Newport™ Solaris Series

Class A+AA Solar Simulators

Leveraging over 50 years of experience in light source and power supply design, the Newport Oriel® brand is proud to offer the latest innovation in solar simulators – the Solaris Series Class A+AA Solar Simulator family. The product family includes:

SOLARIS-12 = 12”x12” Illumination Area

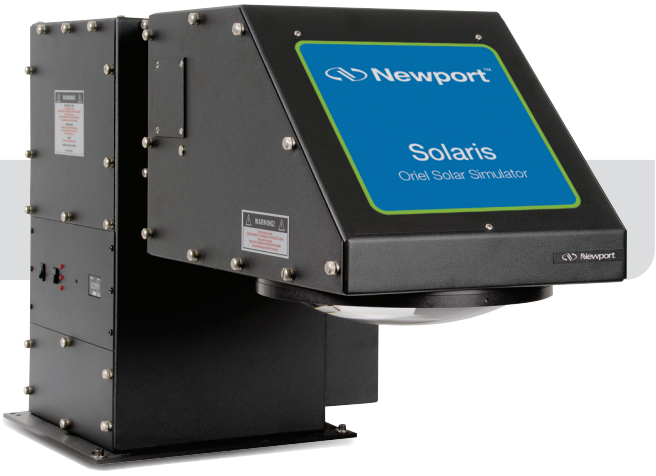
SOLARIS-8 = 8”x8” Illumination Area

SOLARIS-6 = 6”x6” Illumination Area

SOLARIS-4 = 4”x4” Illumination Area

SOLARIS-2 = 2”x2” Illumination Area

All Solaris simulators are certified to IEC 60904-9 2020 standards for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance. By convention, Class A+AA is reported with the first letter representing Spectral performance, the second letter Uniformity of Irradiance, and the third letter Temporal Stability. The Solaris simulators all use a single lamp design to meet not one or two, but all three



performance criteria without compromising the 1 SUN output power, providing true Class A+AA performance. The Solaris series uses a black, non-reflective finish to minimize stray light and incorporates captive screws for all panels requiring user access to facilitate lamp replacement, alignment, and filter changes. Safety interlocks prevent inadvertent exposure to UV light. The Solaris series robust design is backed by the Newport Corporation’s world wide organization.

Features

- Factory certified Class A+AA CW systems
- Calibration certificate validating Class A+AA performance for IEC 60904-9:2020 standards
- Long-lived, highly reliable instruments designed specifically for 24/7 production environments
- Integrated variable attenuator provides capability to vary output from 0.1 to 1.0 SUNs
- Easy lamp replacement
- Non-reflective black finish reduces stray light
- Temperature sensors and interlocks ensure operator safety
- Extended wavelength range certification from 300 to 1200 nm
- Updated testing includes Spectral Coverage and Spectral Divergence data
- Universal AC mains operation

Why Class A+AA?

Photovoltaic (PV) cell research and manufacturing are evolving at an amazing rate, with new technologies like thin film processes, tandem and multi-junction cells (including perovskites), organic thin films, and dye sensitized cells all requiring careful evaluation of their performance. The old designation of “Class A” solar simulators had become standard in most test laboratories and manufacturing environments, but the

definition of Class A has degraded to mean a system that is capable of meeting any one (typically spectral match) of the three performance parameters called out in the test methods. In October 2007 the IEC revised the method used to evaluate the performance of a solar simulator. This previous standard called for quantifying and reporting each of the three performance criteria separately. In September 2020, the IEC revised this standard again, introducing the A+ classification and additional testing requirements from the 2007 edition. A solar simulator is now measured as class A+, A, B, or C for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance. The new Solaris series solar simulators have been designed to meet Class A+ performance for Spectral Match, and Class A performance for Non-Uniformity of Irradiance and Temporal Instability of Irradiance as called out by the IEC 60904-9 2020 edition.

By ensuring measurement uniformity, Class A+AA systems reduce binning variability of photovoltaic cell testing to an increased wavelength reporting range from 300 to 1200 nm. This performance consistency allows for precise and traceable comparison of performance data for researchers developing novel solar materials.

