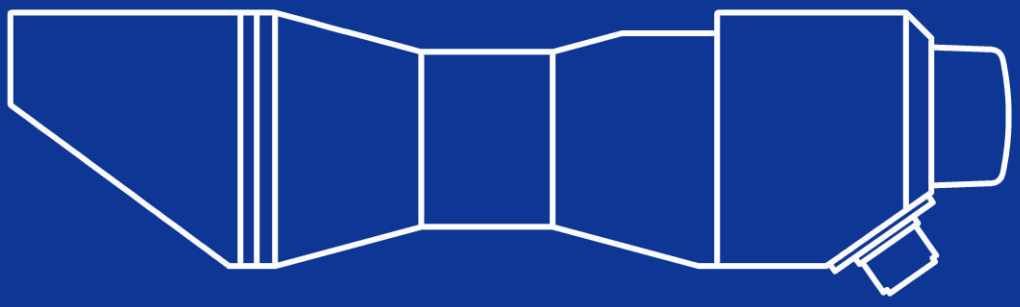
INSTRUCTION MANUAL

MS-57

Pyrheliometer
ISO9060: 2018 Class A
ISO9060: 1990 First class



EKO

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2. Important User Information

Thank you for using EKO Products

Reading this manual is recommended prior to installation and operation of the product. Keep this manual in safe and handy place for whenever it is needed.
For any questions, please contact us at below:

2-1. Contact Information

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2-2. Warranty and Liability

For warranty terms and conditions, please contact EKO Instruments or your distributer for further details.
EKO guarantees that the product delivered to customer has been tested to ensure the instrument meets its published specifications. The warranty included in the conditions of delivery is valid only if the product has been installed and used according to the instructions provided in this operating manual.

In case any manufacturing defect(s) will occur, the defected part(s) will be repaired or replaced under warranty; however the warranty will not be applicable if:

- Any modification or repair has been done by other than EKO service personnel.
- The damage or defect is caused by disrespecting the specifications mentioned on the product brochure or instruction manual.

2-3. About Operating Manual

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This manual was issued: 2019/04/11

Version Number: 3

2-4. Environment

1. WEEE Directive 2002/96/EC (Waste Electrical and Electronic Equipment)

This product is not subjected to WEEE Directive 2002/96/EC however it should not be mixed with general household waste. For proper treatment, recovery and recycling, please take this product(s) to designated collection points.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

2. RoHS Directive 2002/95/EC

EKO Instruments has completed a comprehensive evaluation of its product range to ensure compliance with RoHS Directive 2002/95/EC regarding maximum concentration values for substances. As a result all products are manufactured using raw materials that do not contain any of the restricted substances referred to in the RoHS Directive 2002/95/EC at concentration levels in excess of those permitted under the RoHS Directive 2002/95/EC, or up to levels allowed in excess of these concentrations by the Annex to the RoHS Directive 2002/95/EC.

2-5. ISO/IEC 17025

EKO Instruments Co. Ltd. calibration laboratory is accredited by Perry Johnson Laboratory Accreditation, Inc. (PJLA) to perform pyranometer and pyrheliometer calibrations in accordance with the requirements of ISO/IEC17025, which are relevant to calibration and testing.

EKO is a unique manufacturer who can offer calibration service for pyranometers and pyrheliometers in-house. Based on the applied calibration methods EKO provides the best quality solar sensor calibrations compliant to the international standards defined by ISO/IEC17025 / 9847 (Indoor calibration method) and ISO9059 (Outdoor calibration method).
(http://eko-eu.com/products/solar-radiation-and-photonic-sensors/pyrheliometer)

ISO/IEC17025 provides a globally accepted basis for laboratory accreditation that specifies the management and technical requirements. With calibrations performed at the EKO Instruments laboratory we enable our customers to:

- Clearly identify the applied calibration methods and precision
- Be traceable to the World Radiation Reference (WRR) through defined industrial standards:
  ISO9846 Calibration of a pyranometer using a pyrheliometer
  ISO9847 Calibration of field pyranometer by comparison to a reference pyranometer
  ISO9059 Calibration of field pyrheliometers by comparison to a reference pyrheliometer
- Obtain repeatable and reliable calibration test results through consistent operations

Our clients will obtain a highly reliable data by using an ISO/IEC17025 calibrated sensor. Our Accredited lab is regularly re-examined to ensure that they maintain their standards of technical expertise.

