Designation: ~~F520 – 16~~ F520 – 21

Standard Test Method for Environmental Resistance of Aerospace Transparencies to Artificially Induced Exposures[1]

This standard is issued under the fixed designation F520; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers determination of the effects of exposure to thermal shock, condensing humidity, and simulated weather on aerospace transparent enclosures.

1.2 This test method is not recommended for quality control, nor is it intended to provide a correlation to actual service life.

1.3 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3.1 *Exceptions*—Certain inch-pound units are furnished in parentheses (not mandatory) and certain temperatures in Fahrenheit associated with other standards are also furnished.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics

F319 Practice for Polarized Light Detection of Flaws in Aerospace Transparency Heating Elements

F521 Test Methods for Bond Integrity of Transparent Laminates

G53 Practice for Operating Light-and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials (Withdrawn 2000)[3]

G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

[1] This test method is under the jurisdiction of ASTM Committee F07 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.08 on Transparent Enclosures and Materials.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

3. Summary of Test Method

3.1 Two types of test specimens, duplicating the aerospace transparent enclosure design, are subjected to thermal shock, condensing humidity, and artificial weathering. Edge sealing shall be used if representative of the design.

3.1.1 Type A specimens shall be used to determine the effect of environmental exposure on electrical and optical properties.

3.1.2 Type B specimens shall be used to determine the effect of environmental exposure on bond integrity.

4. Significance and Use

4.1 This test method, when applied to aerospace transparencies of either monolithic glass/plastic or laminated combinations, is a measure of the ability of the transparency to withstand the effects of artificially induced environments. The test applies to ~~on~~ configurations employing electrically conductive coatings, and also to uncoated materials.

4.2 The resistance of the transparent enclosure to environmental effects may vary appreciably depending on the size, geometry, material of construction, coating integrity, coating density, and other factors.

5. Test Specimens

5.1 Each Type A specimen to be evaluated for external coating durability shall be a 250 by ~~250-mm~~250 mm (9.8 by ~~9.8-in.)~~9.8 in.) cross section of the design and shall contain, as applicable, surface coatings of operational, electrically conducting coating systems complete with bus bars, braids, and temperature sensors.

5.1.1 Type A test specimens shall have a fully operational coating system, when applicable, with an average resistivity consistent with the average resistivity of the representative design. Reproduction of multiphase electrical circuits is not required for these test specimens since this type of circuitry is only a design technique used to accommodate limited voltage resources at installation.

5.1.2 Type A specimen testing exposure of an external coating only, are independent of size but shall be of sufficient size to produce representative coatings. When testing external coatings, the recommended specimen size is 250 by ~~250-mm~~250 mm (9.8 by ~~9.8-in.).~~9.8 in.). Type A specimens which are monolithic, or laminated samples where only an external coating system is being tested, shall be tested to the same exposure intervals as 50 by ~~50-mm~~50 mm (2 by ~~2-in.),~~2 in.), Type B specimens (5.2).

5.1.3 Type A specimen testing for effects of exposure to components within a laminated construction, such as electrical components, heating films, and interlayers, taking place due to moisture ingress are dependent on size and shall receive increasing exposure levels as the length of the sides of the specimen increase. 250 by ~~250-mm~~250 mm specimens shall be exposed to humidity 27 times the duration of 50 by ~~50-mm~~50 mm specimens. Use of 150 by ~~150-mm~~150 mm specimen shall be allowed with exposure of 9 times that of corresponding 50 by ~~50-mm~~50 mm specimens, or ~~1/3~~⅓ the duration of 250 by ~~250-mm~~250 mm specimens.

5.1.4 Type A that are both laminated and contain external coatings where both external and internal effects are to be tested after exposure, must be tested independently as externally coated samples, and as laminated samples, since the exposure durations will be different. To test effects on both layers of a particular design, the number of samples must be doubled, the external coating tested on one set, and internal components tested on a second set of specimens.

5.2 Each Type B test specimen shall be 50 by 50 mm (2 by 2 in.) and shall be of a cross section consistent with the edge configuration of the representative design. Type B test specimens are not intended to be operational electrically, but they shall be representative of the average resistivity of the design.

6. Preparation of Test Specimens

6.1 Prepare a minimum of three Type A specimens for each design configuration. If the design contains an electrically activated coating, only one temperature sensor per specimen is required.