MKS Newport puts each Solaris simulator through rigorous testing for all required IEC standards, to ensure compliance and supplies a certificate of calibration for each simulator.

Defining Class A+AA Performance Standards

Photovoltaic standards mandate that Class A+AA solar simulators meet demanding requirements in three key performance areas: spectral match to the solar spectrum, spatial non-uniformity of irradiance, and temporal instability of irradiance.

The Solaris series are tested and certified to the following IEC standards:

- IEC 60904-9 2020 Edition Photovoltaic Devices - Part 9: Classification of Solar Simulator Characteristics

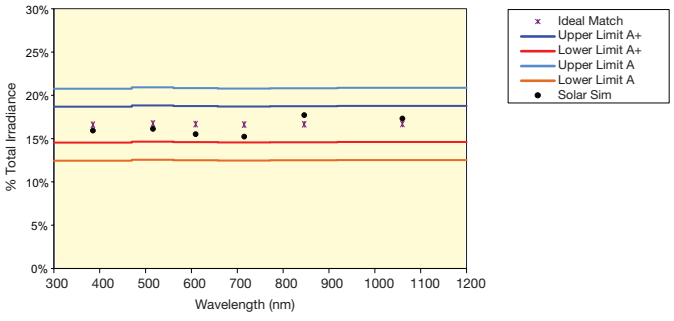
Table 1 Class A+AA Standards and Specifications

Organization	IEC
Performance Parameter	60904-9 2020
Spectral Match (fraction of ideal percentage)	0.875 - 1.125
Non-Uniformity of Irradiance	≤ 2.0%
Temporal Instability	0.5% STI
	<2.0% LTI

Spectral Match

The standards define the spectral match of a solar simulator as a percentage of the integrated intensity in 6 spectral ranges (listed in Table 2). Any deviation from the specified percentages must then lie within a range that determines the class of the simulator. For Class A+AA, this range is 0.875 to 1.125 times the ideal percentage. In addition, for A+ spectral match, four different points are measured on the certified illumination area, with spectrometer uncertainies included in the report.

Figure 1



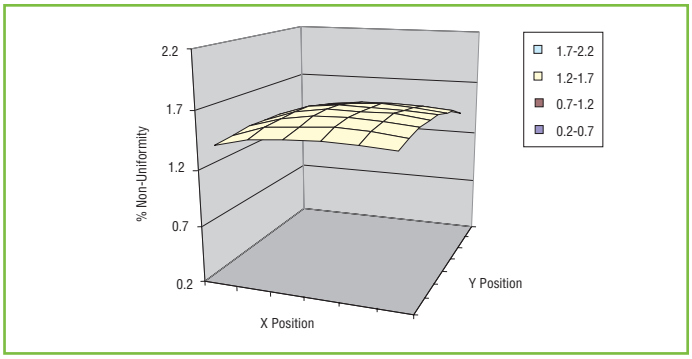
Solaris Series Spectral Match with AM 1.5G spectral correction filter meets IEC Class A+ requirements for spectral match.

Spectral Match

Table 2 Ideal Spectral Match Defined by IEC Standards

Spectral Range (nm)	Total Irradiance Range (%)	Ideal %
300 - 470	14.5 - 18.7	16.6
470 - 561	14.7 - 18.8	16.7
561 - 657	14.6 - 18.8	16.7
657 - 772	14.6 - 18.7	16.6
772 - 919	14.6 - 18.7	16.7
919 - 1200	14.6 - 18.8	16.7

Figure 2

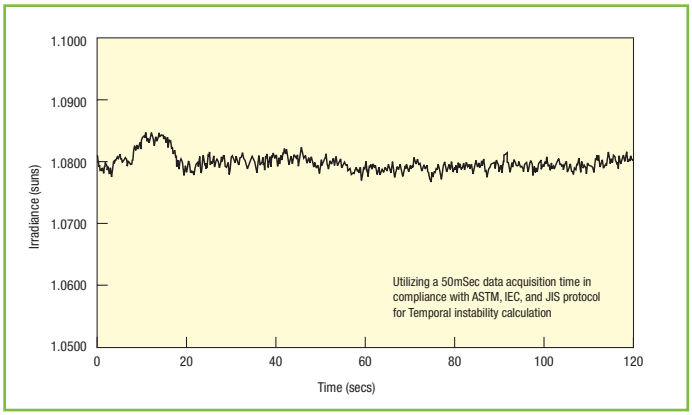


Measured Uniformity of a 2x2" Solaris Solar Simulator.