DECLARATION OF CONFORMITY

We: EKO INSTRUMENTS CO., LTD
1-21-8 Hatagaya Shibuya-ku,
Tokyo 151-0072 JAPAN

Declare under our sole responsibility that the product:

Product Name: pyrheliometer
Model No.: MS-57

To which this declaration relates is in conformity with the following harmonized standards of other normative documents:

Harmonized standards:

EN 61326-1:2013 Class A (Emission)
EN 61326-1:2013 (Immunity)
EN 61000-4-2 EN 61000-4-3
EN 61000-4-4 EN 61000-4-5
EN 61000-4-6

Following the provisions of the directive:

EMC-directive : 2014/30/EU
Low Voltage Directive : 2014/35/EU

Date: July 26, 2016

Position of Authorized Signatory: Deputy General Manager of Quality Assurance Dept.

Name of Authorized Signatory: Shuji Yoshida

Signature of Authorized Signatory: Shuji Yoshida

3. Safety Information

EKO Products are designed and manufactured with consideration for safety; however, please make sure to read and understand this instruction manual thoroughly to be able to operate the instrument safely in the correct manner.

WARNING
CAUTION

Attention to user; pay attention to the instructions given on the instruction manual with this sign.

3-1. General Warnings

1. Setup

- Make sure the instrument and the cables are installed in a location where they will not get soaked.
- When using this instrument by connecting to a measuring instrument, make sure to connect the shield cable to either the signal ground terminal on the measuring instrument side or GND (the reference potential on the single end input side). Noise may be included in the measurement data.
- Although this product is tested to meet EMC Directive compliance requirements, it may not fully satisfy its primary specification/performance when using this product near following locations where strong electromagnetic wave is generated. Please pay attention to the installation environment.

  Outdoor: High voltage power line, power receiver/distribution facility, etc.

  Indoor: Large-size chiller, large rotation device, microwave, etc.
- Do not use this product in environment where corrosive gas, such as ammonia and sulfurous acid gas, are generated. It may cause malfunction.
- Do not install in area that cause salt damages. It may cause malfunction by paint peeling off or corrosion. When installing in area with risk of salt damages, make sure to take following measures:
  1. Wrap the connector with self-fusing tape.
  2. Change the fixing screw to bolt screw made of aluminum.
  3. Run the cables in resin pipe or metal pipe treated with salt-resistant paint such as molten zinc plating.
  4. Periodically clean.
- Do not use this instrument in vacuum environment.
- If the cable and main unit are in risk for getting damaged by birds and small animals, protect the cable and the main unit by using:
  1. Reflective tape
  2. Repellent
  3. Cable duct
  4. Installing bird-spike

To avoid measurement errors, use measuring device with input impedance more than 30MΩ.

2. Handing

- Be careful with glass window when handling instruments. Strong impact to this part may damage the glass and may cause injuries by broken glass parts.

3. Power Supply

- When applying the window heating the power consumption at 12 VDC is approximately 0.5 W. Check your DC output Voltage before operating, higher voltages will lead to permanent damage of the heater.
- Use this instrument with 0.5A fuse connected to the power supply line in series. Without connecting the fuse, it has risks of generating heat and fire due to large-current flowing by the power supply when internal damage on the electronics will occurs.

4. Introduction

4-1. Introduction

The ISO9060:2018 “Fast response and spectrally flat Class A” pyrheliometer MS-57 is a research grade normal incidence direct solar irradiance sensor also known as a pyrheliometer or DNI sensor, which highly suitable for routine operation on automated Sun Tracker. The all-weather MS-57 is sensitive to solar irradiance throughout the spectral range 200 to 4000nm and can work under most extreme conditions in a temperature range from -40°C to 80°C.

