CHAPTER I.

PREVIOUS WORK.

The characteristics of insulator in the rain test has never been researched anywhere in Thailand but in the foriegn contries have been carried out for years and laid down in most specifications. The results of previous testing are as the following:

S. Haraldsen[1] summarized that in order to ensure that electrical equipment for outdoor use shall resist the decreased insulation during difficult climatical conditions, voltage tests under artificial rain are often carried out. Such tests have been done for years, and most countries have specifications for rain testing.

For some time it has been known that reproducibility of rain tests is rather bad. Experiments carried out revealed that one of the causes may be found in the varying time of preraining of the insulators before the voltage is applied. The most important cause presumably lies in the statistical dispersion of the flashover voltage due to the sporadic water bridging of the insulation.

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[1] S. Haraldsen, Comments on rain testing, Technical Memorandum, ASEA Ref. NO. 46.255-3. Record NO. A-3088, 1959.

S. Haraldsen's[2] report:

Recently doubts have arised whether rain tests should be considered to be representive for outdoor conditions, partly because there seem to conditions much more serious and more frequently occuring than heavy rain, and partly because of the large dispersion in laboratory rain testing. As the rain tests in many cases are dimensioning for electrical equipment, a test with large inherent dispersion is not desirable, especially not as delivery test.

1.1 Artificial Rain.

The artificial rain is obtained from special spray apparatus. A water pressure of something between 1.5-6Kg/cm. is suitable for most test objects. The rain should fall as drops at about 45° angle on to the test object, and the resistivity of the water and the rate of precipitation is measured,10,000 ohm.cm. and 3 mm/min.,respectively according to Swedish Standards. The test object shall have a preraining time of 1-5 min. in order to obtain a stationary value.

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[2] Ibid.

1.2 Some practical test.

Specifications are made in order to facilitate reproducable measurement. Factors which may effect reproducibility of wet tests are rate of precipitation, water resistivity, angle of rain, and time of preraining. Keeping these parameters constant and inaccordance with the specifications wet test therefore ought not give rise to any problems. Practical tests have shown that there still exist difficulties when making rain tests.

1.2.1 Effect of Preraining.

Preraining of the test object is matter which is specified in the standards as a minimum time usually between 1 and 5 minutes. During the time, the test object is supposed to come to a stabilized condition regarding the degree of wetting. There are, however, some practical difficulties in adjusting the amount of precipitation and the angle of incidence in five minutes as these parameters cannot be measured continually. Often, therefore, it takes up to half an hour until the correct values are being obtained, and the test object therefore has been thorougly wetted. If the assumption that a stabilized value of wetting is obtained during this time , there is no harm in this long duration shower. Some investigations have recently been carried out at ASEA High Voltage Laboratory on this subject, and the results show rather deviating figures, The tests were performed as short-time tests and 1 minute tests with power frequency voltage on two types of supporting insulators.

In order to carry out test at short time after the starting of the rain, the adjusting of the rain parameters was done on a dummy. The actual test object was put on wheels, and replaced the dummy with a quick manoeuvre. The time to the first flashover could therefore be kept at about 30 seconds. The short time test was done every 60 seconds after the first flashover. Six samples of each type was tested. The test first started at a voltage level assumed not to give flashover. If a flashover did not occur, the voltage was raised one step. If a flashover was obtained the lower level for the next t=1 minute test was chosen. The test was carried out from t= 1 minute to t = 2 minutes, between t = 3 minutes and t = 4 minutes etc. Three samples of each insulator was tested in this way.

For one of the insulators, show in Fig. 1.2 the flash-over voltage show hardly any variation with time, when considering a regression line drawn through the largely spread points on the curve. Fig. 1.1 show the result from the other type of insulator. The flashover voltage shows a definite tendency of decreasing with time. The average value of flashover voltage being about 215 KV. at t = 1/2 minute, has decreased to 190 KV. after 20 minutes of raining. The 1 minute tests shown in Fig. 1.3 and Fig. 1.4 show more or or less the same tendencies as the short time test.

