

Utilization of Ultra-Intense UV Weathering Chambers for Rapid Acceleration of PV Component Testing)

Tatsuo Nakamura, Douglas Vermillion)

Abstract

Crystalline PV component manufacturers continuously strive to improve product durability and reliability through recommended tests, and proprietary in house testing. A 25 – 30 year life cycle is expected.

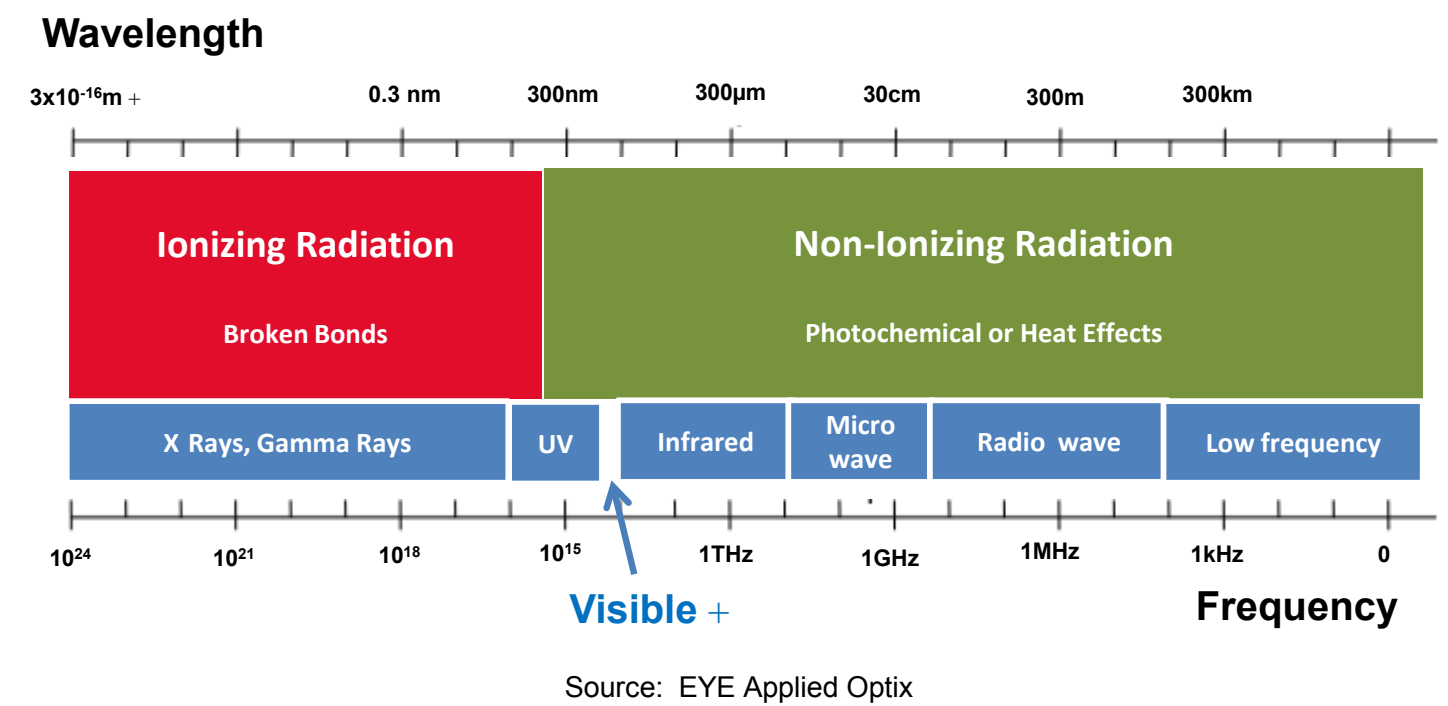
Outdoor exposure testing is necessary for validating long-term product performance, but the use of accelerated testing is necessary for expediting the evaluation process. Fluorescent and Xenon lamp based UV weathering chambers are commonly used for accelerated testing, and are supported by some correlation data to outdoor exposure testing.

PV component manufacturers have recently been utilizing metal halide lamp based UV weathering chambers for proprietary in-house testing to further accelerate the simulation of outdoor exposure. Metal halide tools are relatively new, and the amount of correlation data is somewhat limited, but users have found that the benefit of rapidly accelerated testing is of strategic importance with regard to product development and testing.

Different material compositions will react with different acceleration rates when evaluated in any UV weathering chamber option with fluorescent and Xenon lamp options providing acceleration factors of 1 – 10 times natural sunlight. Metal halide lamp based weathering + chambers provide acceleration factors of up to 30-times natural sunlight. +

UV Light and Ionizing Radiation

- Earth surface UV radiation beginning in the UV-B band is categorized as “Ionizing Radiation” and has enough energy to break chemical bonds.
- The most significant effect on materials from light energy is caused by UV radiation breaking chemical bonds.
- Visible and IR radiation are categorized as “Non-ionizing Radiation” and which have somewhat minimal photochemical and heating effects on materials.



