"Study of Corona Discharge and AC Breakdown Voltage for Different Electrode-Gap Geometry"

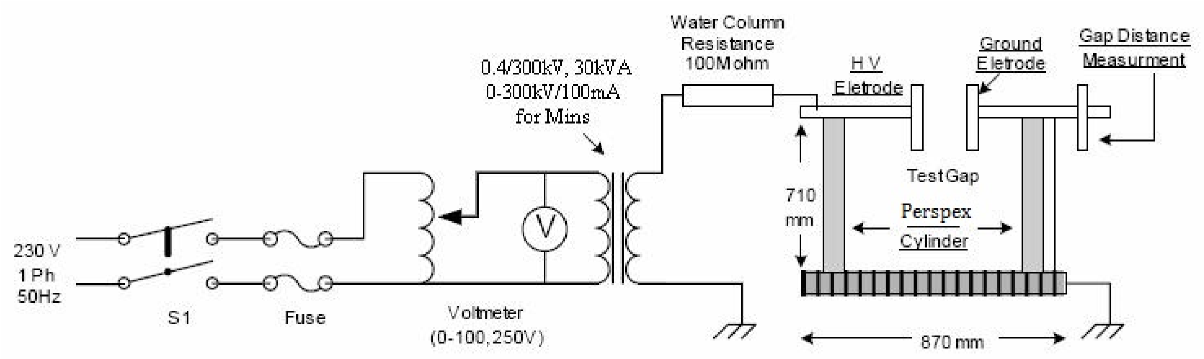
Objectives:

1. Breakdown studies of uniform field and non-uniform field gaps under A.C. excitation

   A) POINT-PLANE. B) SPHERE-SPHERE. C) POINT-POINT.

2. Observation of Corona Inception and Corona Extinction Voltage

Experimental Setup



Procedure:

1. Connect the test gap (A) to the transformer as shown in the circuit diagram.

2. Adjust the gap distance to an initial value of 10 mm.

3. Close the circuit breaker S1.

4. Slowly raise the till faint hissing audible sound is heard. Note the reading on the Controller and actual value from the calibration chart provided. This is the beginning of corona. Hence the *Corona Inception Voltage*.

5. Raise the Voltage further till such time there is a faint visible glow at the high voltage electrode. This is the *Visible Corona Inception* level. Note the value.

6. Then slowly reduce voltage further till such time the hissing sound subsides i.e., dies down or becomes extinct. Note this value as *Corona Extinction Voltage*.
7. Once again rise the voltage till such time there is a Break Down. Note this value as break down Voltage.

8. Reduce the voltage completely and open the circuit breaker.
9. Increase the gap distance by 5 mm and repeat steps 3 to 8.

10. Repeat step 9 for 6 (six) different gap distances.
11. Repeat the experiment for test Gap (B).

12. Correct the observed values for standard atmospheric conditions and plot the gap distance Vs Breakdown voltage for each gap with the help of the instructions given below.

Instructions for correction:

1. Use Table 1.3 to decide on corrections to be applied for any gap.
2. Obtain k_d and k_h from page 23 attached.
3. Since gap distance is less than 1m, so from fig 1.4, m, n and w are unity.
4. Humidity Correction can be obtained from fig 1.3.

Find Out:

1. Why no humidity correction for Sphere-Sphere Gap?
2. What is unique about the High Voltage Testing Transformer?
3. Is Corona useful at all?
4. Precaution to be taken while working with High Voltages?

Further Reading:

1. Kufffel & Zaengel: High Voltage Engineering, Pergamom press
2. M. Khalifa: High Voltage Engineering, Marcel Dekker
3. Naidu & Kamaraju: High Voltage Engineering, Tata McGraw Hill
4. Dieter Kind & Feser: High Voltage Test Techniques, SBA Publications

must be repeated using various different suspension resistivities.

The ambient temperature at the start of the test should not be less than 5°C nor greater than 30°C.

NOTE: Pre-deposited contamination methods are also in use in which constant voltage is applied to the test object before the wetting.

1.3.4.2.2 *The Saline Fog Method.* The test object is placed in a special chamber which can be filled by a saline fog. An example of a method for producing the fog is described in Appendix 1B. The ambient temperature in the chamber at the start of the test should not be less than 5°C, nor greater than 30°C and the test object shall be in thermal equilibrium with the ambient temperature.