The insulator shown in Fig. 1.2 has very little of its surface covered against the rain. The splashes are rapidly wetting the part of the insulators being exposed to the rain, and thereafter nothing more happens, The other insulator is more complicated as shown in Fig.1.1 Because of its shape, it is likely that a relative long time will pass until the underside of the insulator has been wetted. The fact that a stabilized flashover level is not observed, can of course not be interpreted as that such as level will not occur within a reasonable time. The interesting thing is that it does not occur within the first 24 minutes, which in many cases is sufficient time for completion of a wet test. The specifications when stating a minimum time of preraining of 1-5 minutes, therefore do not cover all types of insulators. A voltage test under rain may be carried out at different times of preraining, ranging from five minutes up to half an hour, depending on the luck in adjusting the rain. During this time the result may vary as a function of time of preraining. Similar tests have been carried out on the same types of insulators at Chalmer Institute of Technology[3]

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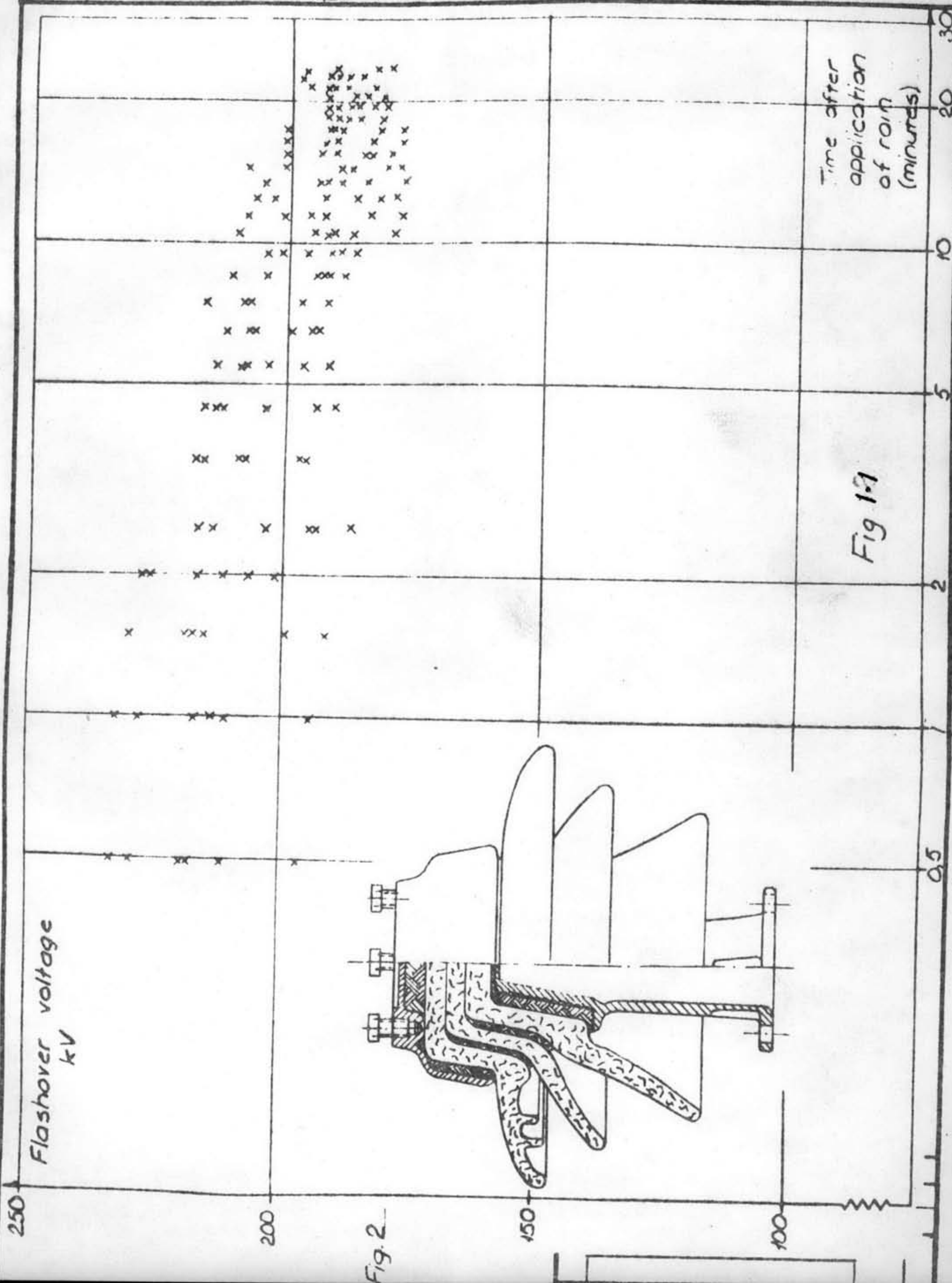
[3] Sven-Erik Bengtsson, Tore Nordin: Investigations on withstand voltage as a function of time in rain tests on insulators, type V and S, Chalmers Institute of Technology, Gothenburgh, Sweden.