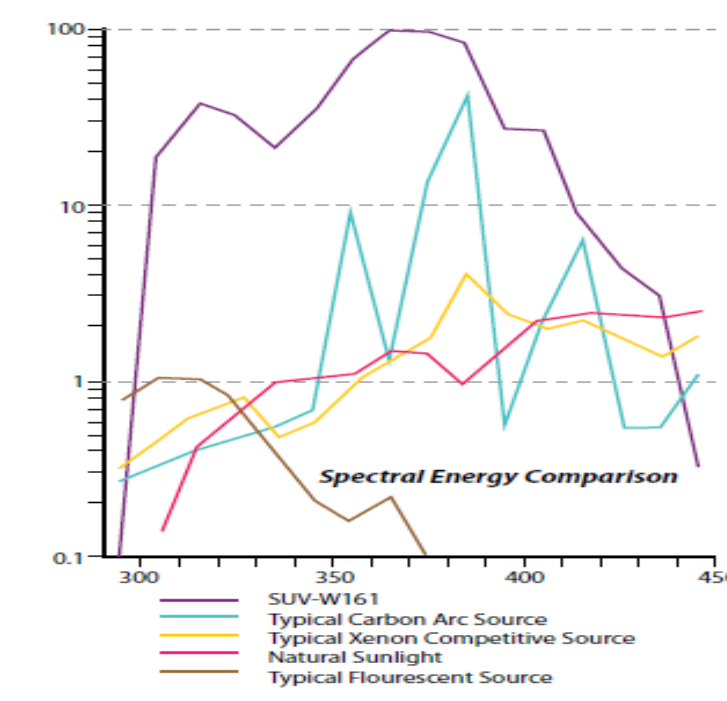
Accelerated Weather Testing Methodology

<p>Procedure +</p> <ul style="list-style-type: none"> • Chamber with Combination Cycling Of: <ol style="list-style-type: none"> 1. Temperature 2. Humidity & Soaking 3. UV Light • Correlation to Outdoor Testing to Validate Acceleration Factors 	<p>UV Light Generating Options</p> <ul style="list-style-type: none"> • Mercury Fluorescent <ul style="list-style-type: none"> - 1 – 3 “Sun” acceleration - partial spectrum matching • Xenon <ul style="list-style-type: none"> - 1 – 10 “Sun” acceleration - full spectrum matching • Metal Halide <ul style="list-style-type: none"> - 20 – 30 “Sun” acceleration - partial spectrum matching
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Metal Halide UV Light Source Acceleration

- Metal halide offers significant acceleration factors compared to traditional mercury fluorescent and xenon light sources due to the intensity of the UV radiation produced (see plot below).
- The use of intense UV radiation expedites the testing process with acceleration factors up to 10 times those of xenon tools.
- Metal halide tools produce repeatable results.

Logarithmic Plot of UV Energy Intensity) Produced by Various Chamber Light Sources)

