# Weather Resistance: UV Light and Moisture Exposure

**Developed in 1999 by AATCC Committee RA64; revised 2000; editorially revised and reaffirmed 2001; reaffirmed 2006.**

## 1. Purpose and Scope

1.1 This test method provides a procedure for the exposure of textile materials of all kinds, including coated fabrics and products made thereof, in a laboratory artificial weathering exposure apparatus employing fluorescent UV lamps as a light source and using condensing humidity and/or water spray for wetting.

## 2. Principle

2.1 Specimens are exposed to a fluorescent UV light source and to periodic wetting under controlled conditions. Resistance to degradation is rated in terms of a comparison standard and the exposure criteria, percent loss in strength or percent residual strength (breaking or bursting as appropriate) and/or color change of the material when evaluated under standard textile conditions.

## 3. Terminology

3.1 **breaking strength,** n.—the maximum force applied to a specimen in a tensile test carried to rupture.

3.2 **bursting strength,** n.—the force or pressure required to rupture a textile by distending it with a force, applied at right angles to the plane of the fabric, under specified conditions.

3.3 **fluorescent UV lamp,** n.—a lamp in which radiation at 254 nm from a low-pressure mercury arc is transformed to longer wavelength UV by a phosphor.

3.4 **irradiance,** n.—radiant power per unit area as a function of wavelength expressed as watts per square meter, $W/m^2$.

3.5 **radiant energy,** n.—energy traveling through space in the form of photons or electromagnetic waves of various lengths.

3.6 **spectral energy distribution,** n.—the variation of energy due to the source over the wavelength span of the emitted radiation.

3.7 **standard atmosphere for testing textiles,** n.—air maintained at 21 ± 1°C and 65 ± 2% relative humidity.

3.8 **ultraviolet radiation**, n.—radiant energy for which the wavelengths of the monochromatic components are smaller than those for visible radiation and more than about 100 nm.

NOTE: The limits of the spectral range of ultraviolet radiation are not well defined and may vary according to the user. Committee E-2.1.2 of the CIE distinguishes in the spectral range between 400 and 100 nm:

| | |
|---|---|
| UV-A | 315-400 nm |
| UV-B | 280-315 nm |
| UV-R | 280-400 nm |

3.9 **UV-A Type Fluorescent UV lamp,** n.—a fluorescent UV lamp where radiant emission below 300 nm is less than 2% of its total light output.

3.10 **UV-B Type Fluorescent UV lamp,** n.—a fluorescent UV lamp where radiant emission below 300 nm is more than 10% of its total light output.

3.11 **weather,** n.—climatic conditions at a given geographic location, including such factors as sunlight, rain, humidity and temperature.

3.12 **weather resistance,** n.—ability of a material to resist degradation of its properties when exposed to climatic conditions.

## 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 Do not operate the test equipment until the manufacturer's operating instructions have been read and understood. It is the responsibility of whoever operates the test equipment to conform to the manufacturer's directions for safe operation.

4.3 The test equipment contains high intensity lamps. Do not look directly at the light source. The door to the test chamber must be kept closed when the equipment is in operation.

4.4 Before servicing the light sources, allow 30 min for cool-down after the lamp operation has been terminated.

4.5 When servicing the test equipment, shut off both the "off" switch on the front panel and the main power disconnect switch. When equipped, ensure that the main power light on the machine front panel goes out.

## 5. Uses and Limitations

5.1 The use of this procedure is intended to simulate the deterioration caused by the UV energy in sunlight and water. Exposures are not intended to simulate the deterioration caused by localized weather phenomena, such as atmospheric pollution, biological attack and salt water exposure.

5.2 Cautions. Variation in results may be expected when operating conditions are varied within the accepted limits of this procedure. Therefore, no reference shall be made to results from the use of this procedure unless accompanied by a report detailing the specific operating conditions in conformance with the section on Report.

5.3 Results obtained from this procedure can be used to compare the relative durability of materials subjected to the specific test cycle used. Comparison of results from specimens exposed in different types of apparatus should not be made unless correlation has been established among devices for the material to be tested. Variations in results may be expected when operating conditions vary within the limits of this procedure. Because of the variability in results obtained using this practice and the variability in results from exterior exposures, use of a single "acceleration factor" that relates hours of an accelerated exposure to a specific period of outdoor exposure is not recommended. Because of possible variations in results, no reference should be made to results obtained from tests conducted in the apparatus using this procedure unless accompanied by the information required in the section on Report.

