ASTM G155 Xenon Arc Weathering
What's Changed and What You Need to Know

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Topics

- ASTM G155 background
- Title and scope changes
- Daylight optical filter clarification
- Test cycle updates
- Other revisions

ASTM G155

- ASTM G155 is ASTM's ***Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials***

- **Performance-based** standard that establishes principles and procedures for operating a xenon-arc accelerated laboratory weathering apparatus
  - Information about xenon arc lamp apparatus
  - Spectral irradiance
  - Temperature and water delivery

- Closely related to ASTM G151 (general laboratory weathering exposures) and ASTM G154 (UV fluorescent lab exposures)

ASTM G155

- ASTM G155 is **widely-used and referenced**, along with related standards like ISO 4892-2
- The standard had not been revised since 2013
- ASTM G03 (Weathering Committee) undertook a major revision, resulting in the recent publication of ASTM G155-21
  - **Project leader:** Brad Reis from Q-Lab
  - Instrument manufacturers (Q-Lab, Atlas, Suga)
  - Users (3M, independent scientists)
- *Today we'll review the important changes made to ASTM G155*

Title and Scope

Designation: G155 – 13

2013 version

Standard Practice for
Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials[1]

Designation: G155 – 21

2021 version

New title indicates broader use beyond non-metallic materials

Standard Practice for
Operating Xenon Arc Lamp Apparatus for Exposure of Materials[1]

Title and Scope

2021 version

1. Scope

1.1 This practice is limited to the basic principles and procedures for operating a xenon arc lamp and water apparatus; on its own, it does not deliver a specific result.

1.2 It is intended to be used in conjunction with a practice or method that defines specific exposure conditions for an application along with a means to evaluate changes in material properties. This practice is intended to reproduce the weathering effects that occur when materials are exposed to sunlight (either direct or through window glass) and moisture as humidity, rain, or dew in actual use. This practice is limited to the procedures for obtaining, measuring, and controlling conditions of exposure.

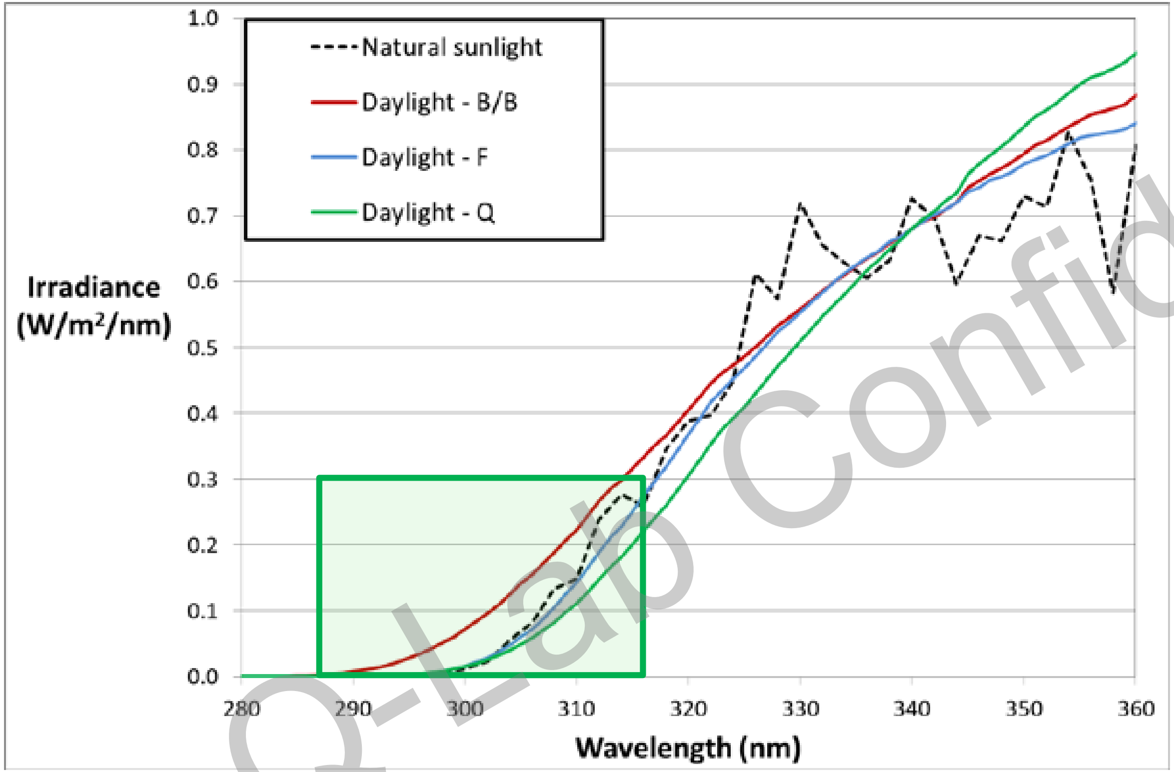
Clarifies that this is simply for the operation of a xenon test, not duration or interpretation of results