6.2 Prepare a minimum of five Type B specimens for each design configuration. Prepare the specimen in such a manner as to produce smooth edges and corners to prevent chipping during testing. Polish at least one edge of each specimen to allow inspection of the internal bonded surfaces during tensile loading. Do not apply edge sealant to the specimens.

6.3 Condition all test specimens by exposing them to not less than ~~40 h~~ 40 h at 23 ± ~~2°C~~2 °C (73.4 ± ~~3.6°F)~~3.6 °F) and 50 ± 5 % relative humidity.

7. Procedure

7.1 *Visual Examination*—Carefully examine Type A and Type B specimens for any signs of material or manufacturing defects. A microscope or magnifying lens, dark background, and cross lighting shall be used, as appropriate, to assist in the identification and classification of visible defects.

7.2 *Optical Tests*—Measure each Type A specimen for luminous transmittance and haze in accordance with Procedure B of Test Method D1003. Make at least two measurements, one in the center and one near the edge, on each specimen. Six measurements are preferred. If greater than 1 % variation exists, prepare a template from polyester film or other suitable material to record these locations for indexing and correlation to readings to be taken after environmental exposure.

NOTE 1—Paragraphs 7.3 – 7.6 are applicable to systems using electrically conductive coatings.

7.3 *Electrical Tests:*

7.3.1 *Bus Bar-to-Bus Bar Resistance*—Measure each Type A specimen for bus bar-to-bus bar resistance. Take precautions to minimize the effects of variable contact resistance. Record results and repeat the measurement after environmental exposure prior to application of over-voltage power.

7.3.2 *Sensing Element*—Measure the resistance of the sensing elements at a specified temperature to assure conformance to the temperature resistance ranges certified by the element manufacturer.

7.3.3 *Electrical Insulation*—Test the electrical insulation by measuring leakage current on each test specimen. Apply an alternating current potential between 1500 and 2500 V rms, depending upon the design application and specified requirements, at 50 or 60 Hz for a period of 1 min between the following:

(1) each sensor lead and each heater lead;
(2) each sensor lead and metal insert or spacer;
(3) each heater lead and the metal insert or spacer;
(4) each heater lead and metal strip placed in contact with the edge of the glass panel; test the entire edge of the glass panel;
(5) each anti-ice and defog heater lead.

Leakage current in excess of 1 mA at 1500 V rms or 4 mA at 2500 V rms is objectionable. Monitor the current during a preliminary low voltage application and terminate the test if the current leakage exceeds the allowable amount prior to full voltage application. Determine the resistance and decide whether to proceed to full voltage in conformance with the test procedure.

7.3.4 Monitor the current during gradual application of a dc voltage. Current in excess of 5 µA is objectionable. If the current exceeds 5 µA dc before 500 V dc is reached, suspend the test and determine the resistance before deciding whether to continue. Gradually apply and remove the potential at no greater rate than 500 V rms/s.

7.3.5 *Electrically Conductive Coating Test*—Test each Type A specimen for electrically conductive coating uniformity in accordance with Test Method F319.

7.3.5.1 For electrically conductive coatings on plastic materials, apply a minimum of ~~110 %~~ 110 % of the nominal design voltage.

7.3.5.2 For electrically conductive coatings on glass, apply a minimum of ~~125 %~~ 125 % of the nominal design voltage.

7.3.5.3 Alternative voltage levels and power-on times may be as specified by contractual documents.

7.3.6 *Overvoltage Test*—Subject each of the electrical heating circuits of Type A specimens to the application of an overvoltage of 150 % maximum operating voltage for the circuit. Apply this voltage to the power leads for a minimum of 5 s. After no less than a ~~2-min~~2 min wait, apply the same voltage for a minimum of 5 s, observing the sample in a darkened room with specific emphasis being on the bus bars for signs of arcing.

7.3.7 *Bond Integrity Test*—Test individual Type B specimens in accordance with Test Methods F521.

7.4 Specimens that fail due to some obvious, non-representative defect shall be disqualified and retests conducted.

7.5 *Environmental Exposure:*

7.5.1 *Artificial Weathering*—Expose test specimens to artificial weathering in accordance with G154 for testing components internal to laminates. Test in accordance with G53 for testing external coatings or surfaces exposed to the environment.