5.4 There are a number of factors that may decrease the degree of correlation between accelerated tests using laboratory light sources and actual use exposures.

5.4.1 Differences in the spectral distribution between the laboratory light source and sunlight.

5.4.2 Shorter than normal wavelength exposures are often used to obtain faster failure rates in laboratory accelerated exposure tests. For outdoor exposures, the cut-on for short wavelength UV radiation is generally considered to be 300 nm. Exposures to UV radiation of wavelengths less than 300 nm, may produce degradation reactions, which do not occur when the material is used outdoors. If a laboratory light source used in an accelerated test contains UV radiation of wave-

lengths shorter than that found in the actual use condition, the mechanism of degradation and stability ranking of materials can be dramatically different in the accelerated test.

5.5 It may not be necessary to simulate daylight over the entire spectrum, if radiation in a specific region is known to produce the type of degradation of interest in the materials being tested and does not alter stability ranking of materials. Laboratory light sources, which have a very strong emission in a narrow band relative to the rest of the ultraviolet or visible spectrum, however, may cause a particular reaction to be favored relative to others which may be very important. This type of light source also may not produce changes caused in exposures to daylight. Exposures to light sources, which only produce ultraviolet radiation may not produce color fade caused by visible radiation, and may cause polymer yellowing that is more pronounced than that produced in exposures to daylight.

## 6. Apparatus (See 17.1)

6.1 Test chamber (see 17.2).

6.2 UV-A type fluorescent UV lamp (see 17.7).

6.3 Moisture system.

6.3.1 Condensation. The moisture system may be used to generate either condensation or water spray or both (see 17.7).

6.3.2 Water spray. The test chamber may be equipped with a means to introduce intermittent water spray onto the test specimens under specified conditions. The spray shall be uniformly distributed over the samples. The spray system shall be made from corrosion resistant materials that do not contaminate the water employed.

6.4 Black panel thermometer (see 17.8 and 17.9).

6.5 Specimen holders (see 17.10).

6.6 Test chamber location (see 17.11).

## 7. Test Samples

7.1 Number of Specimens. Replicate specimens of the material to be tested and a comparable number of the standard for comparison should be used as required to ensure accuracy. It is recommended that at least three replicates of each material evaluated be exposed in each test to allow for statistical evaluation of results.

Expose a sufficient number of specimens so that the expected test result is not more than 5% of the average above or below the true average of the lot at the 95% probability level. Determine the number of specimens using standard deviation with one-sided limits as directed in ASTM Practice D 2905.

7.2 Specimen Dimensions. Certain materials may exhibit a dimensional change as a result of exposure. The test equipment manufacturer, physical test apparatus and number of replicate specimens required will affect the needed specimen dimension. The test procedures which will be used to assess the change in properties should be reviewed to ensure that specimen size is appropriate for performing the subsequent procedures.

Cut strips of fabric at least 102 × 152 mm with the longer dimension parallel to the warp of machine direction, unless otherwise specified, for the following tests:

7.2.1 Bursting Strength (Ball Burst).

7.2.2 Breaking Strength (Grab Tensile).

7.2.3 Color Change.

7.2.4 When required to prevent raveling, the specimens may be edged using a flexible epoxy resin or similar material.

7.2.5 Label each specimen for identification using material resistant to the environment encountered during the test.

## 8. Test Cycle Determination

8.1 The test cycle is best determined by the influencing factors of the end use, in particular, the climatic conditions. Not all materials are affected equally by the same environment. Results obtained by the use of any one test cycle may not be representative of those of any other test cycles or any outdoor weathering test. Any acceleration factor derived for one geographic location does not necessarily apply to any other geographic location. However, certain test cycles are suggested to group similar climates with respect to the test cycle.

8.2 The nature of the test material contributes to the selection of the appropriate test cycle with respect to UV exposure, wetting, wet time and temperature. The following test cycles options have been used for textile materials.

8.2.1 Option 1, General Applications: 8 h UV at an irradiance of 0.77 W/m$^2$ @ 340 nm at 60°C followed by 4 h condensation at 50°C. This option is used for general applications such as outdoor furniture fabrics, tent material, etc.

8.2.2 Option 2, Thermal Shock Applications: 8 h UV at an irradiance of 0.77 W/m$^2$ @ 340 nm at 60°C; followed by 0.25 h water spray; followed by 3.75 h condensation at 50°C. This option has been used for architectural and other applications where thermal shock may be an issue.