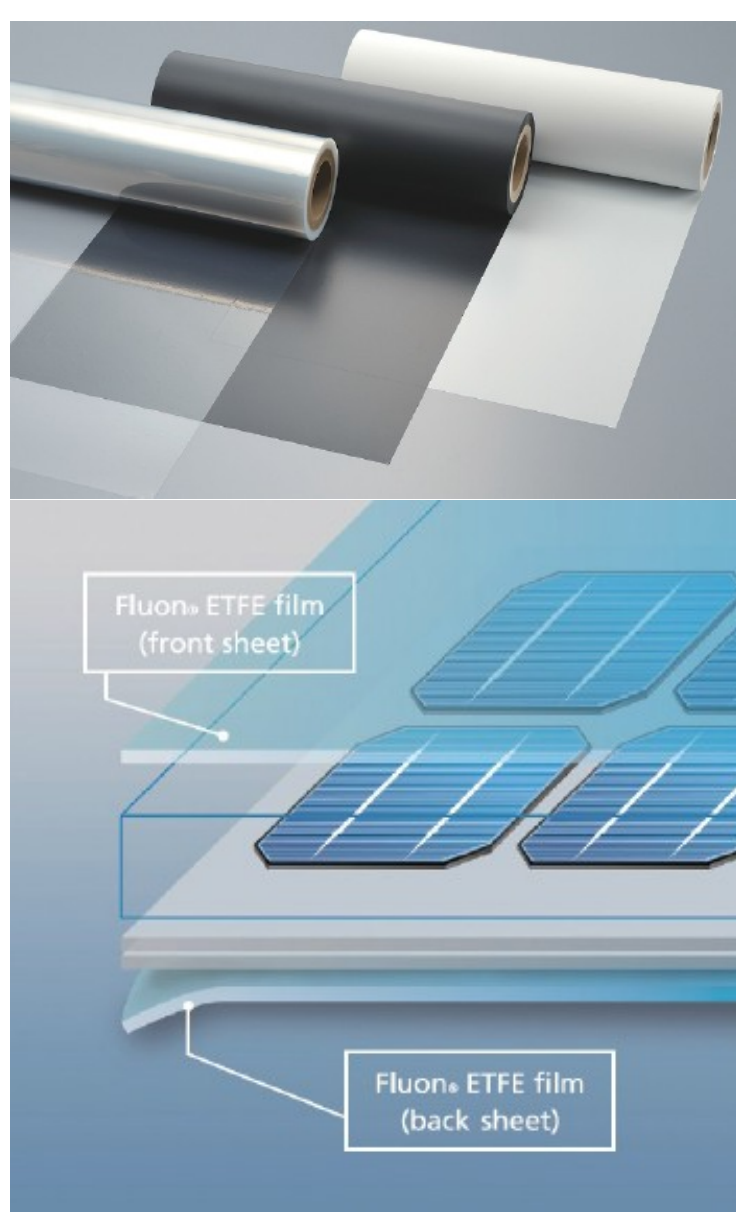


Benefit of Expedited Testing- Time to Color Shift of Material Sample

Light Source	Hours	Days
Natural Sun	10,000	420
Xenon	1000	42
Metal Halide	100	4.2

Source: Iwasaki Electric

AGC Solar Fluon ETFE Film Metal Halide Used for PV Front/Back Sheet R&D)



AGC Solar Accelerated Test Procedure

- 1000W/m² (300 – 400nm)
- Black Panel Temperature = 63° C
- Cycle:
 - ✓ 10 Hours Light Irradiation (50% R.H.)
 - ✓ 10 Seconds Shower
 - ✓ 2 Hours Blackness/Condensation (30° C, 100% R.H.)
 - ✓ 10 Seconds Shower

Source: Information provided courtesy of AGC Solar

AGC Solar Fluon ETFE Film) Accelerated Test Analysis



Retention of Mechanical Properties +

Tensile Test	Zero Hour	After 500 Hours	After 1000 Hours
Elongation	300-400%	95-100% *	95-100% *
Strength	55-65 MPa	90-95% *	85-95% *

* Percent of original measurement

Change in Optical Properties

Test		Zero Hour	500 Hours	1000 Hours
Transparency at 360 nm	%	<=0.1	<=0.1	<=0.1
Visible Light Transmission	%	24 – 26	23 – 26	22 – 25
Solar Transmittance	%	36 – 37	36 – 37	35 – 36
Solar Reflectance	%	60 – 62	61 – 63	61 – 63
Color Difference ΔE*		-	-	<0.7

Source: Information provided courtesy of AGC Solar

Metal Halide Correlation Table

Correlation With Outdoor Data

Test Material	Test Cycle Irradiation/ Humidity (hrs)	Irradiation Level (W/m ²)	BP Temp °C	Humidity (%RH)	Test Duration (hours)	Equivalent Exposure (years)	Acceleration Factor
Polypropylene (PP)	12 / 6	1500	83	50	100	1yr outdoor	88
Polyvinyl chloride (PVC)	4 / 2	1050	50	50	150-300	1yr outdoor	58-29*
Acrylonitrile butadiene styrene (ABS)	12 / 6	1500	83	50	80	1yr outdoor	110
Polycarbonate (PC)	6 / 6	1500	83	50	100	1yr outdoor	88
Polyethyl Methacrylate (PMMA)	12/6	1500	83	50	200	800hr (comp)	4X (comp)
Polyethylene (PE)	6 / 6	1500	83	50	120	1yr outdoor	73
Polyoxymethylene (POM) (polyacetal)	12 / 6	1500	83	50	100	1yr outdoor	88
Polyester	continuous UV	1050	83	N/A	25	1yr outdoor	350
Urethane	6 / 4	1500	83	50	200	2yr outdoor	88
Typical fabric	continuous UV	1050	83	N/A	20	250hr (comp)	12.5X (comp)
Melamine painting	24 / 24	1500	83	50	50	1yr outdoor	175
Fluorine painting	12 / 12	1500	83	50	1000	10yr outdoor	88
Acrylic painting	24 / 24	1500	83	50	50	1yr outdoor	175
Painted Slate	8 / 2	1500	83	50	100	1yr outdoor	88

Source: Japan Weathering Test Center & Iwasaki Electric
Location: Central Honshu Prefecture, approximate equivalent is St. Louis area

Summary

- Metal halide weather testing offers significantly accelerated testing compared with traditional fluorescent and xenon tools by a factor as high as ten.
- Correlation data for metal halide tools does exist.
- Many internationally based companies are using metal halide tools for strategic R & D.
- North American based companies are using metal halide tools for strategic R & D, and + maintain proprietary testing and correlation data. +
- EYE Applied Optix will work with customers and partners to publish additional data over time, and is actively seeking a North American partner for research to present at the next annual session.

Douglas Vermillion
(440) 487-8343
Doug.Vermillion@EyeAppliedOptix.com