Optical Filter Definitions

- ASTM G155 defines three types of Optical Filters:
  - Daylight
  - Window
  - Extended UV

- The 2021 revision clarifies the Spectral Irradiance for Daylight filters, complementing work being done in **ISO 4892-2** (xenon testing of plastics) and **ISO 16474-2** (xenon testing of paint)

Daylight Filters



- Each of these filters meets the ASTM G155 definition of **Daylight**
- Solar cut-on is significantly different for borosilicate (B/B) filters
- Different Daylight filters can give different test results!
- No guidance given in 2013 version of ASTM G155

Daylight Optical Filter Definitions

Spectral Bandpass Wavelength λ in nm	Minimum Percent[C]	Benchmark Solar Radiation Percent[D,E,F]	Maximum Percent[C]
$\lambda < 290$			0.15
$290 \le \lambda \le 320$	2.6	5.8	7.9
$320 < \lambda \le 360$	28.3	40.0	40.0
$360 < \lambda \le 400$	54.2	54.2	67.5

2013 version

Daylight filters described loosely

2021 version – preserves “General” and adds **Type I** and **Type II** classifications

Type I and Type II are mutually exclusive, and both fall within General

Spectral Bandpass Wavelength λ in nm	General[B]		Type I[C]		Type II[D]		Benchmark Solar Radiation Percent[F,G,H]
	Min. %[E]	Max %[E]	Min. %[E]	Max %[E]	Min. %[E]	Max %[E]	
$\lambda < 300$[I]	2.6	8.1	0	0.2	0.2	1.1	5.8
$300 \le \lambda \le 320$			2.6	6	3.5	7.0	
$320 < \lambda \le 340$	28.3	40.0	10.0	17.0	10.0	17.0	40.0
$340 < \lambda \le 360$			18.3	23.2	18.3	23.2	
$360 < \lambda \le 380$	54.2	67.5	25.0	30.5	25.0	30.5	54.2
$380 < \lambda \le 400$			29.2	37.0	29.2	37.0	

Daylight Optical Filter Guidelines

Spectral Bandpass Wavelength λ in nm	General[B]		Type I[C]		Type II[D]		Benchmark Solar Radiation Percent[F,G,H]
	Min. %[E]	Max %[E]	Min. %[E]	Max %[E]	Min. %[E]	Max %[E]	
$\lambda < 300$[I]	2.6	8.1	0	0.2	0.2	1.1	5.8
$300 \le \lambda \le 320$			2.6	6	3.5	7.0	
$320 < \lambda \le 340$	28.3	40.0	10.0	17.0	10.0	17.0	40.0
$340 < \lambda \le 360$			18.3	23.2	18.3	23.2	
$360 < \lambda \le 380$	54.2	67.5	25.0	30.5	25.0	30.5	54.2
$380 < \lambda \le 400$			29.2	37.0	29.2	37.0	

- **Type I**
  - Close match to natural sunlight – **generally recommended**
  - Includes Daylight-Q and Daylight-F (**ASTM D7869** type)
- **Type II**
  - Match to historical borosilicate filters – **recommended only to match historical data**
  - More shortwave UV than natural sunlight