8.2.3 Option 3, Automotive Exterior: 8 h UV at an irradiance of 0.72 W/m$^2$ @ 340 nm at 70°C followed by 4 h condensation at 50°C. UV irradiance may be monitored and maintained by the manual method or by the feed-back-loop method as described in SAE J2020.

8.3 The use of these cycles does not imply, expressly or otherwise, an accelerated weathering test, nor is this method restricted to the use of these cycles. The degree of correlation to any actual outdoor weathering exposure must be determined by quantitative analysis.

## 9. Standards of Comparison

9.1 Standards for comparisons can be made of any suitable textile material where a history of strength degradation or color change rates are known depending upon individual test needs. They must be exposed simultaneously with the test specimen to be investigated. The intent of these standards is to demonstrate uniformity between separate machine and test runs. When test data of the exposed standards differ by more than 10% from the known data, the test machine operating conditions must be thoroughly reviewed and any malfunctions or defective parts corrected. The test is then repeated. If the data still differ by more than 10% from the known data and there is no evidence of machine malfunction, then the test standard should be questioned and re-evaluated. Test data obtained with questionable standards must be treated with caution and resolution provided with quantitative analysis.

## 10. Procedure

10.1 Maintain and calibrate the apparatus in accordance with the manufacturer's recommendations.

10.2 Before beginning the exposure test, bring all specimens, control and test, to moisture equilibrium in the atmosphere for testing textiles in accordance with ASTM D 1776, Standard Practice for Conditioning and Testing Textiles. Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weightings made at intervals of not less than 2 h does not exceed 0.1% of the mass of the specimen. Perform any necessary tests or evaluations necessary to establish a base line for comparing the unexposed specimens to the exposed specimens.

10.3 Specimen Mounting. Mount the specimens in the frames which are supplied with the cabinet with the test surfaces facing the lamp. When the test specimens do not completely fill the racks, the empty spaces must be filled with blank panels to maintain the test conditions within the chamber.

10.3.1 To provide rigidity, flexible specimens may be attached to a backing panel made of aluminum or other noncorrosive heat conductive material.

10.3.2 Holes in specimens and any openings larger than 1 mm around irregularly shaped specimens shall be sealed to prevent loss of water vapor. Porous specimens shall be backed with a vapor barrier such as aluminum or plastic.

10.3.3 Fabrics. Flexible fabric specimens are mounted by simply wrapping them around an aluminum blank and clamping them into place with the spring ring clip. The specimens should present a smooth face to the inside of the chamber (see Fig. 1).

10.3.4 Yarns. Yarns should be wound on frames to a length of 150 mm minimum. Only that portion of the yarns directly facing the radiant energy is tested for breaking (tensile) strength. Single strand or multiple strand testing may be performed. When multiple strand testing is to be performed, the yarns are wound on the frame closely packed to 25.4 mm width. The control specimens must contain the same number of strands as the specimen subjected to exposure. After the exposure has been completed and before the yarns are unwound for testing, those yarns facing the light source are bound together by the use of 20 mm masking or other suitable type tape to maintain the closely packed arrangements on the exposure frame.

10.3.5 In the case of woven, knitted and nonwoven fabrics ensure that the side directly exposed to the radiant source is the one normally used as the face.

10.4 Program the device to achieve the required test conditions and operate the apparatus continuously within the limits specified above. Use test conditions specified in 8.2 or agreed to by mutual consent or as required by a product quality specification.

10.5 Operate continuously, repeating the cycle, except for servicing the instrument and inspection of specimens. Inspect specimens daily during the middle of a condensation cycle to make sure all specimens are uniformly wetted.

10.6 To minimize any effects from temperature or UV light variation, it is recommended that specimens be repositioned as shown in Fig. 2. Rotate samples horizontally once each week by (1) moving the two extreme right hand specimen holders to the far left of the exposure area and (2) sliding the remaining specimen holders to the right.

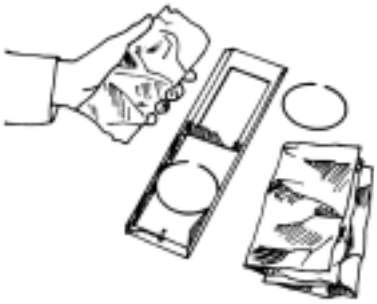

**Fig. 1—Typical mounting for flexible fabric specimens.**

## 11. Periods of Exposure

11.1 Use one of the following methods to determine the duration of the exposure:

11.1.1 A specified number of total hours.

11.1.2 The number of total hours of exposure required to produce an amount of change in either the test specimen or an agreed upon standard sample.

