

Class AAA Solar Simulators

Leveraging over 40 years of experience in light source and power supply design, Newport's Oriel® brand is proud to offer the latest innovation in solar simulators – the Oriel Sol3A™ Class AAA Solar Simulator family. The product family includes:

Model 94123A = 12"x12" Illumination Area

Model 94083A = 8"x8" Illumination Area

Model 94063A = 6"x6" Illumination Area

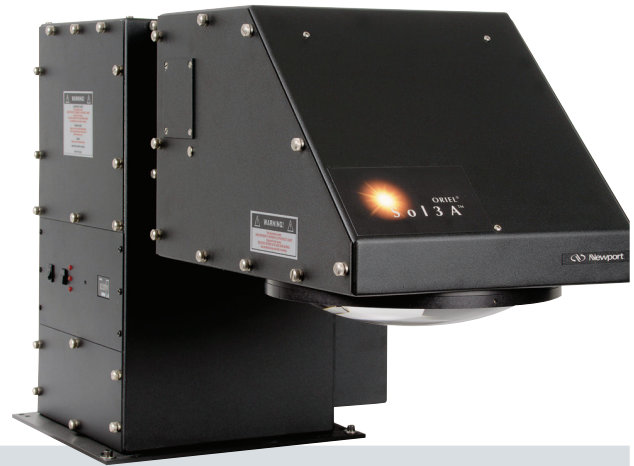
Model 94043A = 4"x4" Illumination Area

Model 94023A = 2"x2" Illumination Area

All Oriel Sol3A simulators are certified to IEC 60904-9 Edition 2 (2007), JIS 8904-9 2017, and ASTM E 927-10 standards for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance. By convention, Class AAA is reported with the first letter representing Spectral performance, the second letter Uniformity of Irradiance, and the third letter Temporal Stability. The Oriel Sol3A 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 AAA performance. The Oriel Sol3A 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 Oriel Sol3A rugged design is backed by the Newport Corporation's world wide organization.

Why Class AAA?

Photovoltaic (PV) cell research and manufacturing are evolving at an amazing rate, with new technologies like thin film processes, tandem and multi-junction cells, 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



Product Features

- Factory certified Class AAA CW systems
- Calibration certificate validating Class AAA performance for all 3 standards: IEC, ASTM and JIS
- 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
- Improved optical design for maximum spatial uniformity
- Improved working distances accommodate larger samples
- Universal AC mains operation
- CE certified

(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. The new standard calls for quantifying and reporting each of the three performance criteria separately. A solar simulator is now measured as class A, B, or C for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance. The new Sol3A solar simulators have been designed to meet Class A performance for all 3 of the test requirements: Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance as called out by IEC 60904-9 Edition 2 (2007) edition, JIS 8904-9 2017, and ASTM E 927-10.

By ensuring measurement uniformity, Class AAA systems reduce binning variability of photovoltaic cell testing as compared to so called Class A, Class B, or non-classified sources. This performance consistency allows for precise and traceable comparison of performance data for researchers developing novel solar materials.

Newport Corporation puts each Oriel Sol3A™ through rigorous testing for all 3 standards (IEC, ASTM, and JIS) to ensure compliance and supplies a certificate of calibration to all three standards. ASTM standards.

Defining Class AAA Performance Standards

Photovoltaic standards mandate that Class AAA 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.