In principle to perform high precision direct solar radiation measurements under non-stable atmospheric conditions, ideally a fast responding detector is required to detect quick radiation changes. Although photodiode type detector offers a quick response but it has a limited spectral sensitive range; in contrary thermopile broadband detectors cover the full spectral range, but it is considered to be slow. The versatile MS-57 combines all those features of a quick broadband detector enabled by an advanced technology thermopile detector. It combines a unique fast response time (<0.5s 99%), high sensitivity, excellent thermal stability and very low temperature coefficient to make it hardly immune to ambient temperature variations, therefore it is suitable to be used in a wide temperature range.

The MS-57 has a standard full 5° (degrees) opening angle and 1° slope angle as defined by ISO Pyrheliometers Standards and greatly performs when used in combination with the EKO STR-21(G), STR-22(G) or STR-32(G) Sun Tracker. The standard built-in thermistor (44031, 10kΩ@25℃) or platinum resistance temperature sensor (Pt100, Class A, IEC751 compliance) can be used as a temperature reference for extensive research purposes. The integrated low power window heater prevents dew deposition or frost on the outside window.

The MS-57 has a robust but compact and smooth design which forms the new generation of EKO Instruments solar radiometers that are designed for most demanding Photovoltaic and Meteorological applications at any place on earth.

Each MS-57 is calibrated and tested at EKO upon manufacture against EKO’s reference sensors which are fully traceable to the WRR (World Radiometric Reference) maintained at the PMOD/WRC (Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center) in Davos, Switzerland. Besides, EKO provides a unique calibration service for pyranometers and pyrheliometers compliant to the international standards defined by ISO/IEC17025 / 9059 (Outdoor calibration method). When an ISO/ IEC17025 calibrated sensor is purchased, EKO offers sensor at nearly constant calibration uncertainty. The Accredited lab is regularly re-examined to ensure that they maintain their standards of technical expertise.

4-2. Content of Delivery

Check the package contents first; if any missing item or damage is noticed, please contact EKO immediately.

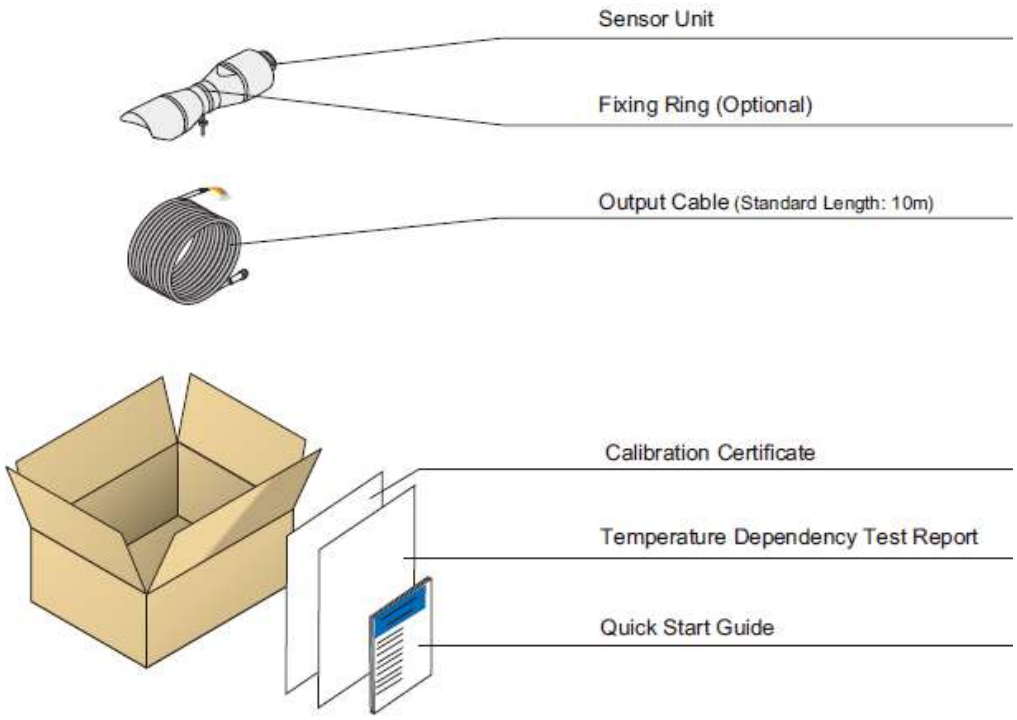


Figure 4-1. Package Contents

5. Getting Started

5-1. Parts Descriptions

MS-57 pyrheliometer is designed to capture direct solar radiation with high precision and long-term reliability. The new concept is a result of combining new technologies with proven pyrheliometer basics to fulfill most stringent demands for solar energy research in the Photovoltaic and Meteorological market.