ASEA	Floshover voltage (short time test) on insulators type V as a function of time.	Fig. page 2	
Ludviko		TM 9228	Blad
			Forts. bl.
Thl 2.7.59	Rit. US Kontr.	Nd	



5 (a)

ASEA	Floshover voltage (short time test) on insulator type 5 as a function of time	Fig. page 3
Ludvika		TM 9228 / Blad
		Forts. bl.
Thl 2.7.59 Ritt. US Kontr. Nd		

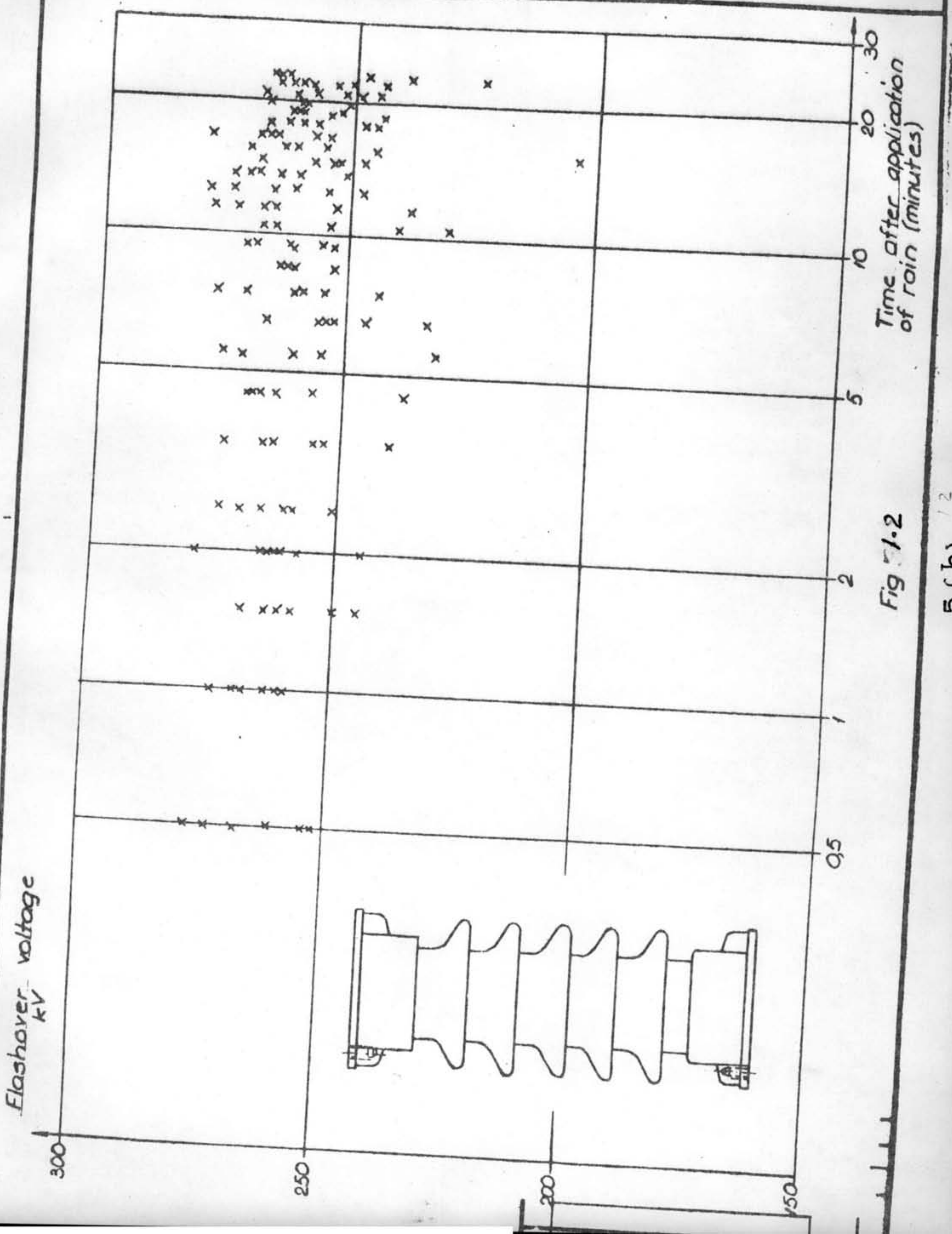


Fig. 1.2

5 (b)

ASEA	Flasnover voltage (1-min test) on insulator type V and S as a function of time	Fig page 4	
Ludvika		TM 9228	Blad
			Forts. bl.
Thl 30.6 59	Rit. US Kontr. Nd		