Spatial Uniformity of Irradiance

The irradiance uniformity over the working area is the most difficult Class A+AA requirement to achieve and maintain. Hot spots can lead to significant errors in measured cell efficiency and can cause inaccurate binning of cells. The Class A spatial non-uniformity performance standard is designed to minimize the impact of hot spots and has a very stringent requirement of ≤ 2%. Figure 2 shows the uniformity of irradiance across a typical simulator working area. A plot of irradiance non-uniformity is provided with every system. The working distance ranges for each simulator are listed in the specifications table. In addition, each tested position in the certified illumination area includes a secondary test point. This provides a relative reference of the intensity measurements, and can normalize the reported data to account for any temporal effects during the full test regiment.

Figure 3



Typical Output Variation of a 1.6 kW Solaris Solar Simulator Over Time.

Temporal Instability

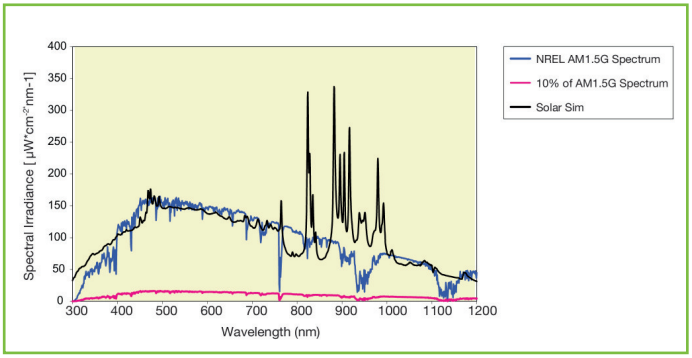
Temporal Instability is the third performance parameter of Class A+AA standards. It requires that the output light be stable over time in order to ensure that the lamp fluctuations do not distort the measurement of solar cell efficiency. MKS Newport's Solaris series easily meets the requirements for temporal instability as defined by the IEC 60904-9 (2020), Figure 3 shows a typical instability response for a Solaris solar simulator utilizing a 50 millisecond data acquisition time, with the tabulated data below:

Elapsed Time (sec)	60
No. of Data Points	1200
% Instability	0.369

Spectral Coverage and Divergence

Included in the IEC 60904-9:2020 standards is the reporting information of Spectral Coverage and Spectral Divergence, to which each Solaris series solar simulator is tested against with data included in the certificate. Figure 4 shows an example graph, detailing how well the solar simulator covers all wavelengths in the full 300 to 1200 nm range, and how much the irradiation curve deviates from the AM1.5G standard, calculated as a percentage.

Figure 4



Example graph of a solar simulator spectral irradiance curve compared to the NREL defined AM1.5G spectrum.

Class A+AA Solar Simulator Key Components

Illuminator Housing

The illuminator housing provides a safe enclosure for the lamp. Its powder-coated, flat black finish provides a durable surface that also minimizes stray light. It is equipped with safety interlock systems to ensure operator and system safety. Panels containing user serviceable components use captive screws that require no tools for ease of removal and replacement. Integral fans provide forced air-cooling to maintain optimal lamp, optics, and housing temperature. The Solaris housing design allows the head orientation to produce a downward, sideways, or upwards facing beam (available on select models, contact your Newport sales engineer for details). A lamp hour indicator has also been integrated into the housing for easy monitoring of lamp usage.

Integrated Shutter

The Solaris Solar Simulator includes an upgraded shutter for production-environment operation. The shutter for the Class A+AA systems is a rugged, single-blade shutter designed for >1 million cycles. Historically, our real-world performance has exceeded 10 million cycles on units in the field for many years. The shutter has a minimum exposure time of 200 ms and can be controlled via a contact closure or logic level input, or a convenient push-button switch on the illuminator housing.