7.5.1.1 *Practice G154 for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials*—UVA-340 is recommended when testing internal components of both glass and plastic laminates. The recommended G154 cycle is Cycle 4, UVA-340, UVA-340 bulbs operating at 1.35 W/m^2/nm typical irradiance, and a cycle of 8 h UV at a constant temperature of ~~158°F (70°C)~~ 158 °F (70 °C) followed by 4 h condensation at a constant temperature of ~~120°F (50°C).~~120 °F (50 °C). Exposure shall be a mutually agreed total number of hours and number of testing intervals. A suggested total exposure time is 1850 h (77 days) with a minimum of 7 test intervals of 264 h (15 days). Apply the cycle continuously for 264 h (15 days) to constitute each interval.

7.5.1.2 *Practice G53 for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials*—Use UVB-313 bulbs and a cycle of 7 h UV followed by 5 h condensation, all at a constant temperature of ~~120°F~~120 °F when testing external coatings, surfaces or surface treatments. A suggested total exposure time is 1176 h (49 days) with a minimum of 7 test intervals of 168 h (7 days). Apply the cycle continuously for 168 h (1 week) to constitute each interval.

NOTE 2—Practice G53 has been shown to produce acceptable accelerated weathering results. Practice G53 is used most extensively in the Transparency Community due to its simplicity, ease of use and low operational costs. The UVB-313 cycle of 7 h UV followed by 5 h condensation, all at ~~120°F~~120 °F have been standard practice for coatings exposures, representing a substantial database of test results.

NOTE 3—Accelerated weathering results shall only be compared for samples exposed using the same practice. Comparison of test results obtained using different practices may result in erroneous conclusions, particularly when comparing the relative performance of different materials.

7.5.2 *Humidity*—Expose Type B test specimens to a minimum exposure of 10 cycles of condensing humidity in a chamber with a controlled temperature of 49 ± ~~3°C~~3 °C (120 ± ~~5°F)~~5 °F) and relative humidity of 95 to 100 %.

7.5.2.1 Type B specimens and Type A specimens testing an external coating or exposed surface shall be tested in intervals of 10 cycles, a minimum of 1 interval is required, and testing shall be continued until the desired level of degradation is verified. Water used to maintain the humidity shall not contain more than 200 ppm total solids. Each cycle shall be a ~~24-h~~24 h exposure in the condensing humidity chamber and an ~~8-h~~8 h exposure to ambient temperature and humidity. As an alternative, continuous exposure to humidity may be used in cycles of 24 h.

7.5.2.2 Type A specimens exposed to test internal components using 150 by ~~150-mm~~150 mm laminated Type A specimens, intervals of 90 cycles are recommended with a minimum of 1 interval exposure.

7.5.2.3 Type A specimens exposed to test internal components using 250 by ~~250-mm~~250 mm laminated Type A specimens, intervals of 270 cycles are recommended with a minimum of 1 interval exposure.

7.5.3 *Thermal Shock*—Place the test specimen in an oven at a temperature of ~~71°C (160°F)~~71 °C (160 °F) and leave until stabilized at ~~71°C (160°F)~~71 °C (160 °F) as determined by a thermocouple attached to the specimen face. After the temperature has stabilized, transfer the specimen as rapidly as possible (within 3 min) to a chamber maintained ~~at – 54°C (–65°F).~~at – 54 °C (–65 °F). Let the specimen stabilize ~~at – 54°C (–65°F)~~at – 54 °C (–65 °F) and as rapidly as possible return it to the oven at ~~71°C (160°F). After each – 54°C (–65°F)~~71 °C (160 °F). After each – 54 °C (–65 °F) cold soak, and while the specimen is stabilized ~~at – 54°C (–65°F),~~at – 54 °C (–65 °F), energize the conductive coating on Type A specimens using the design watt density until the temperature at the sensor stabilizes. Then switch off the power and place the specimen in the ~~71°C (160°F)~~71 °C (160 °F) oven. Repeat this for two cycles unless specified otherwise.

7.6 Upon completion of environmental exposure in accordance with either 7.5.1, 7.5.2, 7.5.3, or any combination thereof, allow all specimens to return to ambient conditions and examine them for signs of delamination, cracking, spalling, or other deterioration.

7.7 Repeat tests 7.1 – 7.4.