Test Cycles in ASTM G155

- 12 test cycles are included in ASTM G155
- The cycle parameters are ***not mandatory!***
  - They appear in an **Appendix**, which is always non-mandatory (informational) in an ASTM document (an **Annex** is mandatory).
- The language clearly states: *Any exposure conditions may be used, as long as the exact conditions are detailed in the report. Following are some representative exposure conditions. These are not necessarily preferred and no recommendation is implied. These conditions are provided for reference only*
  - *In reality, though … everyone treats them as being mandatory*

Test Cycles: 2013 Revision

TABLE X3.1 Common Exposure Conditions

Cycle	Filter	Irradiance	Wavelength	Exposure Cycle
1	Daylight	0.35 W/(m²· nm)	340 nm	102 min light at 63°C black panel temperature 18 min light and water spray (air temp. not controlled)
2	Daylight	0.35 W/(m²· nm)	340 nm	102 min light at 63°C black panel temperature 18 min light and water spray (air temp. not controlled) repeated nine times for a total of 18h; followed by 6 h dark at 95 (±4.0) % RH, at 24°C black panel temperature
3	Daylight	0.35 W/(m²· nm)	340 nm	1.5 h light, 70 % RH, at 77°C black panel temperature 0.5 h light and water spray (air temp. not controlled)
4	Window Glass	0.30 W/(m²· nm)	340 nm	100 % light, 55 % RH, at 55°C black panel temperature
5	Window Glass	1.10 W/(m²· nm)	420 nm	102 min light, 35 % RH, at 63°C black panel temperature 18 min light and water spray (air temp. not controlled)
6	Window Glass	1.10 W/(m²· nm)	420 nm	3.8 h light, 35 % RH, at 63 °C black panel temperature 1 h dark, 90 % RH, at 43 ° C black panel temperature
7	Extended UV	0.55 W/(m²·nm)	340 nm	40 min light, 50 % RH, at 70 (±2) °C black panel temperature and 47 (±2) °C chamber air temperature 20 min light and water spray on specimen face 60 min light, 50 % RH, at 70 (±2) °C black panel temperature; and 47 (±2) °C chamber air temperature 60 min dark and water spray on specimen front and back, 95 % RH, 38 (±2) °C black panel temperature and 38 (±2) °C chamber air temperature
7A	Daylight	0.55 W/(m²·nm)	340 nm	40 min light, 50 (±5.0) % RH, at 70 (±2) °C black panel temperature and 47 (±2) °C chamber air temperature 20 min light and water spray on specimen face; 60 min light, 50 % RH, at 70 (±2) °C black panel temperature; and 47 (±2) °C chamber air temperature 60 min dark and water spray on specimen front and back, 95 % RH, 38 (±2) °C black panel temperature and 38 (±2) °C chamber air temperature
8	Extended UV	0.55 W/m²·nm	340 nm	3.8 h light, 50 % RH, at 89 (±3) °C black panel temperature and 62 (±2) °C chamber air temperature 1.0 h dark, 95 % RH, at 38 (±2) °C black panel temperature and 38 (±2) °C chamber air temperature
9	Daylight	180 W/m²	300–400 nm	102 min light at 63°C black panel temperature 18 min light and water spray (temperature not controlled)
10	Window Glass	162 W/m²	300–400 nm	100 % light, 50 % RH, at 89°C black panel temperature
11	Window Glass	1.5 W/(m²· nm)	420 nm	Continuous light at 63°C black panel temperature, 30 % RH
12	Daylight	0.35 W/(m²· nm)	340 nm	18 h consisting of continuous light at 63°C black panel temperature 30 % RH 6 h dark at 90 % RH, at 35°C chamber air temperature

- Black Panel Temp, Relative Humidity, and Step Type are not always clear
- Chamber air temperatures not included