Xenon Arc Lamp

The Solaris Solar Simulator source is a CW system. This enables testing of all cell materials unlike flash-lamp based systems that are limited by the response time of the material allowing the cell to be soaked at a constant light level prior to testing. The lamp type used in all simulators is an ozone-free xenon short arc lamp. We certify each source with the supplied lamp. For continuous production environments, we suggest purchasing replacement lamps to ensure Class A+AA compliance and reduce down time to the system.

Air Mass 1.5G Filter

The combination of lamp and air mass filter produces the characteristic Class A+AA spectra. Our Air Mass 1.5G Filter retains its optical properties under the operating conditions without degradation of the filter.

Power Supply

The Newport regulated power supply incorporates over 50 years of experience in high voltage power supply design to provide constant electrical power to the xenon lamp. The power supply is CE compliant and features universal AC mains operation for use anywhere in the world. Lamp usage can be monitored in accumulated hours from the power supply, because it is important to replace the lamp at the end of its rated life to maintain the minimum 1 SUN output and spectral characteristics. The lamp's output will significantly decrease and change spectrally with continued use beyond its rated life.

Maintaining the Solaris Solar Simulator

MKS Newport's Solaris Solar Simulators maintain Class A+AA compliance during the rated "performance lifetime" of the lamp. When the lamp is replaced, the instrument should be realigned to maintain Class A+AA compliance. Irradiance uniformity is the most difficult Class A+AA requirement to meet and maintain. In order to facilitate the measurements and adjustments necessary to maintain Class A uniformity, Newport recommends a field recertification service performed by a qualified engineer. Extended warranties and installation service are also available. Please contact a Newport sales engineer for details.

Class A+AA Solar Simulator Specifications

Model	**SOLARIS-2**	**SOLARIS-4**	**SOLARIS-6**	**SOLARIS-8**	**SOLARIS-12**
Illumination Area	2x2 inch (51x51mm)	4x4 inch (102x102mm)	6x6 inch (152x152mm)	8x8 inch (203x203mm)	12x12 inch (305x305mm)
Maximum Angle of Incidence	(half angle) <±4 °	(half angle) <±4 °	(half angle) <±3 °	(half angle) <±2 °	(half angle) <±1.5 °
Typical Power Output	100mW/cm2 (1 SUN) ±20% Adjustable	100mW/cm2 (1 SUN) ±20% Adjustable	100mW/cm2 (1 SUN) ±20% Adjustable	100mW/cm2 (1 SUN) ±20% Adjustable	100mW/cm2 (1 SUN) ±20% Adjustable
Uniformity[1]	≤ 2%	≤ 2%	≤ 2%	≤ 2%	≤ 2%
Uniformity Classification	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)
Temporal Instability[2]	0.5% STI <2.0% LTI	0.5% STI <2.0% LTI	0.5% STI <2.0% LTI	0.5% STI <2.0% LTI	0.5% STI <2.0% LTI
Temporal Instability Classification	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)	A (IEC 60904-9 2020)
Spectral Match[3]	14.5% – 18.7% (300-470 nm) 14.7% – 18.8% (470-561 nm) 14.6% – 18.8% (561-657 nm) 14.6% – 18.7% (657-772 nm) 14.6% – 18.7% (772-919 nm) 14.6% – 18.8% (919-1200 nm)	14.5% – 18.7% (300-470 nm) 14.7% – 18.8% (470-561 nm) 14.6% – 18.8% (561-657 nm) 14.6% – 18.7% (657-772 nm) 14.6% – 18.7% (772-919 nm) 14.6% – 18.8% (919-1200 nm)	14.5% – 18.7% (300-470 nm) 14.7% – 18.8% (470-561 nm) 14.6% – 18.8% (561-657 nm) 14.6% – 18.7% (657-772 nm) 14.6% – 18.7% (772-919 nm) 14.6% – 18.8% (919-1200 nm)	14.5% – 18.7% (300-470 nm) 14.7% – 18.8% (470-561 nm) 14.6% – 18.8% (561-657 nm) 14.6% – 18.7% (657-772 nm) 14.6% – 18.7% (772-919 nm) 14.6% – 18.8% (919-1200 nm)	14.5% – 18.7% (300-470 nm) 14.7% – 18.8% (470-561 nm) 14.6% – 18.8% (561-657 nm) 14.6% – 18.7% (657-772 nm) 14.6% – 18.7% (772-919 nm) 14.6% – 18.8% (919-1200 nm)
Spectral Match Classification	A+ (IEC 60904-9 2020)	A+ (IEC 60904-9 2020)	A+ (IEC 60904-9 2020)	A+ (IEC 60904-9 2020)	A+ (IEC 60904-9 2020)
Nominal Working Distance	12 ±0.5 in.	6 ±0.5 in.	7 ±0.5 in.	15 ±0.5 in.	12.0 ± 0.5 in.
Nominal Lamp Electric Power	450 W	450 W	1000 W	1600 W	1600 W
Power Requirements[4] (Illuminator Housing)	95 - 264 VAC/15A 47 - 63 Hz	95 - 264 VAC/15A 47 - 63 Hz	95 - 264 VAC/15A 47 - 63 Hz	95 - 264 VAC/12A 47 - 63 Hz	95 - 264 VAC/12A 47 - 63 Hz
Line Regulation	0.01 %	0.01 %	0.01 %	0.01 %	0.01 %