## 12. Conditioning

12.1 If the test and control samples are wet upon removal from the tester, dry them at ambient laboratory conditions or at a temperature not exceeding 71°C.

12.2 Condition the test and control samples in the controlled atmosphere for testing textiles. Bring all specimens to moisture equilibrium. Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1% of the mass of the specimen. In general practice, the industry approaches equilibrium from the "As Received" side.

12.3 For each test to be made on the material and control, exposed and unexposed, prepare test specimens by marking and raveling or cutting the central portion of each exposed specimen to the dimensions specified in the respective test procedure. Marking and raveling or cutting of the test specimens is preferred after the exposure but may be done before exposure. Control specimens not exposed are similarly prepared and are wet-out and allowed to dry without tension before testing.

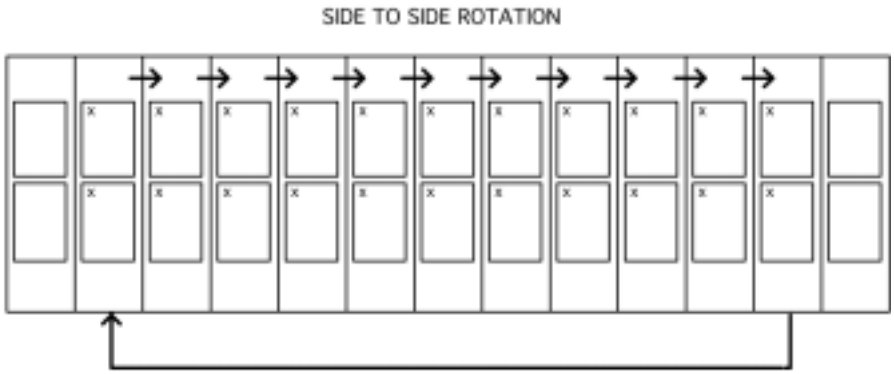


**Fig. 2—Specimen rotation.**

## 13. Evaluation of Results

13.1 Changes in exposed test specimens shall be evaluated or rated by applicable AATCC, ASTM or ISO test methods.

13.2 Physical Properties

13.2.1 Ball Bursting Strength of Fabrics. Determine the ball bursting strength of fabrics as directed in ASTM Test Method D 3787, Test Method for Bursting Strength of Knitted Goods: Constant Rate of Traverse (CRT) Ball Burst Test.

13.2.2 Grab Tensile Test. Determine the grab tensile strength as directed in ASTM D 5034, Test Method for Breaking Strength and elongation of Textile Fabrics (Grab Test).

13.3 Color Change.

13.3.1 Evaluate the color change as directed in AATCC Method 16, Colorfastness to Light.

## 14. Report

14.1 Report the following information on exposure conditions:

14.1.1 Manufacturer and model of fluorescent UV/condensation apparatus.

14.1.2 The manufacturer's designation for the fluorescent UV lamp.

14.1.3 Exposure cycle, for example, 4 h UV/60°C, 4 h CON/50°C.

14.1.4 Total exposure time.

14.1.5 Total UV light exposure time.

14.1.6 Any deviation from the exposure test method

14.2 Report the following information on the test specimen:

14.2.1 The type of fiber(s) of which the material is composed, which side of the fabric was exposed (in the event that the fibers differ on the face and back of the fabric), the fabric weight in g/m$^2$ and the nature of the fabric finish, if known.

14.3 Report the following information on the evaluation:

14.3.1 The evaluation method, rating and relative data for each property evaluated.

14.3.2 The standard used for comparative evaluation, if any.

14.3.3 Data. Average the data for the various replicates, or handle statistically as appropriate, and record a significant value of breaking or bursting strength retention and/or color change after exposure in relation to original strength or color as applicable. Report must contain as a minimum:

(a) Arithmetic mean or average,
(b) The number of tests,
(c) Standard deviation or coefficient of variation.

Statement of a mean without the number of tests and precision is essentially useless.

## 15. Precision and Bias

15.1 *Precision.*

15.1.1 *Laboratory Study.* In early 1999, a small study was done in a single laboratory to get an estimate of intra-laboratory precision. One fabric (greige, #400 style cotton print cloth) was exposed under conditions of this test method and values determined for $\Delta E^*_{ab}$, grab tensile after exposure, and ball burst after exposure.

15.1.2 *Intra-Laboratory Precision.* Components of variance and *within-laboratory* precision shown as critical differences are given for each of these properties, respectively, in Tables I, II and III.