The test object is thoroughly wetted with clean tap water. The saline fog system, supplied by water of the prescribed salinity, is started when the test object is still wet and, simultaneously, the voltage is applied to the test object, raised rapidly to the specified value, and kept constant during the specified time, usually 1 h or until flashover occurs. Usually, this procedure is repeated several times. Before each procedure, the test object is thoroughly washed with clean tap water to remove any trace of salt.

If the test is intended to determine the maximum degree of salinity for a specified withstand voltage, the whole procedure must be repeated using various different salinities.

Pre-conditioning of the test object by a number of flashovers during the application of contamination is recommended before the real test begins. Even this pre-conditioning should be followed by a washing.

1.3.4.3 Degree of Contamination. The degree of contamination of a test object can be specified either by the surface resistivity or by the amount of conductive matter per square centimeter of the insulating surface. Information about these methods is given in Appendix 1C.

1.3.5 Atmospheric Conditions.

1.3.5.1 Atmospheric Correction Factors. The disruptive discharge voltage of external insulation depends upon the prevailing atmospheric conditions. Usually, the flashover voltage for a given path in air is raised by an increase in either air density or humidity. However, when the relative humidity exceeds about 80 percent, the flashover voltage becomes irregular, especially when the flashover occurs across an insulating surface.

By applying correction factors, a measured flashover voltage may be converted to the value which would have been obtained under the reference atmospheric conditions. Conversely, a test voltage specified for the reference conditions can be converted into the equivalent value under the prevailing test conditions.

There are two correction factors:

(1) The air density correction factor k_d (see 1.3.5.3);

(2) The humidity correction factor k_h (see 1.3.5.3).

The disruptive discharge voltage is proportional to k_d/k_h.

If not otherwise specified by the appropriate apparatus standard, the voltage to be applied during a withstand test on external insulation is determined by multiplying the specified withstand voltage by k_d/k_h. Similarly, measured disruptive discharge voltages are corrected to those applicable for standard reference atmosphere by dividing by k_d/k_h.

It is left to the appropriate apparatus standard to specify whether or not corrections have to be applied to the voltage values in those cases where both external and internal insulations are involved. The test report should always contain the actual atmospheric conditions during the test and it must be indicated whether corrections have been applied or not.

1.3.5.2 Standard Reference Atmosphere. The standard reference atmosphere is:

Temperature t_0 = 20°C
Pressure p_0 = 101.3 kPa (760 mmHg)
Humidity h_0 = 11 g water vapor per cubic meter.

NOTES:
(1) A pressure of 1.013 kPa corresponds to a height of 760 mm in a mercury barometer at 0°C. If the height of the barometer is H millimeters of mercury and the temperature is t degrees Celsius, the atmospheric pressure in Pascals is:

$$p = \frac{1.013 \times 10^5 H}{760} (1 - 1.8 \times 10^{-4} \times t)$$

Correction for temperature is negligible under normal temperature conditions.
(2) In previous issues of this standard the reference temperature was 25°C and the reference humidity was 15 g/m^3. The change in temperature has the effect of increasing corrections to standard conditions by 1.8 percent for air density and decreasing those for humidity by approximately 5 percent for alternating voltage and 4 percent for lightning impulse.

1.3.5.3 Air Density and Humidity Correction Factors. The air density correction factor, k_d, is given by:

$$k_d = \left(\frac{p}{p_0}\right)^m \times \left(\frac{273 + t_0}{273 + t}\right)^n$$

where

p = atmospheric pressure under test conditions
t = temperature (in°C) under test conditions

Similarly, the humidity correction factor is:

$$k_h = (k)^w .$$

The constant k is given in Fig 1.3 as a function of absolute humidity, curve a or b being applicable according to the type of voltage. The exponents m, n, and w depend on the type and polarity of the voltage and on the flashover distance d as given in Table 1.3 and Fig 1.4. Lacking more precise information, m and n are assumed to be equal.

The symbols of Table 1.3 are:

Gaps giving an essentially uniform field.

Rod–plane gaps and test objects insulators; that is, electrodes giving a nonuniform field, but with essentially symmetrical voltage distribution.

Rod–plane gaps and test objects with similar characteristics such as support insulators; that is, electrodes giving a nonuniform field with a pronounced asymmetrical voltage distribution.

For any electrode arrangement not falling into one of the preceding classes, only the air density correction factor, using exponents $m = n = 1$, and no humidity correction, should be applied.