There are three standards that define solar simulator performance:

- IEC 60904-9 2007 Edition Photovoltaic Devices – Part 9: Solar Simulator Performance Requirements
- JIS 8904-9 2017, Solar Simulators for Crystalline Solar Cells and Modules
- ASTM E 927-10 (2010) Specification for Solar Simulation for Terrestrial PV Testing

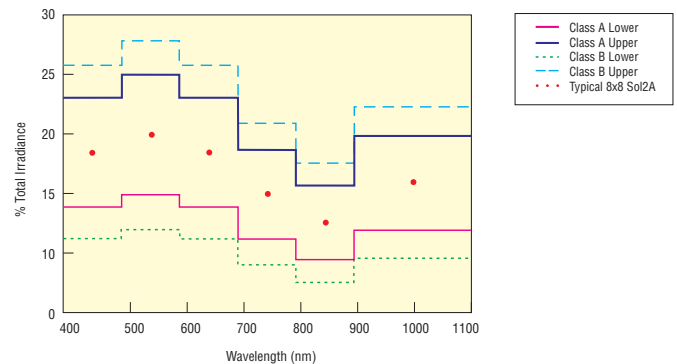
Table 1 Class AAA Standards and Specifications

Organization	IEC	JIS	ASTM
Performance Parameter	60904-9-2007	8904-9 2017	E92-05
Spectral Match (fraction of ideal percentage)	0.75 - 1.25	0.75 - 1.25	.75 - 1.25
Non-Uniformity of Irradiance	2.0%	±2%	2%
Temporal Instability	0.5% STI <2.0% LTI	0.5% STI <2.0% LTI	2%

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 AAA, this range is 0.75 to 1.25 times the ideal percentage.

Figure 1



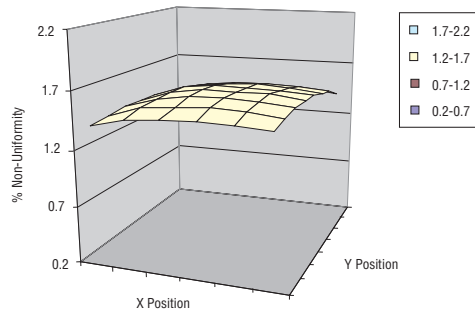
Oriel Sol3A Spectral Match with AM 1.5G spectral correction filter meets IEC, JIS, ASTM Class A requirements to for spectral match.

Spectral Match

Table 2 Ideal Spectral Match Defined by IEC Standards

Spectral Range (nm)	Total Irradiance Range (%)	Ideal %
400 - 500	13.9 - 23.1	18.5
500 - 600	15.1 - 25.1	20.1
600 - 700	13.7 - 22.9	18.3
700 - 800	11.1 - 18.5	14.8
800 - 900	9.2 - 15.3	12.2
900 - 1100	12.1 - 20.1	16.1

Figure 2

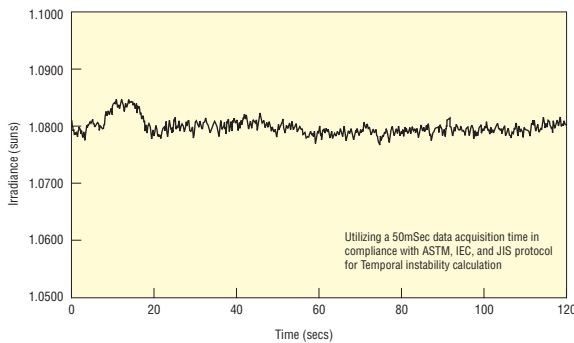


Measured Uniformity of a 2x2" Oriel Sol3A Solar Simulator.

Spatial Uniformity of Irradiance

The irradiance uniformity over the working area is the most difficult Class AAA 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 AAA 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.

Figure 3



Typical Output Variation of a 1.6 kW Oriel Sol3A Solar Simulator Over Time.

Temporal Instability

Temporal Instability is the third performance parameter of Class AAA 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. Oriel's Sol3A easily meets the requirements for

temporal instability as defined by the IEC, ASTM, and JIS standards. The IEC 60904-9 (2007) has the most stringent requirements for short term instability with a maximum allowable level of 0.5%. Figure 3 shows a typical instability response for an Oriel Sol3A utilizing a 50 millisecond data acquisition time.