1. Uniformity is defined as:
   Uniformity (%) = (Max irradiance – Min irradiance)/ (Max irradiance + Min irradiance) x 100%
   Uniformity is measured using following Methods:
   - Compliant to IEC 60904-9 2020 edition - section 5.3, 64 points in an 8x8 grid with detector size no bigger than each grid size.
2. Temporal stability is defined as:
   Temporal stability (%) = (Max irradiance – Min irradiance)/ (Max irradiance + Min irradiance) x 100%
   Temporal stability is measured by taking 20 samples per second for 60 seconds.
3. Spectral match is measured by using a calibrated spectroradiometer with a grating monochromator and a discrete detector. Measurement resolution is set at 2 nm.
4. Power requirements for the Illuminator Housing only. A separate AC Mains is required for the power supply, as noted on the following page.

Power Supply Specifications

Model	69920	69922
Input Voltage	95 - 264 VAC	190 - 264 VAC
Input Frequency	47 - 63 Hz	47 - 63 Hz
Output Power	350 - 1200 W	800 - 1800 W
Output Current	17.5 - 55 A	25 - 70A
Output Voltage Range	0 - 45 VDC	0 - 35 VDC
Line Regulation	±0.05%	±0.05%
Output Voltage Ripple	<0.5% typically	<0.5% typically
Meter Accuracy (% of full scale)	<0.005%	<0.005%
Digital Meter Resolution, Voltage	0.1 VDC	0.1 VDC
Digital Meter Resolution, Power	1 W	1 W
Digital Meter Resolution, Current	0.1 A	0.1 A
Safety Interlock Voltage	12 VDC/GND	12 VDC/GND
Operating Mode	Constant current or constant power	Constant current or constant power
Ambient Operating Temperature	10 - 45°C	10 - 45°C

MKS Newport's solar simulators are designed to operate in a typical laboratory environment (68 to 76 degrees F, up to 45% relative humidity). Temperature and humidity outside of typical laboratory range can contribute to cooling and ignition faults. Cooling issues will cause the over temperature sensor to open, and ignition problems will result from high humidity. Contact a Newport technical representative for more information if operating outside the suggested range.