Test Cycles: 2021 Revision

TABLE X3.1 Some Historical Exposure Conditions

Cycle	Filter	Irradiance and Wavelength	Exposure Cycle	Black Panel Temperature (BPT) (°C)	Relative Humidity (RH) (%)	Chamber Air Temperature (CAT) (°C)
1	Daylight	0.35 $W/(m^2 \cdot nm)$ @ 340 nm	102 min light	63	50[A]	44[A]
			18 min light and water spray[B]	Uncontrolled		44[A]
2	Daylight	0.35 $W/(m^2 \cdot nm)$ @ 340 nm	102 min light[C]	63	50[A]	44[A]
			18 min light and water spray[B,C]	Uncontrolled		44[A]
			6 h dark[D]	24[E]	95	24[A]
3	Daylight	0.35 $W/(m^2 \cdot nm)$ @ 340 nm	90 min light	77	70	63[A]
			30 min light and water spray[B]	Uncontrolled		63[A]
4	Window Glass	0.30 $W/(m^2 \cdot nm)$ @ 340 nm	Continuous light	55	55	45[A]
5	Window Glass	1.10 $W/(m^2 \cdot nm)$ @ 420 nm	102 min light	63	35	47[A]
			18 min light and water spray[B]	Uncontrolled		47[A]
6	Window Glass	1.10 $W/(m^2 \cdot nm)$ @ 420 nm	228 min light	63	35	47[A]
			60 min dark[D]	43	90	43[A]
7	Extended UV	0.55 $W/(m^2 \cdot nm)$ @ 340 nm	40 min light	70	50	47
			20 min light and water spray (front)[B]	Uncontrolled		47
			60 min light	70	50	47
			60 min dark and water spray (front and back)[D]	38	95	38
7A	Daylight (Type II)	0.55 $W/(m^2 \cdot nm)$ @ 340 nm	40 min light	70	50	47
			20 min light and water spray (front)[B]	Uncontrolled		47
			60 min light	70	50	47
			60 min dark and water spray (front and back)[D]	38	95	38
8	Extended UV	0.55 $W/(m^2 \cdot nm)$ @ 340 nm	228 min light	89	50	62
			60 min dark[D]	38	95	38
9	Daylight	180 W/m^2 @ 300 - 400 nm	102 min light	63	50	28[A]
			18 min light and water spray[B]	Uncontrolled		28[A]
10	Window Glass	162 W/m^2 @ 300 - 400 nm	Continuous Light	89	50	Uncontrolled
11	Window Glass	1.5 $W/(m^2 \cdot nm)$ @ 420 nm	Continuous Light	63	50	43[A]
12	Daylight	0.35 $W/(m^2 \cdot nm)$ @ 340 nm	18 hrs light	63	30	47[A]
			6 hrs dark[D]	35	90	35[A]
13	Daylight (Type I)	0.40 and 0.80 $W/(m^2 \cdot nm)$ @ 340 nm	See Note X3.4			

- Black Panel Temp, Relative Humidity, and Step Type now inline for readability
- Chamber air temperatures included (often optional)
- ASTM D7869-type cycle included as Cycle 13

Sources of Spectral Irradiance Variation

6.1.1 The following factors can affect the spectral power distribution of optically filtered xenon arc light sources used in these apparatus:

6.1.1.1 Differences in the composition and thickness of filters will have large effects on the UV radiation transmitted. Exposures conducted using different types or different combinations of optical filters can produce different results.

Filter type

6.1.1.2 Aging of optical filters from exposure can result in changes in spectral transmission, resulting in a significant reduction in the UV radiation emitted by the xenon arc lamp/optical filter system.