The tabulated data is below:

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

Oriel Class AAA 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 fan(s) provide forced air-cooling to maintain optimal lamp, optics, and housing temperature. The Sol3A housing design allows the head orientation to produce a downward, sideways or upwards facing beam. Contact your Sales Engineer for details. A lamp hour indicator has also been integrated into the housing for easy monitoring of lamp usage.

Integrated Shutter

The Oriel Sol3A Solar Simulator includes an upgraded shutter for production-environment operation. The newly designed shutter for the Class AAA 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 Oriel Sol3A 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 AAA 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 AAA spectra. Our Air Mass 1.5G Filter retains its optical properties under the operating conditions without degradation of the filter.

Power Supply

The Oriel regulated power supply incorporates over 40 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 Oriel Sol3A Solar Simulator

Oriel Sol3A Solar Simulators maintain Class AAA compliance during the rated "performance lifetime" of the lamp. When the lamp is replaced, the instrument should be realigned to maintain Class AAA compliance. Irradiance uniformity is the most difficult Class AAA requirement to meet and maintain. In order to facilitate the measurements and adjustments necessary to maintain Class A uniformity, the Newport team offers a field recertification service performed by a qualified engineer. Extended warranties and installation service are also available. Please contact a Sales Engineer for details.

Class AAA Solar Simulator Specifications

Model	94023A	94043A	94063A	94083A	94123A	94123A-CPV	
Illumination Area	2x2 inch (51x51mm)	4x4 inch (102x102mm)	6x6 inch (152x152mm)	8x8 inch (203x203mm)	12x12 inch (305x305mm)	12x12 inch (305x305mm)	
Maximum Angle of Incidence	(half angle) <±4 °	(half angle) <±4 °	(half angle) <±3 °	(half angle) <±2 °	(half angle) <±1.5 °	(half angle) <±0.5 °	
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	100mW/cm2 (1 SUN) ±20% Adjustable	
Uniformity ¹	<±2 %	<±2 %	<±2 %	<±2 %	<±2 %	<±2 %	
Uniformity Classification	A (IEC 60904-9 2007) A (JIS 8904-9 2017) A (ASTM E927 - 10)	A (IEC 60904-9 2007) A (JIS 8904-9 2017) A (ASTM E927 - 10)	A (IEC 60904-9 2007) A (JIS 8904-9 2017) A (ASTM E927 - 10)	A (IEC 60904-9 2007) A (JIS 8904-9 2017) A (ASTM E927 - 10)	A (IEC 60904-9 2007) A (JIS 8904-9 2017) A (ASTM E927 - 10)	A (IEC 60904-9 2007) A (JIS 8904-9 2017) A (ASTM E927 - 10)	
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	0.5% STI <2.0% LTI	
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Spectral Match ³	13.8% - 23.0% (400-500nm) 14.9% - 24.9% (500-600nm) 13.8% - 23.0% (600-700nm) 11.2% - 18.6% (700-800nm) 9.4% - 15.6% (800-900nm) 11.9% - 19.9% (900-1100nm)	13.8% - 23.0% (400-500nm) 14.9% - 24.9% (500-600nm) 13.8% - 23.0% (600-700nm) 11.2% - 18.6% (700-800nm) 9.4% - 15.6% (800-900nm) 11.9% - 19.9% (900-1100nm)	13.8% - 23.0% (400-500nm) 14.9% - 24.9% (500-600nm) 13.8% - 23.0% (600-700nm) 11.2% - 18.6% (700-800nm) 9.4% - 15.6% (800-900nm) 11.9% - 19.9% (900-1100nm)	13.8% - 23.0% (400-500nm) 14.9% - 24.9% (500-600nm) 13.8% - 23.0% (600-700nm) 11.2% - 18.6% (700-800nm) 9.4% - 15.6% (800-900nm) 11.9% - 19.9% (900-1100nm)	13.8% - 23.0% (400-500nm) 14.9% - 24.9% (500-600nm) 13.8% - 23.0% (600-700nm) 11.2% - 18.6% (700-800nm) 9.4% - 15.6% (800-900nm) 11.9% - 19.9% (900-1100nm)	13.8% - 23.0% (400-500nm) 14.9% - 24.9% (500-600nm) 13.8% - 23.0% (600-700nm) 11.2% - 18.6% (700-800nm) 9.4% - 15.6% (800-900nm) 11.9% - 19.9% (900-1100nm)	12.7% - 21.1% (400-500nm) 14.6% - 25.6% (500-600nm) 13.9% - 23.1% (600-700nm) 11.4% - 19.0% (700-800nm) 9.7% - 16.1% (800-900nm) 12.6% - 21.0% (900-1100nm)
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Nominal Working Distance	12 ±0.5 in.	6 ±0.5 in.	7 ±0.5 in.	15 ±0.5 in.	12.0 ± 0.5 in.	4.0 ± 0.5 in.	
Nominal Lamp Electric Power	450 W	450 W	1000 W	1600 W	1600 W	1600 W	
Power Requirements (Simulator)	95 - 264 VAC/15A 47 - 63 Hz	95 - 264 VAC/15A 47 - 63 Hz	95 - 264 VAC/15A 47 - 63 Hz	190 - 264 VAC/12A 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 %	0.5%	

