

Electrical Surface Resistivity of Fabrics

Developed in 1954 by AATCC Committee RA32; revised 1963, 1968, 1970, 1972, 1973, 1982, 1995, 2000 (with title change); reaffirmed 1969, 1975, 1978, 1989; editorially revised 1974, 1984, 1985, 1997, 2004; editorially revised and reaffirmed 1987, 2005.

1. Purpose and Scope

1.1 The purpose of this test method is to determine the electrical surface resistivity of fabrics. The surface electrical resistivity may influence the accumulation of electrostatic charge of a fabric (refer to AATCC Method 84 for determination of electrical resistance for yarns).

2. Principle

2.1 Specimens at equilibrium with specified atmospheric conditions of relative humidity and temperature are measured for electrical resistance between parallel electrodes by means of an electrical resistance meter.

3. Terminology

3.1 **electrical resistivity**, n .—material property of a substance whose numerical value is equal to the ratio of the voltage gradient to the current density.

NOTE: For the purposes of this method, surface resistivity is calculated by using the measured electrical resistance between superficially positioned parallel plates or concentric rings and their spacing and is reported as ohms per square. This test method in effect measures the resistance of a material to the flow of current between two electrodes.

4. Safety Precautions

NOTE: These safety precautions are for information purposes only. The precautions are ancillary to the testing procedures and are not intended to be all inclusive. It is the user's responsibility to use safe and proper techniques in handling materials in this test method. Manufacturers MUST be consulted for specific details such as material safety data sheets and other manufacturer's recommendations. All OSHA standards and rules must also be consulted and followed.

4.1 Good laboratory practices should be followed. Wear safety glasses in all laboratory areas.

4.2 The safety recommendations provided by the manufacturer of the radioactive bar should be followed.

4.3 The radioactive bar emits alpha radiation which is externally harmless to the human body. The radioactive isotope polonium 210 is toxic and precaution should be exercised to prevent ingestion or inhalation of the solid material. Do not take the radioactive bar apart or touch the radioactive strip under the grid. If the strip is touched or handled, wash hands thoroughly at once. Return the device to the manufacturer when it loses its effectiveness as a static eliminator or for disposal if use is to be discontinued. **Do not discard as scrap.**

5. Apparatus and Materials

5.1 Electrical resistance meter (see 11.1).

5.2 Conditioning and test chamber (see 11.2).

5.3 Standard resistors (see 11.3).

5.4 Radioactive bar (see 11.4).

5.5 Two rectangular flat metal surfaces of suitable size to serve as electrodes.

5.5.1 As an alternative, two concentric ring electrodes of spacing suitable to the material being measured and the purpose of the results (see 11.1.1).

6. Test Specimens

6.1 Adjust the size of fabric test specimens to suit the electrodes of the particular equipment being used. When using parallel plate electrodes, the width of the specimen must not exceed the width of the electrodes. When using the concentric rings, any size specimen at least as large as the outer ring may be used. Avoid contaminating the area on which the measurement is to be made.

6.2 *Specimens for use with instruments providing parallel plate electrodes.* Prepare 2 sets of 3 test specimens each, 1 set each so that the direction of testing is parallel to the yarns in the length direction of the fabric and 1 set with the direction of testing parallel to the width direction of the fabric.

6.2.1 *Test specimens for use with instruments providing concentric ring electrodes.* Prepare 1 set (3 test specimens) since, with this type instrument, the resistance is measured in both fabric length and fabric width directions simultaneously.

6.2.2 Depending on the fabric construction or end-use, it may be advisable to differentiate between face and back measurements. Each test specimen should be taken from a different part of

the fabric.

7. Procedure

7.1 Calibrate the electrical resistance meter according to the manufacturer's recommendations. This calibration should be repeated periodically (see 10.3).

7.2 Condition the test specimens in a suitable testing chamber or conditioning room at a predetermined relative humidity that will reflect the conditions at which information on the electrical resistivity of the fabric is needed.

7.2.1 For most fabrics which require antistatic treatments or whose static propensity is critical, measurements at 20% relative humidity will be most meaningful.

7.2.2 In less critical situations 40% relative humidity may be employed.

7.2.3 For special requirements other relative humidities may be used. For example, preconditioning at $50\% \pm 2\%$ RH at $21 \pm 2^\circ\text{C}$ is required for antistatic sheeting, film and textiles for use in hospital operating rooms (see 11.2.1). Measurements may be made under other conditions or ranges of conditions that are applicable to the end use (such as 65% RH and 24°C). It is preferable to keep the temperature or humidity consistent for all measurements.

7.2.4 If it is necessary to measure electrical resistivity under a broad range of conditions, additional tests may be run at 65% RH and at 24°C or other settings applicable to the end use. It is preferable to keep the temperature or humidity consistent for all measurements.

7.3 Optionally remove static charges on the surface of the fabric by passing a radioactive bar over both sides of the fabric (see 11.4).

7.4 Place a test specimen in firm contact with the electrodes. The contact with the electrodes should be such that, when additional pressure is applied between the fabric and the electrodes, the test results are not affected.

7.4.1 In the case of equipment using parallel plate electrodes, place the test specimen in contact with the electrodes with the direction of the test perpendicular to the adjacent edges of the electrode. Measure the electrical resistance of the fabric in both the length and width directions. Since the charge will follow the path of least resistance, record only the lower reading by direction.

