Sun Simulator for Solar Panel Testing

Controlled, standardized, and reproducible — the science of indoor solar simulation.

Content Partner: J. v. G. technology GmbH

Turnkey solar module production lines — since 1997

www.jvg-thoma.com

Technical Overview: Sun Simulator for PV Testing

Created as part of the PVKnowHow Knowledge Network

Prepared by J.v.G. Technology GmbH

European specialists in turnkey solar module production lines

Key Project Data: Sun Simulator Reference Specification

~1000 W/m²

Light Intensity

"1 sun" — standard test condition irradiance for terrestrial PV testing

A/B/C

Classifier Classes

Three-letter rating system: spectral match, spatial uniformity, temporal stability

3

Light Technologies

LED, Xenon, and Metal Halide — each with distinct performance trade-offs

Parameter	Detail	Notes
Application	Solar module testing / quality control	R&D and production line use
Equipment	Sun simulator (Class A/B/C)	Rated per IEC 60904-9 / ASTM E927
Light Intensity	~1000 W/m² ("1 sun")	Standard test condition (STC)
Technologies	LED, Xenon, Metal Halide	Flash or steady-state configurations
Standards	IEC 60904-9, ASTM E927	Spectral match, uniformity, stability
Source	**PVKnowHow / J.v.G. Technology GmbH**	Composite reference scenario

Source: PVKnowHow / J.v.G. Technology GmbH — composite scenario based on real consulting and manufacturing data

What Is a Sun Simulator?

Core Function

- Replicates solar irradiance in a controlled indoor environment
- Enables repeatable, standardized electrical performance testing
- Eliminates dependence on outdoor conditions and weather variability

Why It Matters

- Required for module certification under IEC 61215 / IEC 61730
- Enables accurate I-V curve measurement at standard test conditions (STC)
- Underpins quality control at every production stage

Classification System: Class A, B, and C

Class A — Research & Certification Grade

- Highest precision in spectral match, spatial uniformity, and temporal stability
- Required for R&D, certification testing, and reference measurements
- Three-letter rating applies independently to each performance metric (e.g., AAA)

Class B — Production Line Grade

- Suitable for inline quality control on manufacturing lines
- Acceptable accuracy for production pass/fail decisions
- Lower cost than Class A; sufficient for volume output verification

Class C — Basic Testing Grade

- Basic units for simple experiments and educational use
- Not suitable for certification or commercial production validation
- Lowest cost; limited to non-critical applications

Three Classification Metrics: What Gets Rated

1

Spectral Match

Output spectrum compared to AM1.5G reference — rated A through C per wavelength interval

2

Spatial Non-Uniformity

Consistency of irradiance across the test plane — critical for full-module testing accuracy

3

Temporal Instability

Stability of light output over the measurement duration — flash vs. steady-state distinction applies

Per IEC 60904-9 (2020), a simulator receives one rating per metric — reported as a three-letter code (e.g., ABB = Class A spectral, B spatial, B temporal).

Light Source Technologies: LED, Xenon, Metal Halide

LED Simulators

- Tunable spectrum; narrow-band emission combined to match AM1.5G
- Long operational life; low heat output; energy efficient
- IEC 60904-9:2020 introduced spectral coverage metric partly in response to LED adoption

Xenon Arc Simulators

- Broadband emission closely resembling solar spectrum
- Widely used for flash testing; high intensity possible
- Requires filtering to remove strong emission lines

Metal Halide Simulators

- Gas discharge lamp with broad spectral output
- Cost-effective option for steady-state production testing
- Warm-up time required; intensity drifts with lamp aging

Flash vs. Steady-State: Two Testing Paradigms

Flash (Pulsed) Simulators

- Very short, high-intensity pulses (milliseconds)
- Prevents thermal build-up in the device under test
- Standard approach for full-module I-V curve measurement on production lines
- Intensity and spectrum inherently transient — calibration discipline critical

Steady-State Simulators

- Continuous illumination at target irradiance
- Preferred for detailed I-V curve analysis, degradation studies, and R&D
- Enables extended measurement sequences not possible with flash units
- More demanding thermal management of light source required

Large Area vs. Small Area Simulators

Large Area Simulators

- Cover the full footprint of a production-scale solar module
- Required for whole-module certification testing per IEC 61215
- Uniformity spec is most demanding at large test plane sizes

Small Area Simulators

- Focused illumination on individual cells or sub-areas
- Used for detailed material and cell-level characterization
- Typically higher spatial resolution; suited for R&D environments

Sun Simulator in Manufacturing: Quality Control Integration

End-of-Line Testing

Every finished module measured at STC (~1000 W/m^2, 25°C, AM1.5G) — power class sorted by flash simulator result

Certification Compliance

Simulator output required for IEC 61215 type approval — Class A or better mandated for test laboratory use

Regular Calibration

Routine recalibration against reference cells maintains measurement traceability and output accuracy over time

Process Documentation

Simulator measurement records form part of quality system documentation delivered with turnkey production equipment

Competitive Comparison: Simulator Technologies at a Glance

Criterion	LED	Xenon	Metal Halide
Spectral Match	Tunable; can reach Class A+	Broadband; Class A standard	Broadband; Class A achievable
Temporal Stability	Excellent (steady-state)	Good (flash)	Moderate; warm-up drift
Operational Life	Very long (50,000+ hrs)	Limited (~1,000 hrs)	Moderate (~6,000 hrs)
Typical Use	R&D, precision testing	Production flash testing	Steady-state production
Heat Output	Low	High	High
Capital Cost	Higher upfront	Mid-range	Lower upfront

Standards Compliance: IEC 60904-9 & ASTM E927

ASTM E927 (Origin)

First standard to define solar simulator classification — spectral match, spatial non-uniformity, temporal instability

Originally developed in 1979 for terrestrial PV testing

1

IEC 60904-9 (Global Adoption)

International standard aligning global PV test requirements

2020 revision introduced Class A+ and extended spectral range to 300–1200 nm

2

Compliance Impact

Simulator class directly determines whether test data can support product certification

Class A or better required for IEC 61215 module type approval submissions

3

Standards apply to both production-line simulators and accredited test laboratory equipment. Correct classification is a prerequisite for market acceptance of module test data.

Key Takeaways: Sun Simulator Selection Criteria

01

Match the Class to the Application

Class A for certification and R&D; Class B sufficient for production-line sorting; Class C for basic screening only

02

Select the Right Light Source Technology

LED for precision and longevity; Xenon for flash production testing; Metal Halide as a cost-effective steady-state option

03

Verify Standards Compliance

Confirm IEC 60904-9 and/or ASTM E927 rating before procurement; misclassified equipment invalidates test data

04

Plan for Calibration and Maintenance

Regular recalibration with reference cells is mandatory; lamp replacement schedules must be integrated into quality plans

Source: PVKnowHow / J.v.G. Technology GmbH — composite scenario based on real consulting data. All information is realistic but simplified for educational purposes.

About the Content Partner

J. v. G. technology GmbH — The DESERT Company

Founded in 1997 in Bavaria, Germany. Family-owned engineering company specializing in turnkey solar module production lines.

More than 90 factory projects delivered worldwide.
On-site team training included — no prior manufacturing experience required.

Key areas:

Turnkey PV manufacturing lines | DESERT Technology® | TÜV-certified module designs | Factory planning to production

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