15.1.3 For each of the properties noted, when differences are due only to chance causes, the differences between test results should not exceed the value shown in 95 of the 100 comparisons.

15.1.4 Analysis of variance or *t*-tests may be used to compare averages. See any standard statistical text for more information.

15.2 *Bias.*

15.2.1 There is no referee test method for determining definitive values to establish bias in this test method. The test method has no known bias.

**Table I—$\Delta E^*_{ab}$**

| Mean | Sample Variance | Standard Deviation |
|---|---|---|
| 9.7 | 0.2 | 0.4 |
| | 95% Level | |
| Values in Average | Standard Error | Critical Difference |
| 1 | 0.4 | 1.2 |
| 2 | 0.3 | 0.8 |
| 3 | 0.2 | 0.7 |
| 4 | 0.2 | 0.6 |
| 5 | 0.2 | 0.5 |
| 6 | 0.2 | 0.5 |
| 7 | 0.2 | 0.5 |
| 8 | 0.2 | 0.4 |
| 9 | 0.1 | 0.4 |
| 10 | 0.1 | 0.4 |

**Table II—Grab Tensile after Exposure**

| Exposed Grab | | |
|---|---|---|
| Mean | Sample Variance | Standard Deviation |
| 59 | 29 | 5.4 |
| | 95% Level | |
| Values in Average | Standard Error | Critical Difference |
| 1 | 5.4 | 15.1 |
| 2 | 3.8 | 10.4 |
| 3 | 3.1 | 8.7 |
| 4 | 2.7 | 7.5 |
| 5 | 2.4 | 6.7 |
| 10 | 1.7 | 4.8 |
| Control Grab | | |
| Mean | Sample Variance | Standard Deviation |
| 75.2 | 6.6 | 2.6 |

**Table III—Ball Burst after Exposure**

| Exposed Ball Burst | | |
|---|---|---|
| Mean | Sample Variance | Standard Deviation |
| 83 | 81 | 9 |
| | 95% Level | |
| Values in Average | Standard Error | Critical Difference |
| 1 | 9.0 | 25.2 |
| 2 | 6.4 | 17.8 |
| 3 | 5.2 | 14.6 |
| 4 | 4.5 | 12.6 |
| 5 | 4.0 | 11.3 |
| 10 | 2.8 | 8.0 |
| Control Ball Burst | | |
| Mean | Sample Variance | Standard Deviation |
| 87 | 55 | 7.4 |

## 16. Referenced Documents

16.1 The following AATCC documents are referenced:

16.1.1 Evaluation Procedure 6, Instrumental Color Measurement (see 17.3).

16.1.2 Test Method 16, Colorfastness to Light (see 17.3).

16.2 The following ASTM documents are referenced:

16.2.1 ASTM D 123, Standard Terminology Relating to Textiles (see 17.4)

16.2.2 ASTM D 3787, Test Method for Bursting Strength of Knitted Goods: Constant Rate of Traverse (CRT) Ball Burst Test (see 17.4).

16.2.3 ASTM D 5034, Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test) (see 17.4)

16.3 The following SAE document is referenced:

16.3.1 SAE J2020, Standard Test Method for Accelerated Exposure of Automotive Exterior Materials Using a Fluorescent UV and Condensation Apparatus (see 17.5).

## 17. Notes

17.1 Apparatus and lamps which conform to this test method are available from the following companies: Q-Panel Lab Products, 26200 First St., Cleveland OH 44145; tel: 440/835-8700; fax: 440/835-8738; SDL Atlas L.L.C., 1813A Associate Lane, Charlotte NC 28217; tel: 704/329-0911; fax: 704/329-0914; e-mail: info@sdlatlas.com; and Suga Test Instruments, 5-4-14 Shinjuku-Ku, Tokyo 160, Japan; tel: 81 (3) 3354 5248; fax: 81 (3) 3354-5275.

17.2 The exposure chamber shall be a Fluorescent UV/Condensation Apparatus constructed of corrosion-resistant materials enclosing eight fluorescent UV lamps, a heated water pan, water spray system (optional), test specimen racks and provisions for controlling and indicating operating times and temperatures

17.3 Available from AATCC, P.O. Box 12215, Research Triangle Park NC 27709; tel: 919/549-8141; fax: 919/549-8933; e-mail: orders@aatcc.org.

