	57.0	81.5
	27.5	52.0	72.5	31.0	57.0	82.5
	27.0	50.0	72.5	31.5	56.0	85.0
	27.5	50.0	72.0	31.5	55.0	78.5
	27.5	49.0	71.0	31.5	56.0	86.0
	27.5	50.0	72.0	31.5	56.0	81.5
	27.5	49.5	70.5	31.0	55.0	81.0
	27.0	50.0	71.0	31.5	56.0	81.0
	27.5	49.5	71.0	31.5	56.0	80.0
	27.5	48.5	72.0	31.0	56.0	82.5
	28.0	49.0	71.5	32.0	54.0	81.5
	28.0	49.5	70.0	31.0	56.0	81.5
	28.0	49.0	70.0	30.0	56.0	82.5
Average KV.	27.4	49.5	71.6	31.1	56.0	81.7
Efficiency %		90.4	87.3		90.0	87.5

TABLE 5.19

Wet String Flashover Voltage (KV.) of String Suspension Insulators type S-2 at different resistivity of water

Medium size of rain drop

Artificial rain from under ground water and water supply

Pressure of water = 35 lb/in^2

Number of Unit	Under ground water				Water supply		
	1	2	3	4	1	2	3
	36.0	65.0	91.0	110.0	38.5	63.0	96.0
	35.5	62.5	85.0	108.0	38.5	61.5	96.5
	35.0	61.5	88.0	106.0	39.0	62.0	88.0
	35.0	61.5	88.0	105.5	36.0	61.5	94.0
	35.0	61.5	87.0	106.0	37.0	60.5	90.5
	35.0	61.5	89.0	106.0	37.0	60.0	88.0
	34.0	61.0	90.0	106.0	36.0	60.5	81.0
	34.0	61.5	85.0	105.0	35.5	62.0	94.0
	34.5	62.5	86.0	106.0	36.5	61.0	88.0
	34.0	60.5	82.5	106.0	36.0	62.0	90.0
	34.0	62.0	82.0	107.0	35.5	60.0	92.0
	34.5	62.5	84.0	106.0	36.0	59.0	90.0
	34.0	61.5	83.0	108.0	37.0	60.5	92.0
	35.0	61.5	85.0	106.0	37.0	59.5	92.5
	35.5	62.0	87.0	108.0	37.0	61.0	92.0
Average KV.	34.8	61.8	86.1	106.5	36.8	61.0	90.9
Efficiency %		89.0	82.6	76.5		85.1	82.2

insulator decreases when increase the number of unit in a string; owing to the earth capacitances between the metal fittings (caps and pins) of an insulator string and the support. The potentials across the units adjacent to the line conductor are greater than those across units nearer to the supporting cross-arm.

It is also seen that for a larger size of rain drops gives a little higher efficiency of a string than that a smaller size of rain drops. The results have been shown in table 5.20.

5.8.2 Pin Insulator in Parallel.

The pin insulators type P - 3 are tested in parallel connection as shown in Fig. 4.28. The results shown in table 5.21. are not different of flashover voltage between the one and two units in parallel. It is possible to say that the parallel connection of pin insulator not change the arc - over distance of insulator .

TABLE 5.20

Wet Flashover Voltage (KV.) (Short time test) on String of Suspension Insulators type S-3 at different size of rain drop

Precipitation = 4 mm/min.

The artificial rain from water supply

Size of drop	Large		Medium		Small	
Number unit	1	2	1	2	1	2
	48.0	88.0	51.0	94.0	52.0	100.0
	46.0	83.5	49.0	92.0	50.5	98.0
	45.0	85.0	48.5	92.0	50.5	98.0
	45.5	84.0	49.0	88.0	52.0	99.5
	45.0	85.0	49.5	87.5	51.0	100.0
	45.0	87.0	48.5	91.0	49.0	97.0
	44.5	82.5	48.0	90.0	50.0	96.0
	45.0	85.0	48.5	90.0	50.5	98.0
	44.5	88.0	49.0	90.0	51.0	95.0
	44.5	85.0	49.0	93.5	49.5	97.0
	44.0	87.0	48.5	87.5	50.0	97.0
	45.0	88.0	49.0	87.0	50.5	98.0
	45.0	85.0	48.0	93.5	50.0	96.0
	45.0	85.5	48.0	91.5	50.0	100.0
	45.0	85.0	48.5	91.5	49.0	95.0
Average	45.1	85.5	48.8	90.4	50.3	97.4
Efficiency %		94.8		92.6		91.9

TABLE 5.21

Wet Flashover Voltage (Short time test) on Pin Insulator type P-3

Medium size of rain drop. Angle of rain = 45°

Artificial rain from under ground water

No.of reading	Unit No. 1	Unit No. 2	2 unit in parallel
1	56.0	57.5	57.0
2	55.0	54.5	55.0
3	55.0	55.0	56.0
4	55.0	53.5	53.0
5	54.5	52.0	54.0
6	54.5	50.5	55.0
7	54.0	50.0	52.0
8	55.0	50.5	53.0
9	52.0	52.0	51.0
10	50.5	54.5	54.0
11	52.0	53.5	55.0
12	52.0	50.5	52.0
13	52.5	52.0	52.0
14	52.0	53.0	53.0
15	52.5	50.0	53.0
Average KV.	53.5	52.6	53.7

5.9 Comparison Dry and Wet Characteristics

The flashover voltage of insulators in wet conditions are much lower than that in dry condition (ambient temperature). In table 5.22 shows the ratio of wet flashover voltage to dry flashover voltage has the maximum ratio about 0.53 and the lowest ratio is about 0.38

TABLE 5.22

Average Flashover Voltage Characteristics of Insulators

P-1		P-2.1		P-2		S-1		S-2	
dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
66.4	34.0	95.8	49.9	116.1	53.2	81.1	31.5	85.9	38.5
65.5	33.0	95.0	49.2	124.5	52.7	80.5	31.0	82.0	39.0
65.8	33.0	88.9	49.2	124.7	50.5	81.3	30.0	84.7	37.0
67.0	34.0	97.2	49.6	121.1	52.4	80.0	30.5	84.8	36.0
66.3	33.0	96.3	49.1	116.1	54.4	79.8	31.0	81.5	35.5
65.2	33.0	92.3	49.4	121.0	52.7	81.1	31.0	82.8	37.0
66.0	33.1	94.2	49.5	120.7	53.2	80.8	30.9	83.6	37.1
$Wet/_{Dry}$	0.50		0.53		0.44		0.38		0.44