

Test Method for Electrical Resistance Before and After Various Exposure Conditions

Foreword

This test method provides guidance for testing durability of e-textile resistance. The method includes a procedure for testing electrical resistance as well as modifications of established industry methods for laundering, drycleaning, water, perspiration, acids and alkalis, ultraviolet (UV) radiation, and microbe exposure. Test exposures relevant to the expected end use of sample. Similar modifications to other established methods may also be possible. Additional modifications may be required to accommodate large or unusually-shaped samples that cannot be cut into standard swatches. If the referenced industry methods are also used for their original purpose (e.g., colorfastness), use a separate set of specimens.

1. Purpose and Scope

1.1 This test method is used to determine the electrical resistance of e-textiles before and after exposure to laundering, drycleaning, water, perspiration, acids and alkalis, ultraviolet (UV) radiation, and/or microbes.

1.2 this test method is applicable to e-textile fabrics or end products with incorporated (woven, knitted, printed, embroidered, etc.) conductive paths/traces. It is not for evaluation of yarns or fibers.

2. Principle

2.1 Electrical resistance is measured along a conductive path or segment of a conductive path before and after various exposure conditions. Any or all of the provided exposure methods may be used: laundering, drycleaning, water, perspiration, acids and alkalis, ultraviolet (UV) radiation, and microbes. Resistance is reported in ohms (Ω), where a higher value indicates more resistance (less conductance). Change in resistance after exposure is also calculated and reported as percent change, where a higher value indicates more change (typically a greater increase in resistance).

3. Referenced Documents

NOTE: Use current versions of all publications unless otherwise specified.

3.1 AATCC EP13, Evaluation Procedure for Electrical Resistance of Electronically-Integrated Textiles (see 16.1).

3.2 AATCC LP1, Laboratory Procedure

for Home Laundering: Machine Washing (see 16.1).

3.3 AATCC LP2, Laboratory Procedure for Home Laundering: Hand Washing (see 16.1).

3.4 AATCC TM6, Test Method for Colorfastness to Acids and Alkalis (see 16.1).

3.5 AATCC TM15, Test Method for Colorfastness to Perspiration (see 16.1).

3.6 AATCC TM22, Test Method for Water Repellency-Spray Test (see 16.1).

3.7 AATCC TM100, Test Method for Antibacterial Finishes on Textile Materials: Assessment of (see 16.1).

3.8 AATCC TM106, Test Method for Colorfastness to Water: Sea (see 16.1).

3.9 AATCC TM127, Test Method for Water Resistance: Hydrostatic Pressure Test (see 16.1).

3.10 AATCC TM158, Test Method for Dimensional Changes on Drycleaning in Perchloroethylene: Machine Method (see 16.1).

3.11 AATCC TM186, Test Method for Weather Resistance: UV Light and Moisture Exposure (see 16.1).

3.12 ASTM D1776, Standard Practice for Conditioning and Testing Textiles.

4. Terminology

4.1 **electronically-integrated textile (e-textile)**, n. —a fabric or textile product with permanently-integrated electrical circuits or parts of electrical circuits.

4.2 **electrical resistance**, n. — A specific textile's ability to reduce electric current flowing through it at a given voltage. Resistance, R, is expressed in units of ohms (Ω).

5. 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. Users MUST consult manufacturers for specific details such as safety data sheets and other manufacturer's recommendations. Consult and follow all applicable OSHA standards and rules.

5.1 Follow good laboratory practices. Wear safety glasses in all laboratory areas.

5.2 Follow manufacturer's safety recommendations when operating laboratory testing equipment.

6. Uses and Limitations

6.1 Each conductive path to be measured must be accessible, at least at the two measurement points. Connectors may be used to provide accessibility. The measured specimen should mimic the intended design of the end product, if known.

6.2 The exposure procedures referenced in this document were not developed to measure changes in electrical resistance. Electrical resistance changes after various exposure conditions may not accurately reflect end use results but provide a relative measure of electrical resistance durability.

