

Test Method for Colorfastness to Ozone in the Atmosphere under High Humidities

Developed in 1962 by AATCC Committee RA33; editorially revised 1973, 1974, 1981, 1989, 1997, 2008, 2019; revised 1972, 1975, 1985, 2005, 2011; reaffirmed 1990, 2001, 2016; editorially revised and reaffirmed 1996, 2010. Partly equivalent to ISO 105-G03.

1. Purpose and Scope

1.1 This test method is used for determining the resistance of the color of textiles to the action of ozone in the atmosphere at elevated temperatures with relative humidities above 85%.

2. Principle

2.1 A test specimen and a swatch of control sample are simultaneously exposed to ozone in an atmosphere which is maintained at $87.5 \pm 2.5\%$ RH and a temperature of $40 \pm 1^\circ\text{C}$ ($104 \pm 2^\circ\text{F}$) until the control sample shows a color change corresponding to that of a standard of fading. The cycles are repeated until the specimen shows a definite color change or for a prescribed number of cycles.

2.2 On certain fibers, dye fading does not readily take place at humidities below 85%. Testing at high humidities is required to produce color change that predicts service fading under warm, humid conditions (see 11.1).

3. Terminology

3.1 **colorfastness**, *n.*—the resistance of a material to change in any of its color characteristics, to transfer of its colorant(s) to adjacent materials or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material.

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 Ozone is a sensory irritant. The test cabinet should be ventilated to the outside atmosphere in accordance with the manufacturer's instructions.

4.3 Exposure to chemicals used in this procedure must be controlled at or below levels set by governmental authorities (e.g., Occupational Safety and Health Administration's [OSHA] permissible exposure limits [PEL] as found in 29 CFR 1910.1000; see web site: www.osha.gov for latest version). In addition, the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) comprised of time weighted averages (TLV-TWA), short term exposure limits (TLV-STEL) and ceiling limits (TLV-C) are recommended as a general guide for air contaminant exposure which should be met (see 11.2).

5. Apparatus and Materials (see 11.3)

5.1 Ozone Chamber for elevated temperatures and relative humidities above 85% (see 11.4).

5.2 Control Sample No. 129 for high humidities (see 11.5, 11.7 and 11.8).

5.3 Standard of Fading No. 129 for high humidities (see 11.6, 11.7 and 11.8).

5.4 Gray Scale for Color Change (AATCC EP1) (see 11.7).

6. Test Specimens

6.1 Cut each test specimen at least 100×60 mm (4.25×2.375 in.). For subsequent color comparison, the unexposed sample should be kept in an airtight container away from light to avoid further shade change.

6.2 When a laundered or drycleaned specimen is used, base the effects of ozone exposure on comparisons with the color of the laundered or drycleaned swatch. In the preparation of specimens for testing after laundering or drycleaning, use AATCC TM61, Test Method for Colorfastness to Laundering: Accelerated, and AATCC TM132, Test Method for Colorfastness to Drycleaning.

7. Procedure

7.1 Suspend test and control specimens (see 11.5 and 11.7) in the exposure chamber (see 11.4) which is maintained at 87.5

$\pm 2.5\%$ RH and a temperature of $40 \pm 1^\circ\text{C}$ ($104 \pm 2^\circ\text{F}$). Ozone concentrations must range from 10-35 pphm which should produce one cycle of fading in 3-28 h of test.

7.2 Examine the control specimen periodically until the resulting color corresponds to that of the standard of fading (see 11.6 and 11.7) when compared in daylight ranging from average to slightly bluish north sky light, or equivalent artificial light. This constitutes one cycle (see 11.9).

7.3 Remove those specimens which exhibit a color change at the end of one cycle. One cycle will generally produce a measurable color change in specimens which are ozone sensitive.

7.4 Suspend a fresh control specimen and continue exposure of any remaining specimens for a second cycle.

7.5 Run additional similar cycles as necessary.

8. Evaluation

8.1 At the end of each cycle immediately compare those specimens which are removed from the exposure chamber with the preserved original from which they were drawn.

8.2 Rate the effect on color of test specimens after any specified number of cycles by reference to the Gray Scale for Color Change (AATCC EP1) or using AATCC EP7, Instrumental Assessment of the Change in Color of a Test Specimen, and record the numerical rating that corresponds to the appropriate one on the Gray Scale. Report the number of cycles run (see 11.7, 11.10 and 11.11).

9. Report

9.1 Report the numerical rating for the change in color of the test specimen, the number of cycles run and the temperature and relative humidity at which the test was performed.

10. Precision and Bias

10.1 Precision.

10.1.1 Interlaboratory Study. Four laboratories participated in this study. Twenty-one carpet materials were evaluated for colorfastness under conditions of the test method. Four specimens were assigned to each laboratory for each material. Three specimens were exposed in an

ozone-humidity chamber, and one was retained in the original condition to evaluate color retention using EP1. The ILS exposure plan contained these factors: laboratories 4, materials 21, specimens 3, with 1 determination per specimen. Each laboratory assigned grades to specimens using EP1.