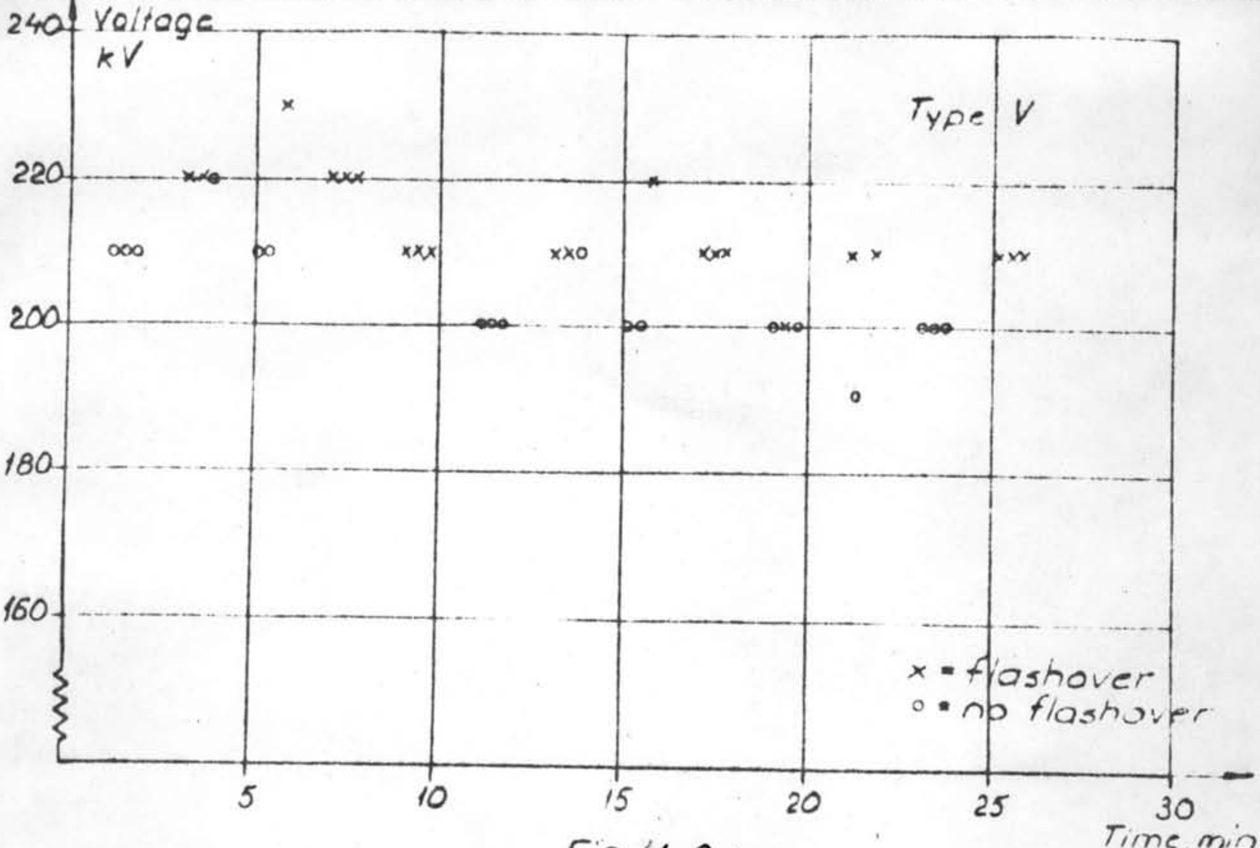


Fig. 1·3

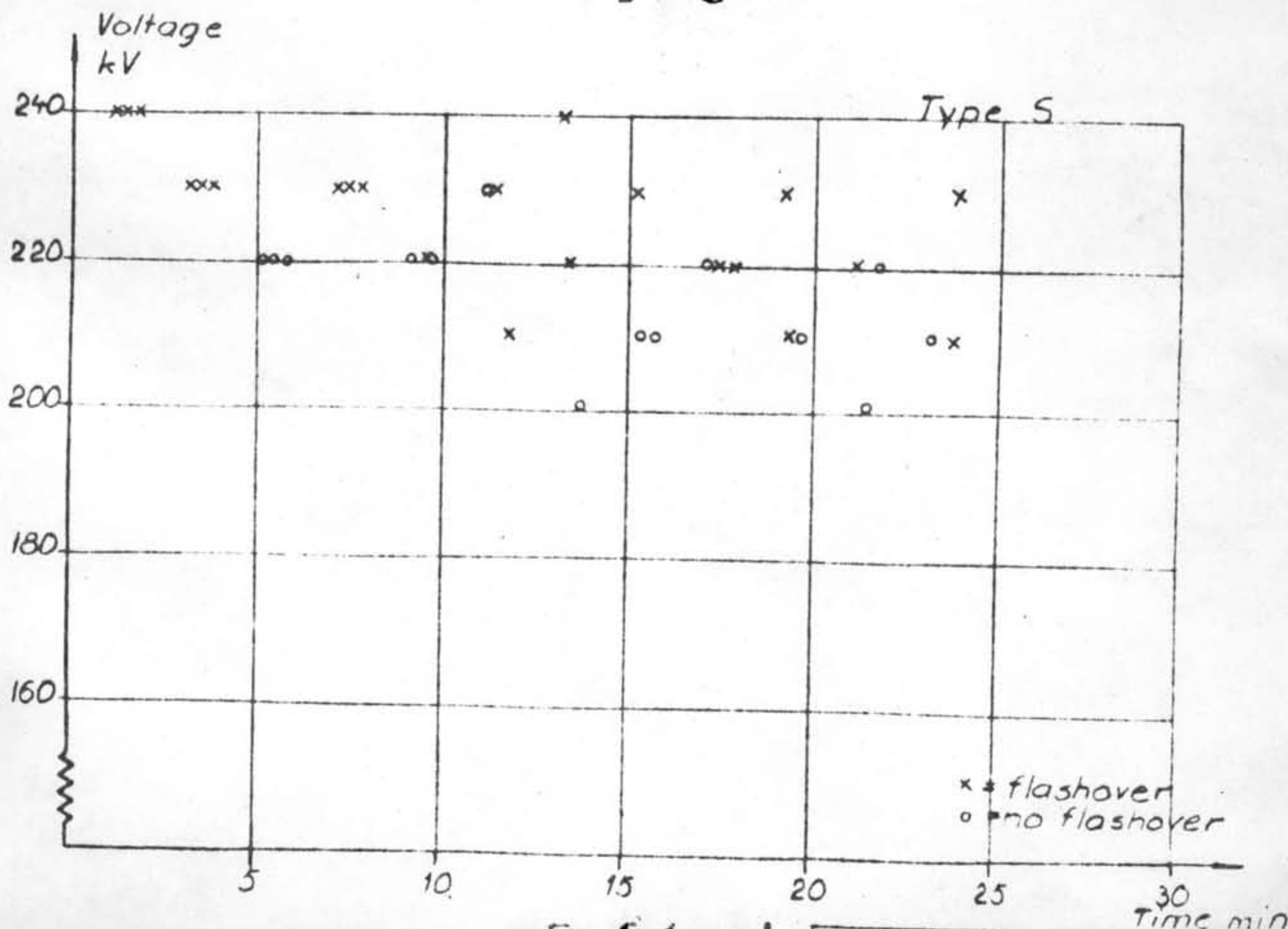


Fig. 1·4

Gothenburgh, giving result which more or less confirm those obtained at ASEA High Voltage Laboratory.

1.2.2 Size of rain drops.

The character of the rain has been mentioned briefly. The rain reaching the test object should have the form of drops and not jets. The size of drops is determined by the construction of the nozzles and the water pressure.

The water pressure normally ranges from 1.5 Kg/Cm^2 up to 6 Kg/Cm^2, depending on the distance to the test object (in other words, the test voltage) and the extension of the test object. With a pressure of 6 Kg/Cm^2, there will be a considerably fog drifting along with the larger rain drops. Most of this will fall down before it reaches the test object, but some of it will sweep in under the insulator and affect the flashover voltage. The size of the actual rain drops may also affect the flashover voltage, although it is difficult to establish the mathematical relation between these two because of problems related to the measurement of the drop sizes. A test comparing two rain apparatus of approximately same design gave a difference of 10% in average flashover at power frequency. The apparatus giving the higher flashover values, could be observed to give larger drops than the other one. The precipitation, angle and resistivity were all the time the same.

1.2.3 Dispersion.

The flashover voltage is not only governed by the different systematic changes occuring when adjusting the parameters mention. In dry flashovers there may be a considerable dispersion due to the changing ionisation conditions of the gap. In rain testing an additional variable , also due to the laws of chance, is introduced, and that is bridging of the insulator by the rain drops.