7.4.2 For concentric ring electrodes, the charge follows the path of least resistance automatically.

7.5 Measure the electrical resistance of the test specimen according to the operating instruction and procedures for the particular resistance meter being used. Allow the current to pass through the test specimen for 1 min or until a constant reading is obtained. The criterion for constant electrical resistivity is a change in the value of Log R of less than 0.1 units per minute. The time to reach a constant reading may vary with the applied voltage and with the resistance of the test sample. High voltages for prolonged periods of time may damage the fabric.

7.6 For referee purposes, 80-100 volts at 25 mm electrode separation for 1 min should be used for the parallel plate configuration, and a similar voltage gradient for the concentric ring case (see 11.6).

7.7 Avoid the use of any electrically conductive liquids on either the fabric test specimens or the apparatus.

8. Evaluation

8.1 Compute the resistivity to the nearest ohms per square as follows:

8.1.1 For the parallel electrode case:

$$R = O \times W/D$$

where:

R = resistivity in ohms per square
 O = measured resistance in ohms
 W = width of specimen
 D = distance between electrodes

8.1.2 For the concentric ring case:

$$R = 2.73(O)/\log r_o/r_i$$

where:

R = resistivity in ohms per square
 O = measured resistance in ohms
 r_o = outer electrodes radius
 r_i = inner electrodes radius

8.2 Calculate the average resistivity for each sample and for the lot.

8.3 Determine the logarithm (base 10) of the resistivity (Log R) for each sample and for the lot.

9. Report

9.1 Report the following information:

9.1.1 The Log R for each sample and for the lot.

9.1.2 the number of specimens tested.

9.1.3 The relative humidity and temperature used.

9.1.4 The direction of testing if parallel plate electrodes were used.

10. Precision and Bias

10.1 *Precision*. Precision for this test method has not been established. Until a precision statement is generated for this test method, use standard statistical techniques in making any comparisons of test results for either *within-laboratory* or *between-laboratory* averages. Experience has shown that, with care, reproducibility should be $\pm \leq 2\%$ average Log R .

10.2 *Bias*. Electrical resistivity can be defined only in terms of a test method. There is no independent method for determining the true value. As a means of estimating this property, the method has no known bias.

11. Notes

11.1 The resistance meter in conjunction with the electrode system should be capable of measuring values in the range of 10^8 - 10^{15} for any critical uses. Equipment that is capable of measuring values in the range of 10^8 - 10^{13} ohms is suitable for work where the product performance is known to be acceptable if resistance is $< 10^{13}$ ohms.

11.1.1 A concentric ring instrument complete with adequate shielding, capable of measuring values in the range of 10^8 - 10^{15} ohms, is available from Keithley Instruments Inc., 28775 Aurora Rd., Cleveland OH 44139; tel: 440/248-0400.

11.1.2 Instruments capable of measuring values in the range of 10^8 - 10^{13} ohms are available from Teradyne Inc., 600 River Park Dr., North Reading MA 01864; tel: 978/370-2700.

11.1.3 A description of an instrument that will not allow measurements $> 10^{13}$ ohms is described by Hayek & Chromey in *American*

Dyestuff Reporter, Vol. 40, 1951, pp 164-8.

11.1.4 Other resistance testers also may be satisfactory for this test.

11.2 A conditioning and testing chamber is required capable of providing relative humidity control of $\pm 2\%$ (preferably effective over a range of 20-65% RH) and temperature control of $\pm 1^\circ\text{C}$ ($\pm 2^\circ\text{F}$) with circulating air. Since equilibration of a test specimen from the dry versus the wet condition relative to the humidity of the test chamber may show hysteresis, it is recommended that specimens approach equilibrium from the dry side relative to the humidity in the test chamber whenever possible.

11.2.1 National Fire Protection Association, Standard NFPA Code #56 A-1973 Section 4663.

11.3 Standard resistors suitable for calibration of the electrical resistance meter are available from Victoreen LLC, 6000 Cochran Rd., Cleveland OH 44139-3395; tel: 440/248-9300; fax: 440/248-9301.

11.4 The following radioactive bar, Static-master Ionizing Unit, Model 2 U 500, has been found to be suitable for the removal of electrostatic charges from fabrics and is available from NRD Inc., 2937 Alt. Blvd. North, Grand Island NY 14072; tel: 716/773-7634.

11.5 Accumulation of static electricity generally is greater the lower the relative humidity (and vice versa). Fabrics which show a low degree of static accumulation of 40% RH may exhibit severe static accumulation of 20-25% RH, while fabrics which exhibit static problems at 40% RH may exhibit a low degree of static accumulation of 65% RH. The relationship between the tendency for static accumulation and relative humidity varies with the specific antistatic agent, fiber, fabric construction, surface character, etc. Therefore, 40% RH may not provide significant information as to the probable antistatic performance properties of a fabric unless the tests are also run at 20-25% RH, an atmospheric condition not unusual in modern heated and air-conditioned buildings. Complete information may also require information of resistivity at the upper level of 65% RH.

11.6 For more detailed information regarding the measurement of resistances, see ASTM Test D 257, Tests for D-C Resistance or Conductance of Insulating Materials (ASTM Committee D-20).