7. Apparatus and Materials (see 16.2)

7.1 Electrical Resistance Measurement

7.1.1 Conditioning facilities and racks with pull-out, perforated shelves for laying specimens flat (see 16.1).

7.1.2 Flat workbench with grounded electronic static dissipation (ESD) mat. The surface should be at least as large as the specimen.

7.1.3 Indelible ink marking pen (see 16.1) or needle and sewing thread, for making benchmarks.

7.1.4 Digital multimeter or ohmmeter, resolution to at least 0.1 Ω and 0.9% accuracy. For samples with resistance less than 1 Ω , use a four-wire (four-point) system with resolution to at least 0.01 Ω . Select probes appropriate to the test material. Weighted probes of an appropriate size may improve repeatability.

7.1.5 Tape or rule marked in millimeters.

7.2 Exposure 1: Home Laundering

7.2.1 For home laundering using a washing machine, refer to AATCC LP1 for apparatus and materials.

7.2.2 For home laundering by hand washing, refer to AATCC LP2 for apparatus and materials.

7.3 Exposure 2: Drycleaning

7.3.1 Refer to AATCC TM158 for apparatus and materials related to drycleaning exposure.

7.3.2 The measuring scale referenced in AATCC TM158 is NOT necessary for evaluation of electrical resistance.

7.4 Exposure 3: Water: Spray

7.4.1 Refer to AATCC TM22 for apparatus and materials related to water spray exposure.

7.5 **Exposure 4: Water: Hydrostatic Pressure**

7.5.1 Refer to AATCC TM127 for apparatus and materials related to hydrostatic pressure exposure.

7.6 Exposure 5: Water: Salt (Sea)

7.6.1 Refer to AATCC TM106 for apparatus and materials related to salt-water exposure.

7.6.2 Multifiber fabric referenced in AATCC TM106 is NOT necessary for evaluation of electrical resistance.

7.6.3 Scales for chromatic transference, color change and staining referenced in AATCC TM106 are NOT necessary for evaluation of electrical resistance.

7.6.4 Swatches or items larger than 60 × 120 mm require a modified apparatus capable of applying the specified pressure over the entire area and an oven large enough to accommodate the apparatus.

7.7 Exposure 6: Perspiration

7.7.1 Refer to AATCC TM15 for apparatus and materials related to perspiration exposure.

7.7.2 Multifiber fabric referenced in AATCC TM15 is NOT necessary for evaluation of electrical resistance.

7.7.3 Scales for chromatic transference, color change and staining referenced in AATCC TM15 are NOT necessary for evaluation of electrical resistance.

7.7.4 Swatches or items larger than 60 × 120 mm require a modified apparatus capable of applying the specified pressure over the entire area and an oven large enough to accommodate the apparatus.

7.8 Exposure 7: Acids and Alkalis

7.8.1 Refer to AATCC TM6 for apparatus and materials related to acids and alkalis exposure.

7.8.2 Gray Scale for Color Change referenced in AATCC TM6 is NOT necessary for evaluation of electrical resistance.

7.8.3 Additional reagent volume and vessels may be required to test large or unusually-shaped samples.

7.9 Exposure 8: Ultraviolet (UV) Radiation and Moisture

7.9.1 Refer to AATCC TM186 for apparatus and materials related to UV radiation and moisture exposure.

7.9.2 Swatches or items larger than 70 × 120 mm may require a modified sample holder and a test chamber large enough to accommodate the sample.

7.10 Exposure 9: Microbes

7.10.1 Refer to AATCC TM100 for apparatus and materials related to microbe exposure.

7.10.2 Swatches or items larger than 48 mm in diameter may require a larger volume of inoculum and a Petri dish or other shallow container large enough to accommodate the sample.

8. Specimens

8.1 Each conductive path (or section of a path) is considered a specimen. Measure at least three identical specimens for each exposure condition.

8.1.1 Additional identical specimens may be used to improve accuracy. Various path types or lengths may be tested as separate samples. Do not compare results for different path types or lengths.

8.1.2 If possible, cut swatches that each contain at least one straight conductive path. Cut swatches such that specimens are centered. Swatch and specimen dimensions are specified for individual exposure conditions.