The test on supporting insulators shown in Fig. 1.2 gives a difference of 13% between highest and lowest value. The supporting insulator shown in Fig.1.1 have a difference of 27% between highest and lowest. On test on a large experimental circuit breaker, consisting of several vertical supporting insulators and other supporting insulators at an angle of about 30° to the vertical, the following withstand levels (AC 1 minute) was obtained at different times: 700,500 and 650 KV. The rain was adjusted according to the specifications.

The AIEE Working Group on Rain Test has published a paper[4] on wet test carried out in different American Lab.

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[4] AIEE Working Group on Rain Tests: The influence of water resistivity and precipitation rate upon sixty cycle wet flashover voltage, AIEE trans. paper 1958-27.

The test were done mainly to see the effect of varying rain intensity and rate of precipitation, but as all flashovers are platted, the report gives some information about the dispersion.

On a six unit suspension insulator, 16 flashovers varying between 320 and 235 KV. were obtained ($\pm$ 17% on both sides of the average) The resistivity and rate of precipitation was constant during the test.

He gave the reason for the dispersion that; the S insulator is a simple porcelain without intermediate metal flanges. The rain drops may bridge a large ~~a large~~ number of variable distances. This may be the explanation why the scatter is so high on S-insulator relative to V-insulator. The latter, which during this test had only two units, had less number of possibilities of being bridged by the water. An increase of the number of insulator units and the highest of the insulators, should according to this theory increase the dispersion.

1.3 <u>Increasing reliability of wet testing</u>.

Slight modifications of the standards could do away with some of the uncertainties in wet testing. The size of the rain drops may be kept within reasonable tolerances by standardization of the spray nozzles. The collection of dirt and deposition of salts in the nozzles should, however, not be overlooked. Some need for regular control of the spray apparatus output would therefore be needed in the same way as other laboratory instruments and equipment are regularly checked.

The experiment with the S- and V-insulators showed that the standards did not cover the decreasing average flashover voltage due to the successively wetting of the insulator surface. The assumption that insulators got into some stabilized condition during the first five minutes in evidently not always the case. At least 30 minutes of preraining should therefore be necessary on some insulators in order to get a good reproducbility of the test.

1.4 Are wet test realistic ?

Rain testing has been considered to give an acceptable dimensional basis for outdoor equipment. An interesting French report[5] gives figures of flashovers on the suspension

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[5] Me'thodes d'e'ssais des isolatours Soumis a la pollution atmosphe'rigue actuellment en cours d'e'tude en Frence. Extraits du Bulletin de la societ' francaise des Electriciens, Tome III, Nos. 92 et 93.

insulators. In one year 18 flashovers due to rain were recorded, 923 morning flashovers (dew), and 388 flashovers due to fog and pollution. These results give rain testing a rather doubtful right of existence.

An insulator having past a rain test may behave quite otherwise when exposed to a continuously wetting of all the surface. Insulator designs based on preventing splashes on certain parts, and otherwise with a short creepage distance, will be a weak design when exposed to the dewy morning air. Two factors would be necessary to consider in order to make good insulators with special thoughts to dew flashovers, namely the hygroscopic nature of the insulator surface and the creepage length of the insulator. The surface of porcelain do not vary much in the respect of taking up water, sothe important thing to know is therefore the creepage distance along the surface. This can be measured by means of a measuring tape, which should make life much easier testing engineers.

The flashover due to dirt another problem, quite different from rain testing and much more complicated. Special pollution chambers would be necessary, which would be a considerable extra cost for most laboratories. Even if such tests could be specified exactly, there is reason to suspect that the dispersion would be at least as large as with rain testing.

1.5 Characteristics of the spray.

The following table are two sets, one in general accordance with European practice in majority of laboratories, the other with practice in the U.S.A.

Characteristic	Practice	
	Europe	U.S.A.
1.Precipitation rate(mm/min) vertical component.	3+± 10%	5 ± 10%
2. Resistivity of water(cm)	10,000± 10%	17,800± 15%
3.Temperature of water °C	Ambient temp. ± 15	Ambient temp. ± 15
4.Duration of wet withstand test	1 minute	10 seconds.

1.6 Potential Distribution[6]

The potential distribution from line to ground in a string of suspension insulators is determind by the

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6 The manual book Nippon Gaishi of Nippon Gaishi Kabushiki Kaisha, Nagoya Nippon, Japan 1937,p 1-40

individual capacity of units and combinations thereof. This has been determined to be about 0.00002 microfarad for the standard 254 mm. suspension units.

In graph sheet NO. 1.1 shows the characteristics of a string of 254 mm. suspension insulator type 2A-500A.