The Pyrheliometer is based on a well balanced light weight thermopile detector, which gives a highly stable output under most critical situations and variable measurement conditions. Each detector is individually characterized and temperature compensated to guarantee its best performance. During field operating, the detector temperature can be monitored with a thermistor (YSI 44301 / 10kΩ) or platinum resistance temperature sensor (Class A Pt100) to extend further research applications.

Although the MS-57 dimensions are relatively small, it has a full 5° opening angle and 1° slope angle geometry. The front aperture has a unique integrated alignment sight for easy and precise alignment of the instrument on a Sun Tracker. The removable rain cap can be used as a rain shield but can also be taken off when the measurement conditions allow. In order to attain the proper spectral characteristics and spectral range, the pyrheliometer has Quartz precision optics and ultra-low reflective black detector absorber to capture direct solar radiation in the specified spectral range.

The large volume desiccant cartridge ensures a dry environment inside the pyrheliometer to protect delicate optical parts from any condensation. A cable with plug in connector is provided for easy handling and flexibility during installation, maintenance and service. The basic construction outline is shown in the assembly drawing.

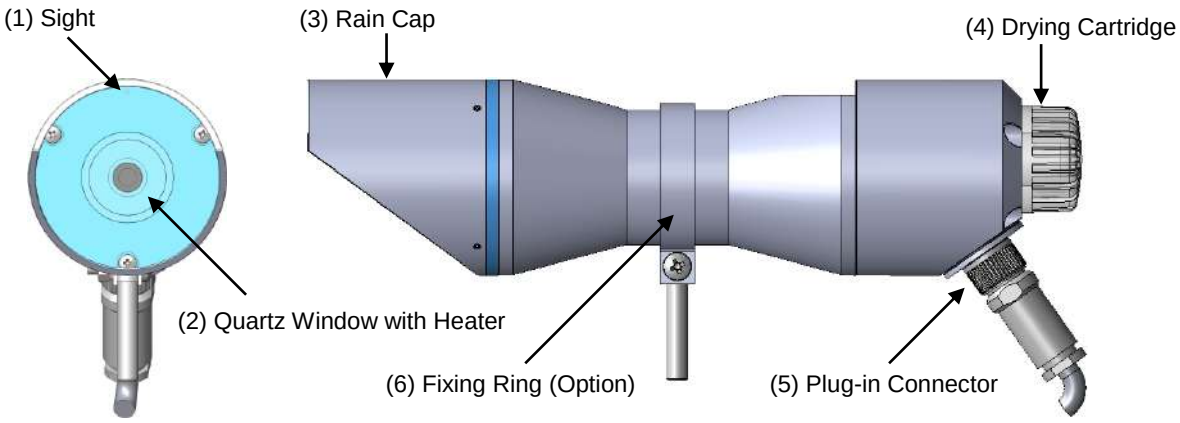
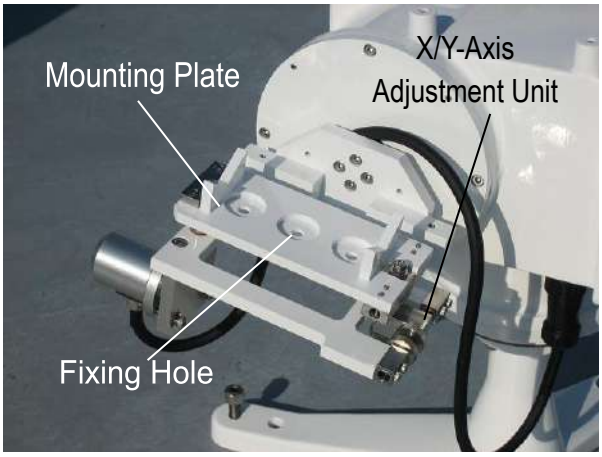