For wet tests the air density correction factor should be applied but not the humidity correction factor. For artificial contamination tests neither correction factor should be used.

NOTE: In Table 1.3 and Figs 1.3 and 1.4, a simplification of the existing information is given. The available experimental data from different sources always show large dispersions and are often conflicting; moreover, rele-

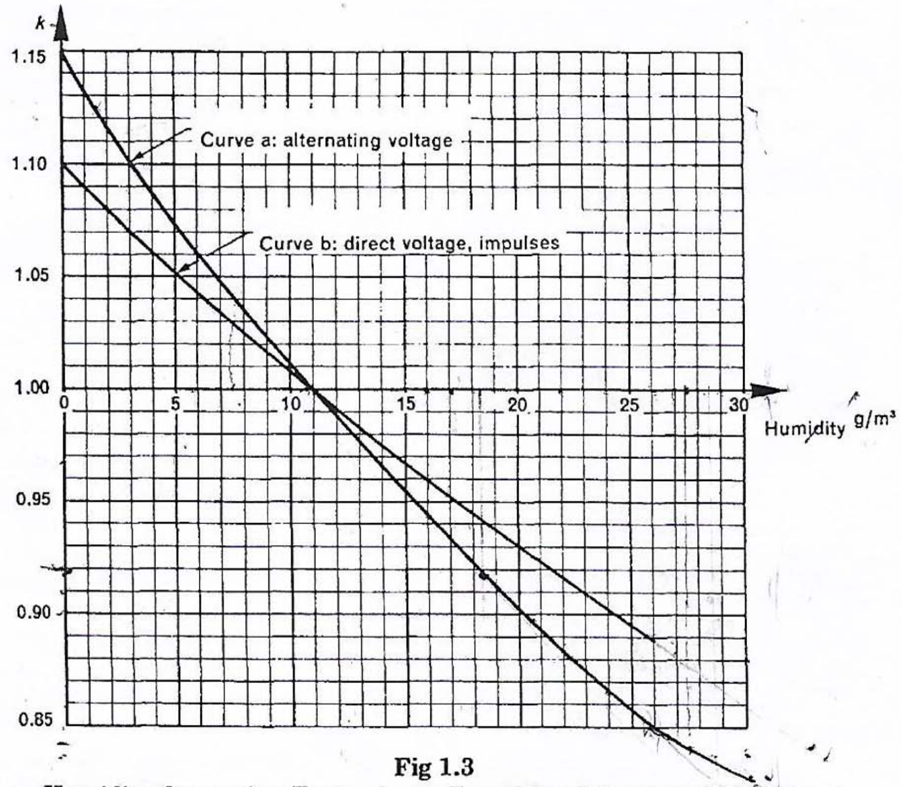


Fig 1.3
Humidity Correction Factor k as a Function of Absolute Humidity.
(For applicability, see 1.3.4.3 and Table 1.3).

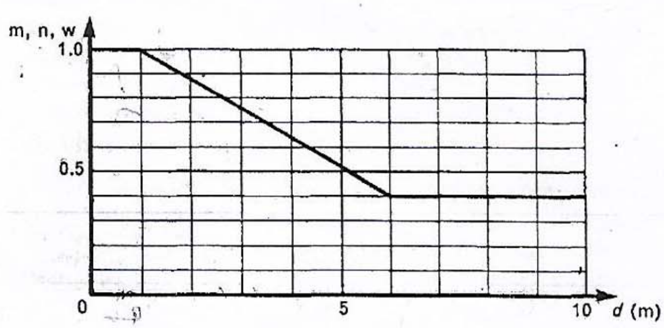


Fig 1.4
Values of the Exponents m and n for Air Density Correction and w for Humidity Corrections, as a Function of Sparkover Distance, in Meters.
(See 1.3.4.3 and Table 1.3.)