Filter aging

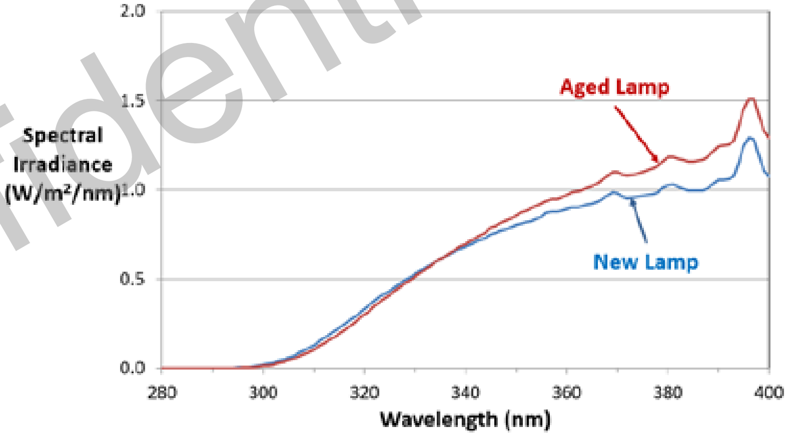
6.1.1.3 Accumulation of deposits, dirt, or other residue on the optical filters or xenon arc lamp can affect the UV radiation emitted by the xenon arc lamp/optical filter system.

Contamination

6.1.1.4 Aging of the xenon arc lamp from use can result in changes in spectral output of the lamp.

NOTE 5—More information on the effects of composition, aging, and deposits on a xenon arc lamp/optical filter system can be found in Refs (2-7).

Lamp aging



6.1.2 As a result of the potential for significant changes in spectral irradiance due to effects described in 6.1.1.2, 6.1.1.3, and 6.1.1.4, users should follow the apparatus manufacturer's instructions for maintenance and replacement of xenon arc lamps and optical filters.

Contact Q-Lab for maintenance info!

Step Transitions

6.5.3 Aspects of the apparatus' design, along with its heating, cooling, and control systems and ambient laboratory conditions, can have a significant impact on the amount of time it takes for the apparatus' thermometer to reach steady-state temperature during an exposure step. As a result, this affects how long specimens remain at the desired temperature, since exposure steps are typically fixed in total duration. The rate and magnitude of specimen degradation during exposure can be significantly impacted by these factors. Users are cautioned when comparing results from apparatus with different thermometer time-to-steady-state temperature characteristics.

8.2 Transition times between different thermometer temperature, chamber air temperature, and relative humidity conditions in an exposure cycle can affect test results. Variations in these transition times can adversely affect repeatability and reproducibility. The significance of this effect is dependent upon the exposure cycle used, the specimens under test, and how the specimens are mounted in the apparatus. Transition times are not specified in this standard. Apparatus where the specimen conditions reach and maintain steady state faster may produce different degradation results. Users are cautioned when comparing results from apparatus with different specimen-time-temperature characteristics.

- Transition times are not defined in weathering test standards
- This revision acknowledges this and cautions that transitions may affect test result reproducibility

Specimen Repositioning

9.5 *Specimen Repositioning*—Periodic repositioning of the test specimens during exposure is good laboratory practice, and may be employed to minimize the effect of variability in irradiance, temperature, and moisture exposure in the test chamber. Irradiance uniformity shall be determined in accordance with Practice G151 Annex A1 (Procedures for Measuring Irradiance Uniformity in Specimen Exposure Area). Recommendations for repositioning procedures, if used, are provided in Practice G151 Appendix X2 (Suggested Procedures for Reducing Variability By Periodic Random Positioning or Systematic Repositioning of Specimens).

- Specimen repositioning still not **required**, but **recommended** as good practice
- Options for repositioning provided

Other Changes

- ISO and ASTM references updated
- References added to good laboratory practice documents
- Clarification of moisture addition techniques (condensation, humidity, water spray)
- Irradiance and temperature onboard sensor requirements and calibration recommendations updated
- Provision for specimen washing added
- Clarification of front+back spray in SAE J2527 test
- Caution added regarding “reciprocity” at high irradiance

Summary

- ASTM G155 was revised in 2021, for the first time since 2013. This was a significant improvement driven by a multidisciplinary committee led by Q-Lab's Brad Reis.
- **Daylight** optical filters definition clarified so users understand the true spectral irradiance
- *Example* test cycle table updated and reformatted for easier reading; ASTM D7869 cycle incorporated
- Language improved throughout for ease of use and understanding of key factors (spectral irradiance, transitions) that can affect test results

Questions?

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