Ordering Information

Solaris Series Ordering Information

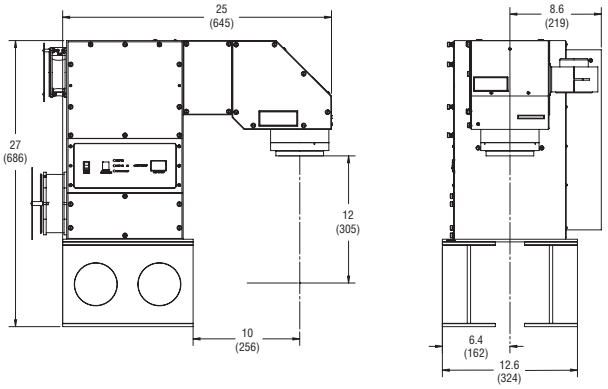
Model	Description	Lamp	Illumination Area
SOLARIS-2	Solaris Class A+AA Solar Simulator, IEC	450 Watt Xenon	2x2
SOLARIS-4	Solaris Class A+AA Solar Simulator, IEC	450 Watt Xenon	4x4
SOLARIS-6	Solaris Class A+AA Solar Simulator, IEC	1000 Watt Xenon	6x6
SOLARIS-8	Solaris Class A+AA Solar Simulator, IEC	1600 Watt Xenon	8x8
SOLARIS-12	Solaris Class A+AA Solar Simulator, IEC	1600 Watt Xenon	12x12
940X3A-P	Variable Aperture for partial sun illumination on Solaris solar simulators		

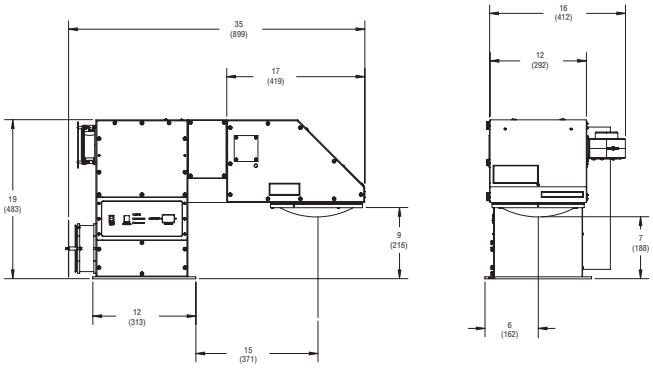
Replacement Lamps and Filters

Model	Description
6280NS	450 Watt Xenon Short Arc Lamp, Ozone Free (SOLARIS-2 or SOLARIS-4)
6272	1000 Watt Xenon Short Arc Lamp, Ozone Free (SOLARIS-6)
62726	1600 Watt Xenon, Ozone Free Arc Lamp (SOLARIS-8 or SOLARIS-12)
81389	Air Mass Filter 1.5 Direct
81311	Air Mass Filter AM0

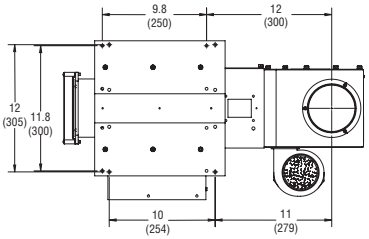
Contact a Sales Engineer for pricing of optional accessories.

Dimensional Drawings

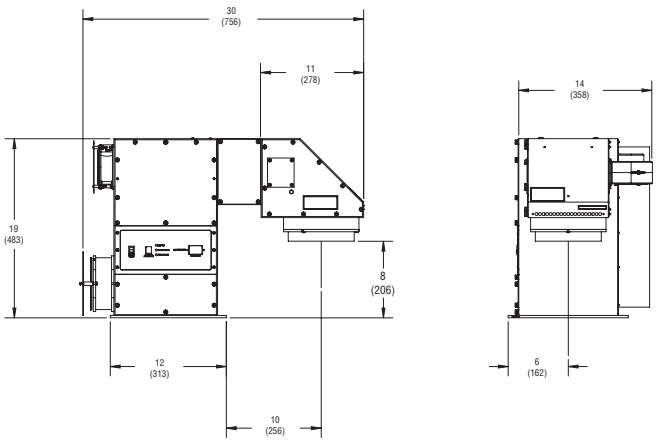




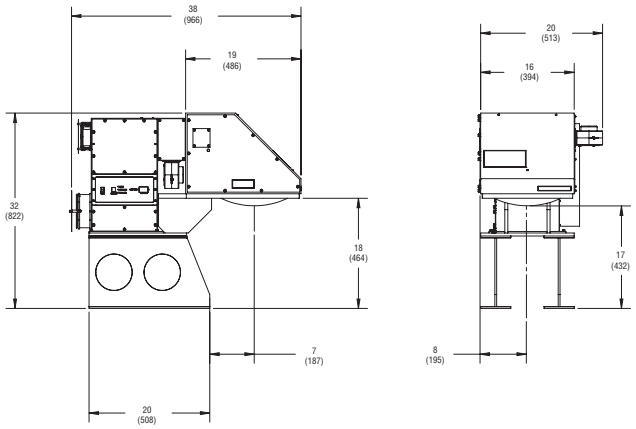
Dimensional diagram of SOLARIS-6 Solar Simulator.