1. Uniformity is defined as:

$$\text{Uniformity (\%)} = (\text{Max irradiance} - \text{Min irradiance}) / (\text{Max irradiance} + \text{Min irradiance}) \times 100\%$$

Uniformity is measured using following Methods:

- Compliant to IEC 60904-9 2007 edition - section 5.3, 64 points in an 8x8 grid with detector size no bigger than each grid size.
- Compliant to JIS C 8912 - section 4.2, 17 points in a pre-defined pattern with detector size no bigger than 2 x 2 cm square.
- Compliant to ASTM E 927-10 section 8.3, 64 points in an 8x8 grid with detector size no bigger than each grid size.

2. Temporal stability is defined as:

$$\text{Temporal stability (\%)} = (\text{Max irradiance} - \text{Min irradiance}) / (\text{Max irradiance} + \text{Min irradiance}) \times 100\%$$

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.

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	0.01 %	0.01 %
Output Voltage Ripple	< 0.05%	< 0.05%
Meter Accuracy (% of full scale)	0.1 VDC	0.1 VDC
Digital Meter Resolution, Voltage	1 W	1 W
Digital Meter Resolution, Power	0.1 A	0.1 A
Digital Meter Resolution, Current	12 Vdc/GND	12 Vdc/GND
Safety Interlock Voltage	Constant current or constant power	Constant current or constant power
Operating Mode	0 - 45 °C	0 - 45 °C
Ambient Operating Temperature	20 (9) [lb (kg)]	20 (9) [lb (kg)]

Oriel 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

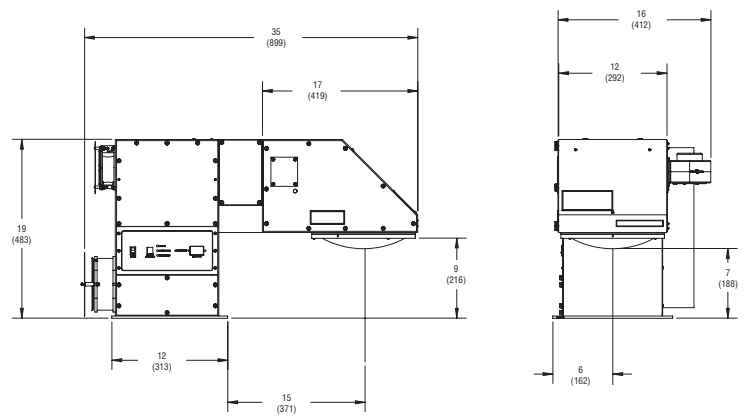
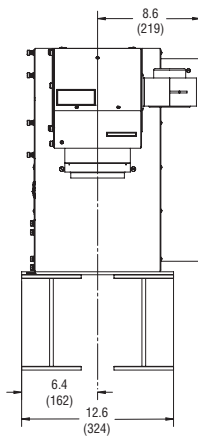
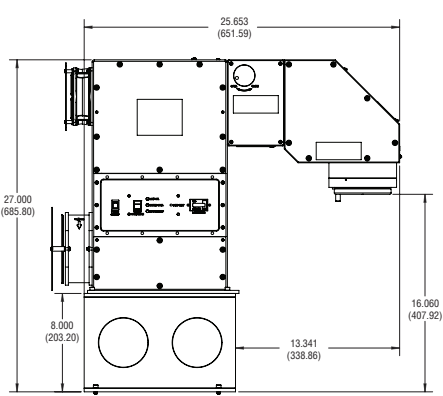
Sol3A Ordering Information