10.1.2 Components of Variance. Variance components were derived for carpet materials (VF), laboratories (VL), interaction (VFL), and residual (V). Components VL and V were needed to compute precision estimates for tests done on a single carpet material, as shown in Table I and using equations:

$$95 \text{ CD Within Lab} = \frac{2.83(V/3)}{0.5}$$

and

$$95 \text{ CD Between Lab} = \frac{2.83(V/3 + VL)}{0.5}$$

stated in spreadsheet notation. These equations give expected critical differences not to be exceeded (1) in two test results of a single carpet materials within one laboratory, or (2) in single test results of two laboratories from a single carpet material, when either difference is not significant.

10.1.3 Precision Estimates. Table II values are computed at the 95% confi-

dence level. Values are Critical Differences. This study used three specimens (noted in bold). Other specimen values show the effect of the number of specimens in an average on the magnitude of a critical difference.

10.2 Bias.

10.2.1 This test method has no known bias. There is no known referee test method, nor any known standard materials by which test method bias may be established.

11. Notes

11.1 At high humidities, the fading of dyes by ozone on small fibers (such as nylon) is altered greatly by relatively small variations in relative humidity. Therefore, to achieve reproducibility and good interlaboratory correlation in test results, temperature and relative humidity must be closely controlled.

11.2 Available from Publications Office, ACGIH, Kemper Woods Center, 1330 Kemper Meadow Dr., Cincinnati OH 45240; tel: +1.513.742.2020; web site: www.acgih.org.

11.3 For potential equipment information pertaining to this test method, please visit the online *AATCC Buyer's Guide* at www.aatcc.org/bg. AATCC provides the possibility of listing equipment and materials sold by its Corporate members, but AATCC does not qualify, or in any way approve, endorse or certify that any of the listed equipment or materials meets the requirements in its test methods.

11.4 The ozone exposure chamber for elevated temperatures and relative humidities above 85% can be of variable construction as long as it meets the conditions of $87.5 \pm 2.5\%$ RH, $40 \pm 1^\circ\text{C}$ ($104 \pm 2^\circ\text{F}$) temperature and contains an ozone concentration in the range of 10-35 pphm.

11.4.1 Blueprints of a suitable apparatus are available from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: +1.919.549.8141; fax: +1.919.549.8933; e-mail: ordering@aatcc.org; web site: www.aatcc.org.

11.4.2 For information regarding the measurement of ozone concentration, see the following references:

Schulze, Fernand, "Versatile Combination Ozone and Sulfur Dioxide Analyzer," *Analytical Chemistry*, Vol. 38, May 1966, pp748-752.

"Selected Methods of the Measurement of Air Pollutants," Public Health Service Publication No. 999-AP-11, May 1965. Office of Technical Information and Publication (OTIP), Springfield VA, PB167-677.

11.5 The control sample for tests made at elevated temperatures and relative humidities above 85% is a tertiary shade, avocado, prepared by dyeing a Y-cross-section nylon 6 unautoclaved knitted sleeve with the following formula: 0.15% C.I. Disperse Red 4, 0.63% C.I. Disperse Yellow 3 and 0.25% C.I. Disperse Blue 3 based on the weight of the fabric.

11.6 The standard of fading for tests made at elevated temperatures and relative humidities above 85% is a dyeing of the same Y-cross-section nylon 6 unautoclaved knitted sleeve with the following formula: 0.557% C.I. Acid Yellow 79, 0.081% C.I. Acid Red 361 and 0.102% C.I. Acid Blue 277.

11.7 Available from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: +1.919.549.8141; fax: +1.919.549.8933; e-mail: ordering@aatcc.org; web site: www.aatcc.org.

11.8 CAUTION: Both the control sample and the standard of fading must be kept in airtight containers to prevent color change encountered in normal atmospheres. The control fabric is also sensitive to other atmospheric contaminants such as oxides of nitrogen. Its fading rate will vary considerably at different humidities and temperatures and its use in natural or end-use testing as a measure of exposure to ozone is not recommended. The color change produced on the control will reflect the combined effects of the atmospheric contaminants present, and temperature, humidity variations and not just the effects of exposure to ozone.

11.9 An alternative method of determining one cycle of fade is to terminate the exposure cycle when the Control Sleeve 129 exhibits a color change of 22.5 ± 1.4 CIELAB units for Lot No. 10 (see 11.10).

11.10 Make colorimetric or spectrophotometric measurement of Control Sleeve 129 with the specular component included. Calculate colorimetric data using the CIE 1964 10° observer data for Illuminant D_{65} . The color difference shall be expressed in CIELAB units.

11.11 An automated electronic grading system may be used as long as the system has been demonstrated to provide results that are equal to and provide equal or better repeatability and reproducibility than an experienced grader performing visual evaluation.

Table I—Components of Variance

COV	Unit Var
VL	0.038
V	0.026

Table II—Critical Differences

Specimens in Average	95 CD Within Lab	95 CD Between Lab
1	0.46	0.70
3	0.26	0.61
5	0.20	0.40