1.7 Wet arc-over voltage.

The Nippon Gaishi's manual book[7] gives the description about the wet arc - over voltage as follow: Wet arc - over voltage must be changed by the quantity of rain and its conductivity . In heavy rain conditions arc - over voltage decreases but does not decrease in regard to low conductivity of rain. Types of insulators control the wet arc - over, and especially in non -currugated insulators, the proceeding of rain corona is rapid and so insulators for outdoor use must have petticoats or rain shields.

And also gives the specifications about the wet test that, the rate of precipitation 5 mm. per 1 minute. The rate of rainfall in ordinary cases on the ground is 0.3 mm. to 1 mm. per minute and its resistance is about 20,000 ohm.

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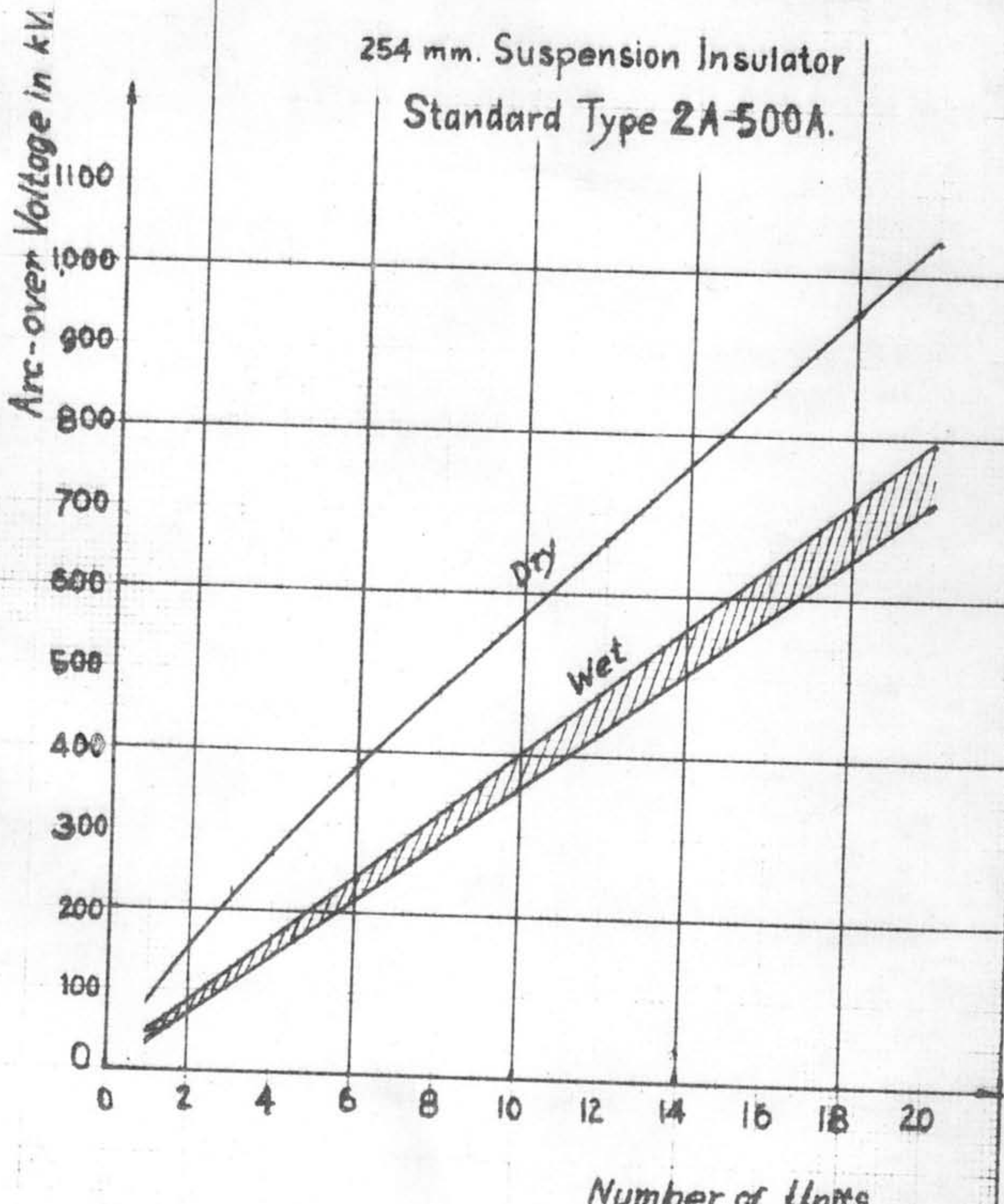
[7] Ibid pp. 1-42-- 1-43.