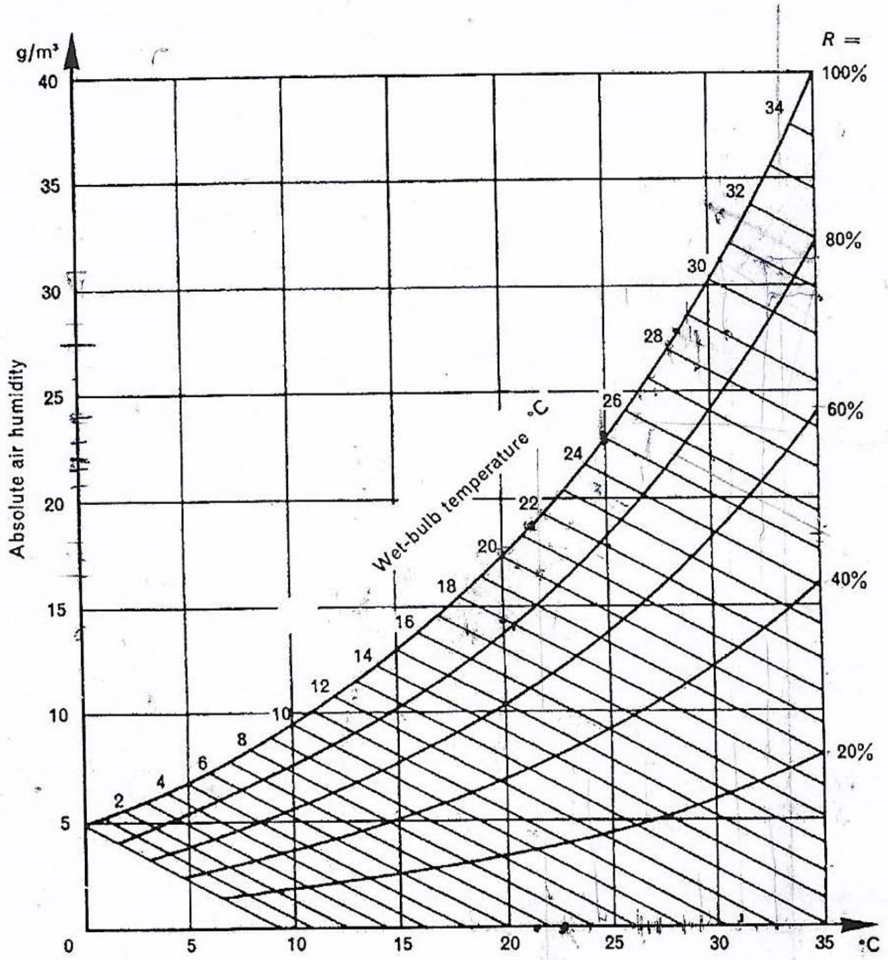
Table 1.3
Application of Atmospheric Correction Factors

Type of Test Voltage	Electrode Form	Polarity	Air Density Correction: Exponents m and n (see note in 1.3.5.3)	Humidity Correction: Factor k	Humidity Correction: Exponent w
Direct voltage		+ −	1.0	see Fig 1.3, (curve b)	0 0
		+ −			1.0 1.0
		+ −			1.0 0
Alternating voltage		~	1.0	see Fig 1.3 (curve a)	0
		~	see Fig 1.4		see Fig 1.4
		~	see Fig 1.4		see Fig 1.4
Lightning impulse voltage		+ −	1.0	see Fig 1.3 (curve b)	0 0
		+ −			1.0 0.8
		+ −			1.0 0
Switching impulse voltage		+ −	1.0 1.0	see Fig 1.3 (curve b)	0 0
		+ −	see Fig 1.4 0*		see Fig 1.4 0*
		+ −	see Fig 1.4 0*		see Fig 1.4 0*

*Very little information is available. At present no correction is recommended.

vant information for direct voltages and for switching impulses is scarce. The correctness of using equal exponents m and n, and of their numerical values as given, is therefore uncertain.

1.3.5.4 Measurement of Humidity. The measurement of humidity is usually made by means of a hygrometer consisting of two ventilated accurate thermometers, one being dry, the other wetted. The absolute humidity as a function of the two thermometer readings is determined by Fig 1.5, which also permits a determination of the relative humidity. It is important to provide adequate air



27.5

Fig 1.5
Absolute Humidity of Air as a Function of Dry- and Wet-Bulb Therometer Readings. (See 1.3.4.4.) Curves of Percentage Relative Humidity are also Given.

flow (4-10 m/s)[1] to reach steady-state values of the readings and to read the thermometers carefully, in order to avoid excessive errors in the determination of humidity.

Other methods for the determination of the humidity are available and may be used if it can be demonstrated that they give sufficient accuracy.

[1]*Smithsonian Meteorological Tables,* 6th Revised Edition, Smithsonian Publication 4014, p 365.