17.4 Available from ASTM 100 Barr Harbor Dr., West Conshohocken PA 19428; tel: 610/832-9500; fax: 610/832-9555.

17.5 Available from SAE International, 400 Commonwealth Dr., Warrendale PA 15098-0001; tel: 412/776-4841.

17.6 The limits of the spectral range of ultraviolet radiation are not well defined and may vary according to the user. Committee

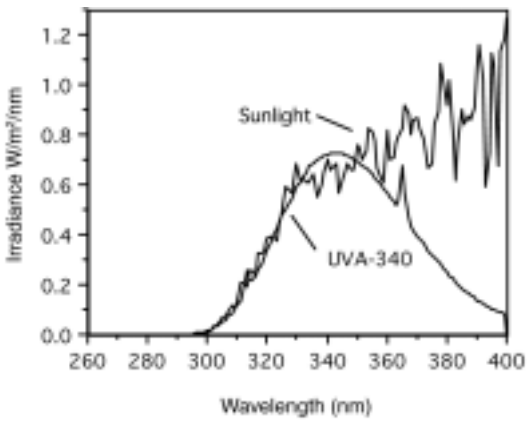


**Fig. 3—Representative spectral power distribution, UVA-340 fluorescent lamps**

E-2.1.2 of CIE distinguishes in the spectral range between 400 and 100 nm:

| | |
|---|---|
| UV-A | 315-400 nm |
| UV-B | 280-315 nm |
| UV-C | 100-280 nm |

Unless otherwise specified, the lamps shall be UV-A Type Fluorescent UV lamps with a peak emission at 343 nm and a spectral energy distribution (SED) as shown in Fig. 3.

17.7 Condensation Mechanism. Water vapor shall be generated by heating a water pan extending under the entire specimen mounting area and containing a minimum water depth of 25 mm. Specimen racks and the test specimens themselves shall constitute the sidewalls of the chamber. The backside of the specimens shall be exposed to cooling effects of ambient room air. The resulting heat transfer causes water to condense on the test surface.

17.7.1 The specimens are arranged so that condensate runs off the test surface by gravity and is replaced by fresh condensate in a continuous process. Vents along the bottom of the test chamber shall be provided to permit an exchange of ambient air and water vapor to prevent oxygen depletion of the condensate.

17.7.2 Water supply with an automatic control to regulate the level in the water pan shall be provided. Distilled, deionized or potable tap water are equally acceptable for purposes of the test, because the condensation process itself distills water onto the test surface.

17.8 Specimen temperature shall be measured by a Black Panel Thermometer with a remote sensor attached to a black aluminum panel. The thermometer shall be precise to ± 1°C through a range from 30-80°C and shall be positioned in the center of the exposure area so that the sensor is subject to the same conditions as the specimens.

17.9 During UV exposure, the selected equilibrium temperature shall be maintained within ± 3°C by supplying heated air to the test chamber. During condensation exposure, the selected equilibrium temperature shall be maintained within ± 3°C by heating the water in the water pan.

17.10 The test specimens shall be mounted in stationary racks with the plane of the test surface facing the lamps and exposed within an area 210 mm in height by 900 mm wide on each side of the apparatus located as shown in Fig. 4. It is possible to mount specimens above, below, and beside the 210 × 900 mm area, but specimens so mounted will be exposed to lower UV intensities.

17.11 Apparatus shall be located in an area maintained at a temperature between 20°C and 30°C. The room temperature shall be measured by thermometers mounted on interior walls or columns approximately 1500 mm above the floor level and at least 300 mm from any heated apparatus. Three or more thermometers located at various points will show any temperature variation in the area.

17.11.1 It is recommended that the apparatus be located at least 300 mm from walls or other apparatus. Nearby heat sources, such as ovens or heated test apparatus, should be avoided or shielded, because such heat sources can reduce the cooling required for condensation.

17.11.2 The room where the apparatus is located shall be ventilated to remove the heat and moisture produced and to maintain the temperatures specified above. Two to four air changes per hour will normally provide sufficient ventilation.

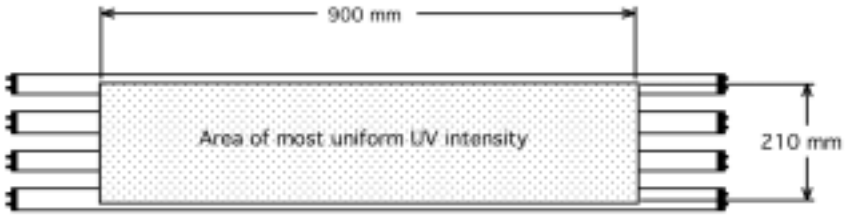


**Fig. 4—Area of most uniform light intensity.**