Model	Description	Lamp	Illumination Area
94023A	Sol3A Class AAA Solar Simulator IEC/JIS/ASTM	450 Watt Xenon	2x2
94043A	Sol3A Class AAA Solar Simulator IEC/JIS/ASTM	450 Watt Xenon	4x4
94063A	Sol3A Class AAA Solar Simulator IEC/JIS/ASTM	1000 Watt Xenon	6x6
94083A	Sol3A Class AAA Solar Simulator IEC/JIS/ASTM	1600 Watt Xenon	8x8
94123A	Sol3A Class AAA Solar Simulator IEC/JIS/ASTM	1600 Watt Xenon	12x12
94123A-CPV	Sol3A Class AAA Solar Simulator IEC/JIS/ASTM	1600 Watt Xenon	12x12, Concentrator
940X3A-P	Variable Aperture for partial sun illumination on Sol3A solar simulators		

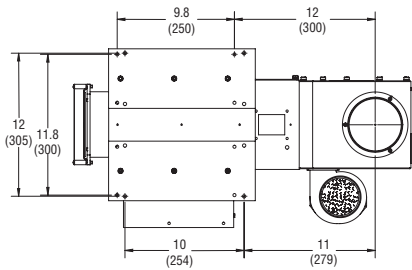
Replacement Lamps and Filters

Model	Description
6280NS	450 Watt Xenon Short Arc Lamp, Ozone Free (94023A or 94043A)
6272	1000 Watt Xenon Short Arc Lamp, Ozone Free (94063A)
62726	1600 Watt Xenon, Ozone Free Arc Lamp (94083A) or (94123A (-CPV))
81388	Air Mass Filter 1.5 Global (all models except 94123-CPV)
81389	Air Mass Filter 1.5 Direct (94123A-CPV)
81311	Air Mass Filter AM0

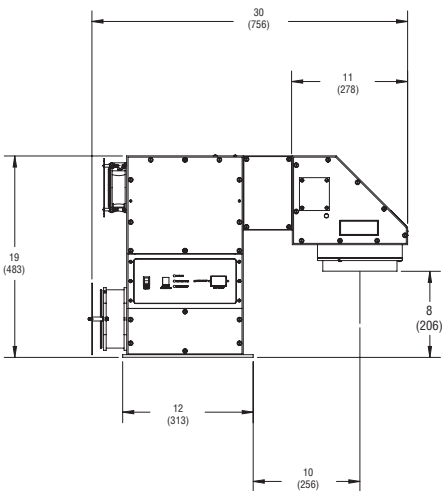
Contact a Sales Engineer for pricing of optional accessories.