8.1.3 If end products cannot be cut without interrupting the pathway, specimens will depend upon product design. Test identical specimens from three end-product items. Modification of the exposure conditions may be required to accommodate non-standard sample sizes or forms.

8.2 Exposure 1: Home Laundering

8.2.1 If possible, cut three swatches, 400 × 400 mm, each containing at least one straight conductive path (specimen), 150-300 mm in length. Cut each swatch such that the specimen is near the center, and at least 65 mm from all edges.

8.2.2 The procedure for home laundering exposure is easily adapted to most uncut and other non-standard samples.

8.3 Exposure 2: Drycleaning

8.3.1 If possible, cut three swatches, 500 × 500 mm, each containing at least one straight conductive path (specimen), 150-300 mm in length. Cut each swatch such that the specimen is near the center, and at least 65 mm from all edges.

8.3.2 The procedure for drycleaning exposure is easily adapted to most uncut and other non-standard samples.

8.4 Exposure 3: Water: Spray

8.4.1 If possible, cut three swatches, 180 × 180 mm, each containing at least one straight conductive path (specimen), about 150 mm in length. Cut each swatch such that the specimen is near the center.

8.4.2 The procedure for water spray exposure can be adapted to some uncut and other non-standard samples, but only a circular test area with about 155-mm diameter will be exposed to water. The test area must be flat. Conductive elements at the perimeter of the test area may be damaged by the specimen holder.

8.5 Exposure 4: Water: Hydrostatic Pressure

8.5.1 If possible, cut three swatches, 200 × 200 mm, each containing at least one straight conductive path (specimen), about 90 mm in length. Cut each swatch such that the specimen is near the center.

8.5.2 The procedure for hydrostatic pressure exposure can be adapted to some uncut and other non-standard samples, but only a circular test area with about

100-mm diameter will be exposed to water. Conductive elements at the perimeter of the test area may be damaged by the clamping mechanism.

8.6 Exposure 5: Water: Salt (Sea)

8.6.1 If possible, cut three swatches, 60 × 120 mm, each containing at least one straight conductive path (specimen), about 125 mm in length, diagonally across the swatch. Align swatch to achieve the longest possible conductive path; it is not necessary to align swatch edges with machine direction of the fabric.

8.6.2 Adaptation of the procedure for salt-water exposure to uncut and other non-standard samples may be difficult, particularly if the sample is not a single flat layer.

8.7 Exposure 6: Perspiration

8.7.1 If possible, cut three swatches, 60 × 120 mm, each containing at least one straight conductive path (specimen), about 125 mm in length, diagonally across the swatch. Align swatch to achieve the longest possible conductive path; it is not necessary to align swatch edges with machine direction of the fabric.

8.7.2 Adaptation of the procedure for perspiration exposure to uncut and other non-standard samples may be difficult, particularly if the sample is not a single flat layer.

8.8 Exposure 7: Acids and Alkalis

8.8.1 For each reagent [HCl, CH₃COOH, NH₃, Na₂CO₃, NH₄OH, Ca(OH)₂], use three swatches or end-product items of any convenient size, each containing at least one conductive path (specimen)—18 specimens in total. If possible, select straight specimens, 150-300 mm in length.

8.8.2 No adaptation of the procedure for acids and alkali exposure is required to test most large or unusually-shaped samples.

8.9 Exposure 8: UV Radiation and Moisture

8.9.1 If possible, cut three swatches, 70 × 120 mm, that each contain at least one straight conductive path (specimen), about 130 mm in length, diagonally across the swatch. Align swatch to achieve the longest possible conductive path; it is not necessary to align swatch edges with machine direction of the fabric.

8.9.2 Adaptation of the procedure for UV radiation and moisture exposure to uncut and other non-standard samples may be difficult, particularly if the sample is not a single flat layer.

8.10 Exposure 9: Microbes

8.10.1 For each test bacteria (*Staphylococcus aureus* and *Klebsiella pneumoniae*), cut three circular swatches with a 48-mm diameter that each contain at least one straight conductive path (specimen),