Figure 5-1. MS-57 Body

5-2. Setup

1. Installation

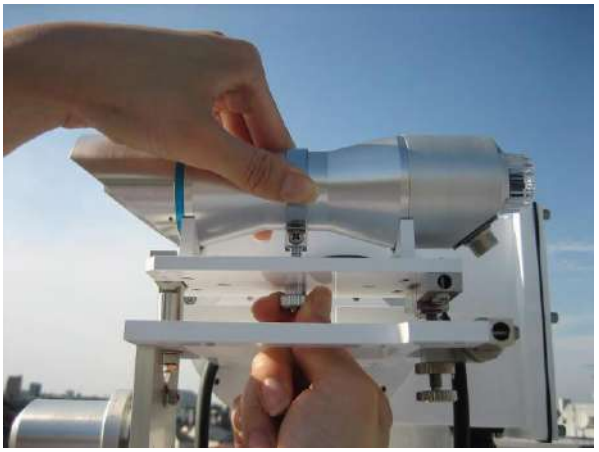
In this application the MS-57 is mounted on the EKO Sun Tracker STR-21G/22G/32G, which is a fully automatic sun tracking system supporting solar sensors capable of measuring Direct, Diffuse and Global radiation.



1) When mounting the MS-57, use the fixing hole in the middle of the mounting plate.
*If the mounting plate is the 2-hole version, it is necessary to replace with 3-hole version. (See following [2. How to Replace Mounting Plate (Optional)])

2) Remove the knurling nut from the MS-57 mounting screw by hand. (Above picture shows condition the knurling nut is removed.)

3) Place the MS-57 on the Sun Tracker mounting plate. Insert the mounting screw through the mounting plate center hole.



4) Attach the knurling nut which was removed earlier back on the mounting screw; tighten so the MS-57 is fixed securely.

2. How to Replace the Mounting Plate (Optional)

When installing MS-57 on EKO Sun Tracker STR-21G/22G/32G, 3-hole mounting plate is required.

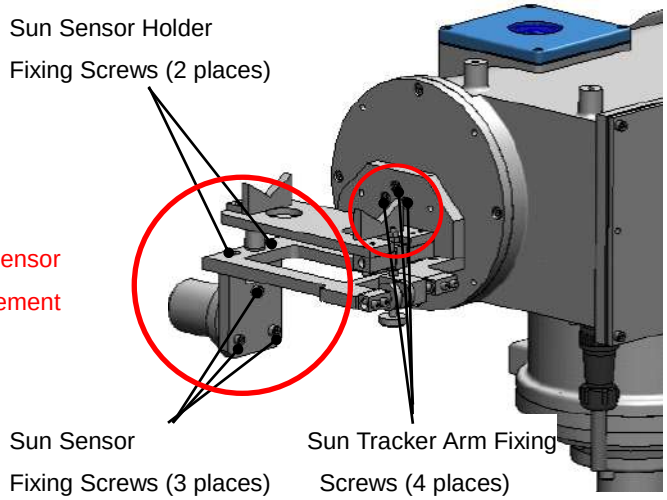
If you already have EKO Sun Tracker purchased before July 2011, you need to purchase the “3-hole mounting plate” (optional part) separately for installing MS-57. If the 3-hole mounting plate is already installed, skip this section and go to [3. Electrical Connection].

「Prepare the following tool for installation」: One Allen Key 2.5 (for M3 screw).

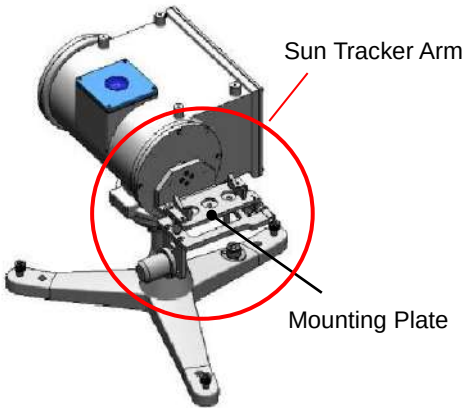
WARNING: DO NOT TOUCH!!