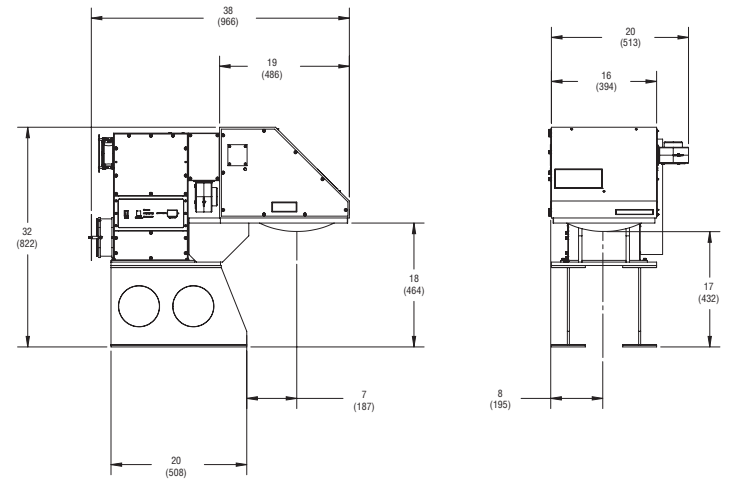
Dimensional diagram of 94063A Sol3A Solar Simulator.



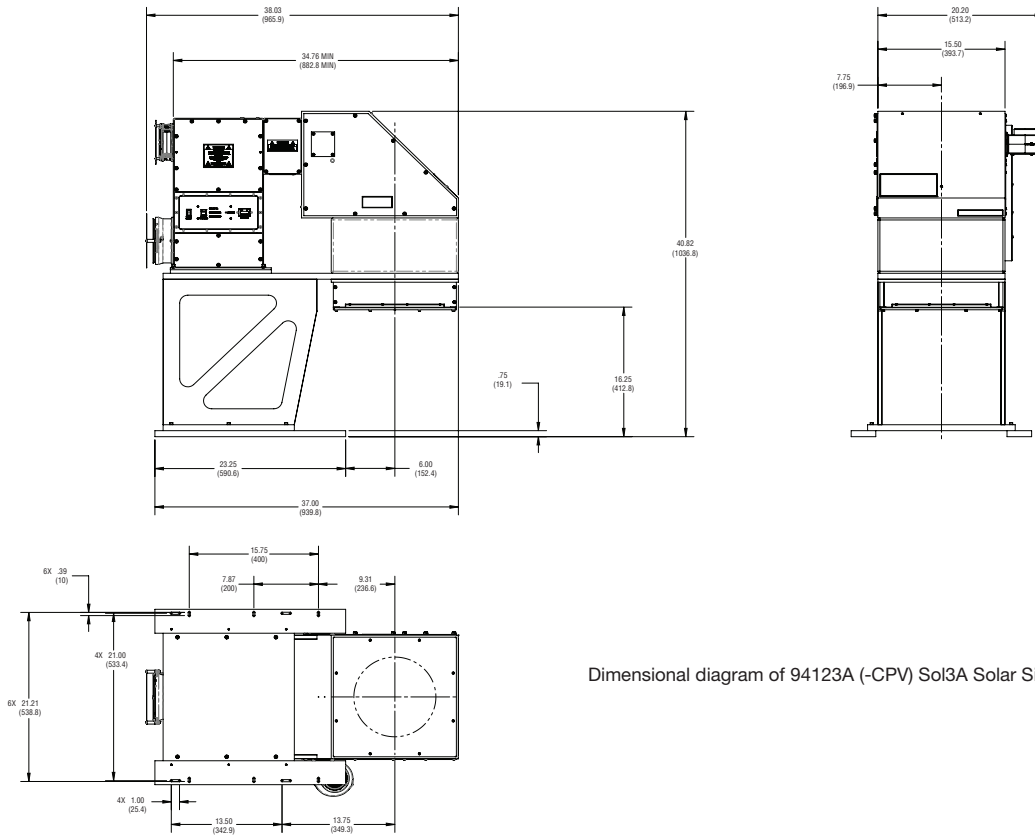
Dimensional diagram of 94023A Sol3A Solar Simulator.



Dimensional diagram of 94043A Sol3A Solar Simulator.



Dimensional diagram of 94083A Sol3A Solar Simulator.



Dimensional diagram of 94123A (-CPV) Sol3A Solar Simulator.