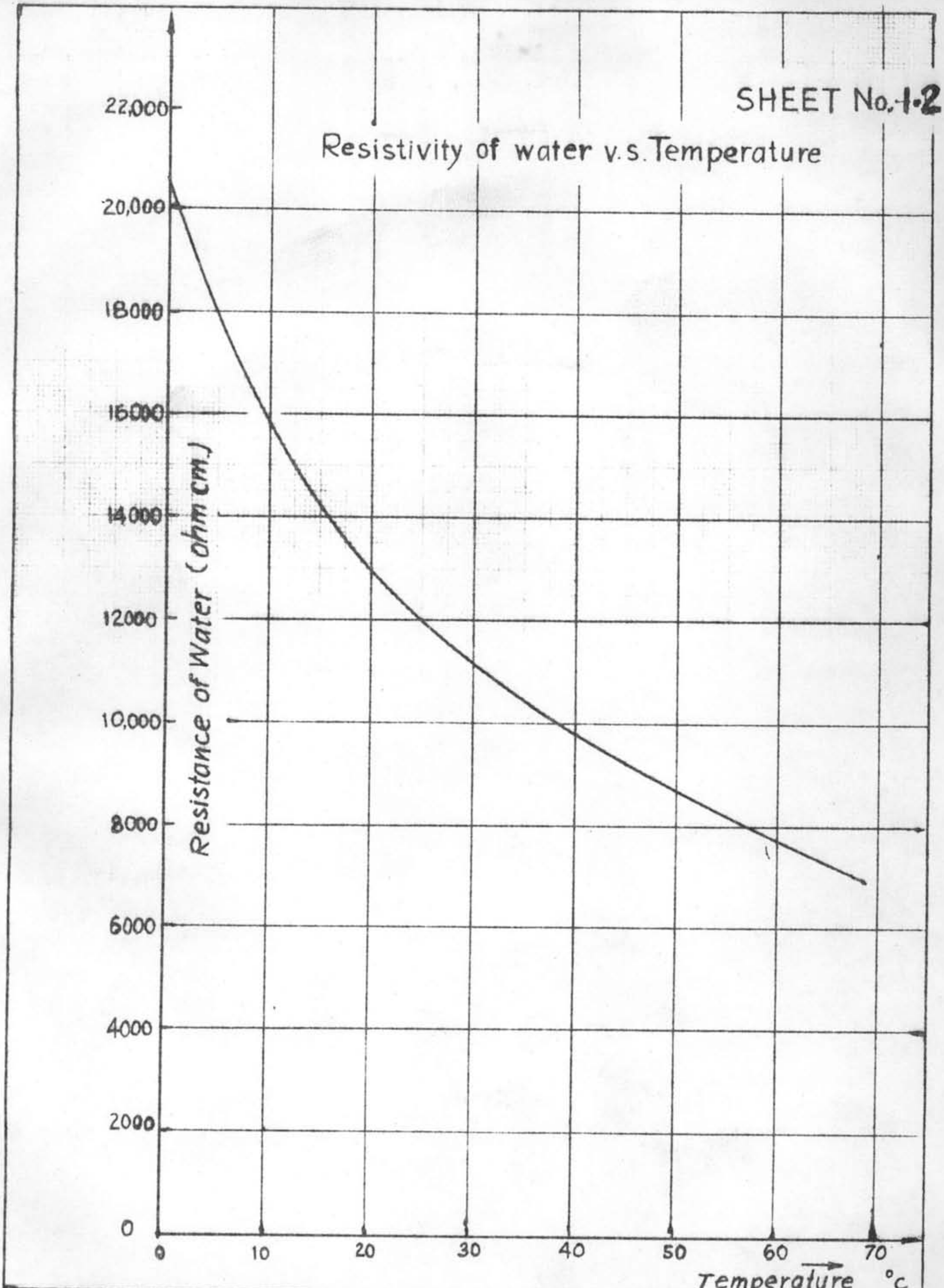
centimeter and so the condition of rain test in insulator examination is much more severe than ordinary conditions.

ARC-OVER VOLTAGE CURVES

254 mm. Suspension Insulator

Standard Type 2A-500A.




SHEET No. 1·2
Resistivity of water v.s. Temperature
22,000
20,000
18000
16000
14000
12000
10,000
8000
6000
4000
2000
0
Resistance of Water (ohm cm.)
0
10
20
30
40
50
60
70
Temperature °c