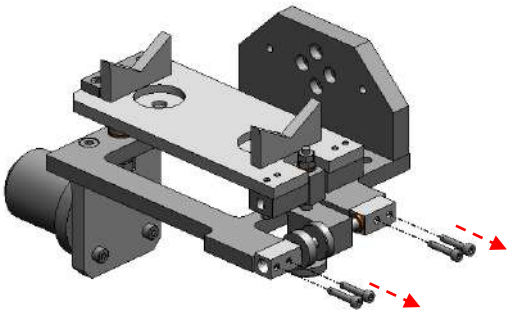
Do Not loosen these screws!

If these screws are loosen, the Sun Sensor position may shift and accurate measurement cannot be taken.



[How to Replace]

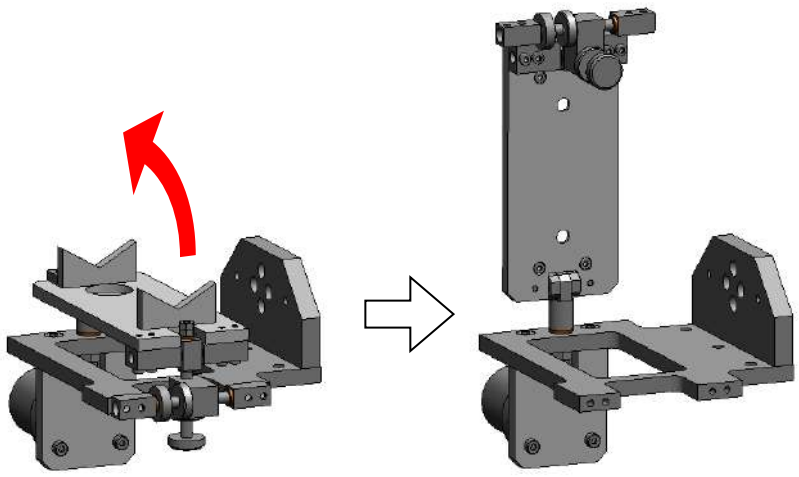




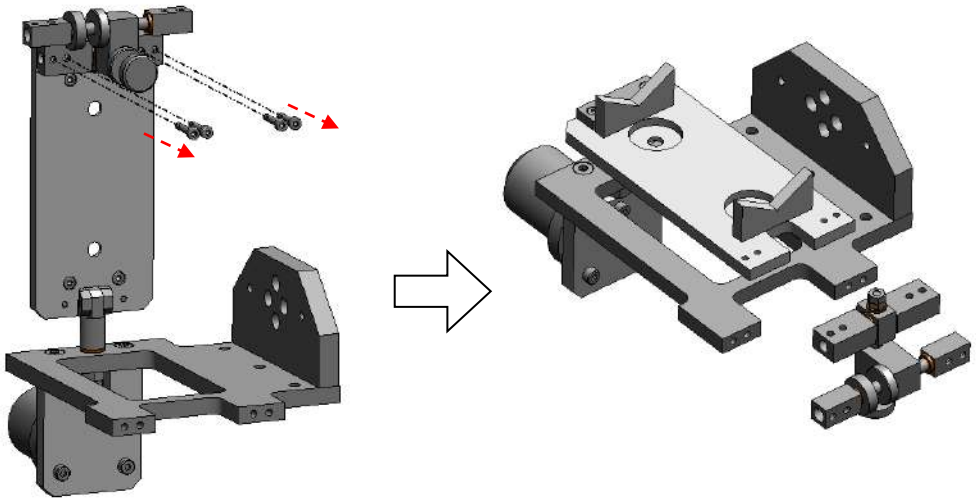
Screws for X/Y-Axis Adjustment Unit
(M3 x 15mm in 4 places)

(1) Remove the 4 fixing screws (M3 x 15mm) which are securing the X/Y-Axis adjustment unit on the Sun Tracker Arm (see above image)