Dimensional diagram of SOLARIS-2 Solar Simulator.

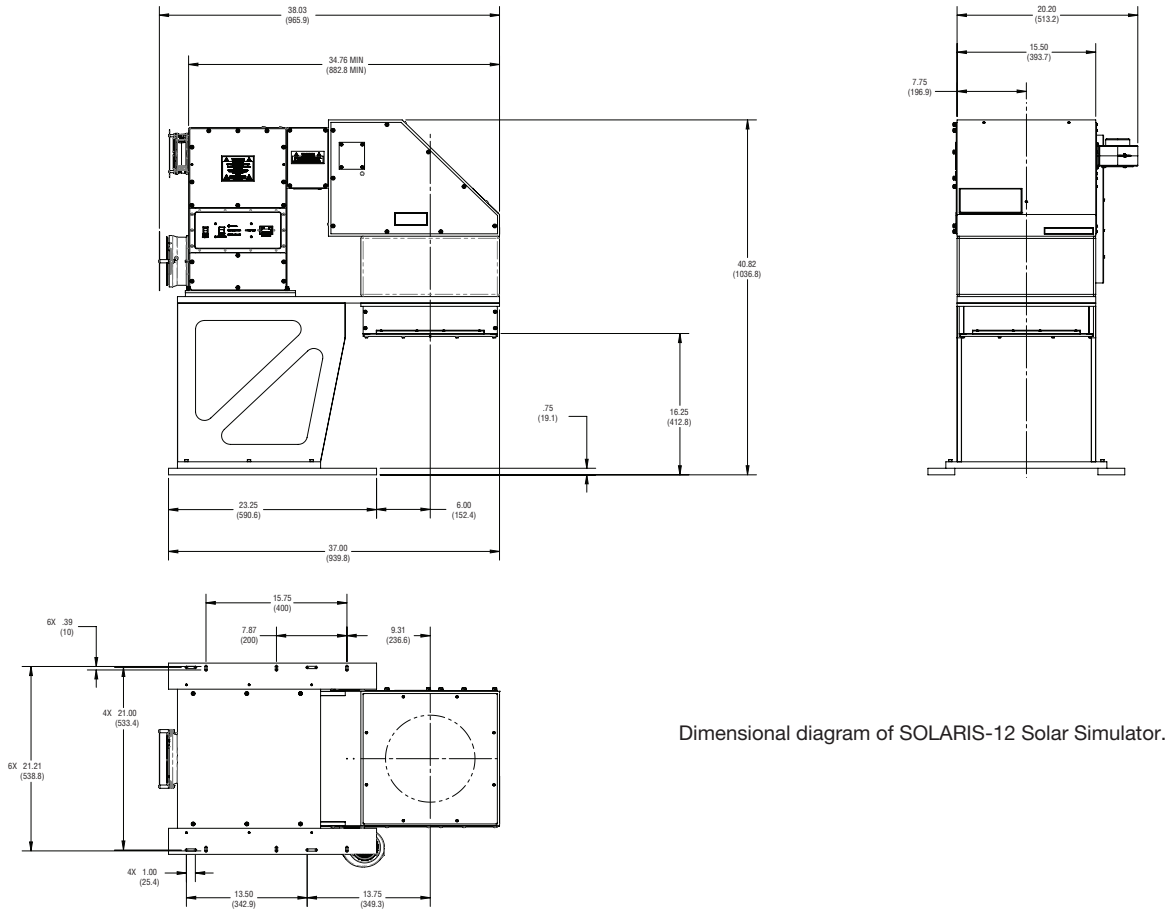


Dimensional diagram of SOLARIS-4 Solar Simulator.



Dimensional diagram of SOLARIS-8 Solar Simulator.

Dimensional Drawings continued



Dimensional diagram of SOLARIS-12 Solar Simulator.

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