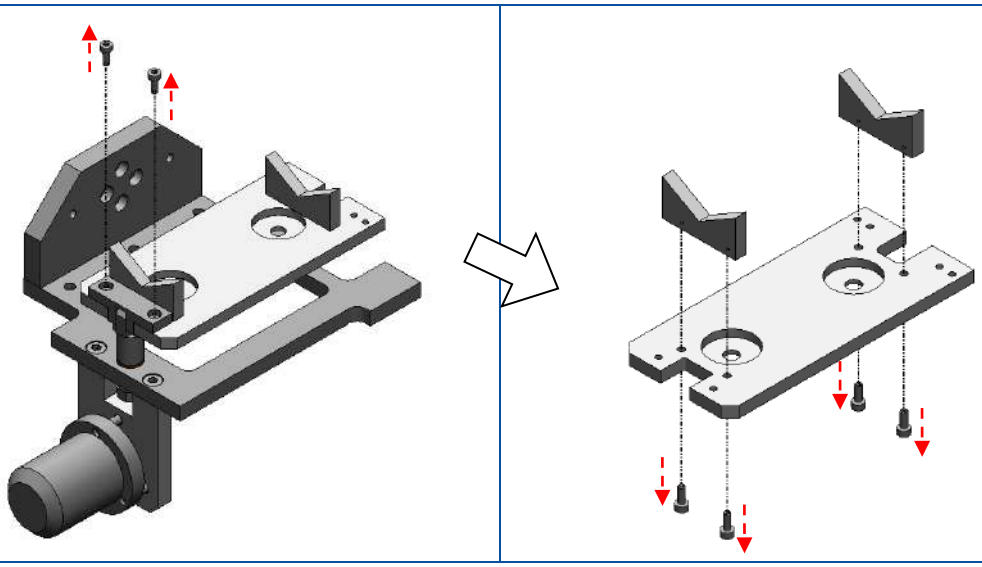
*Be careful not to lose the removed screws!



(2) Lift up the mounting plate as shown on the image above.

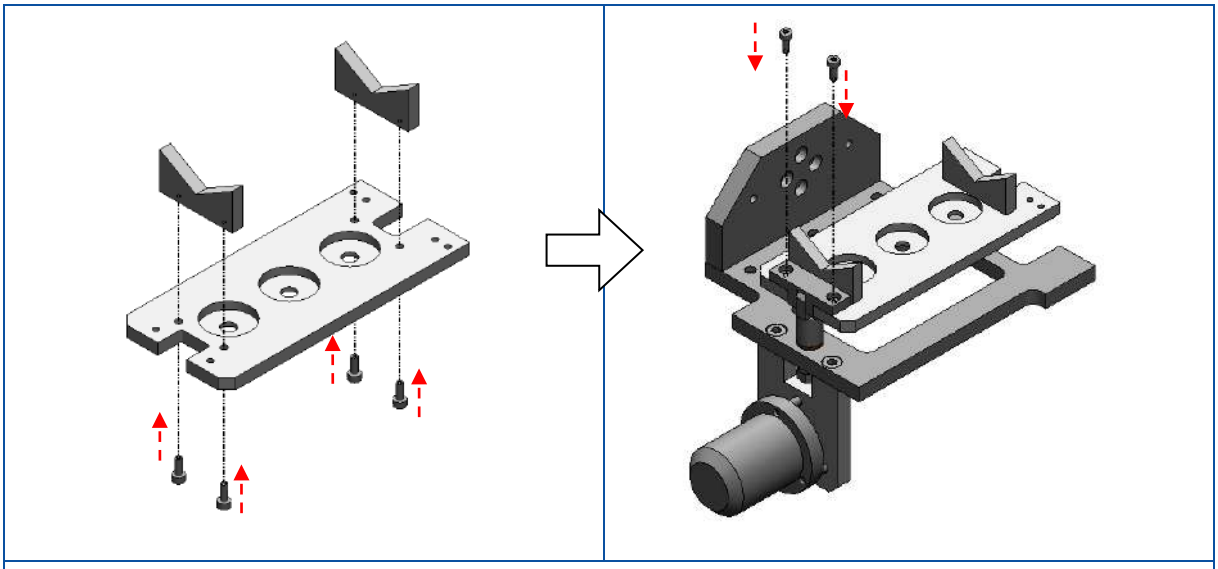


(3) As the mounting plate is lifted, remove another 4 fixing screws (M3 x 15mm) on X/Y-Axis adjustment unit then detach the X/Y-Axis adjustment unit from the mounting plate.

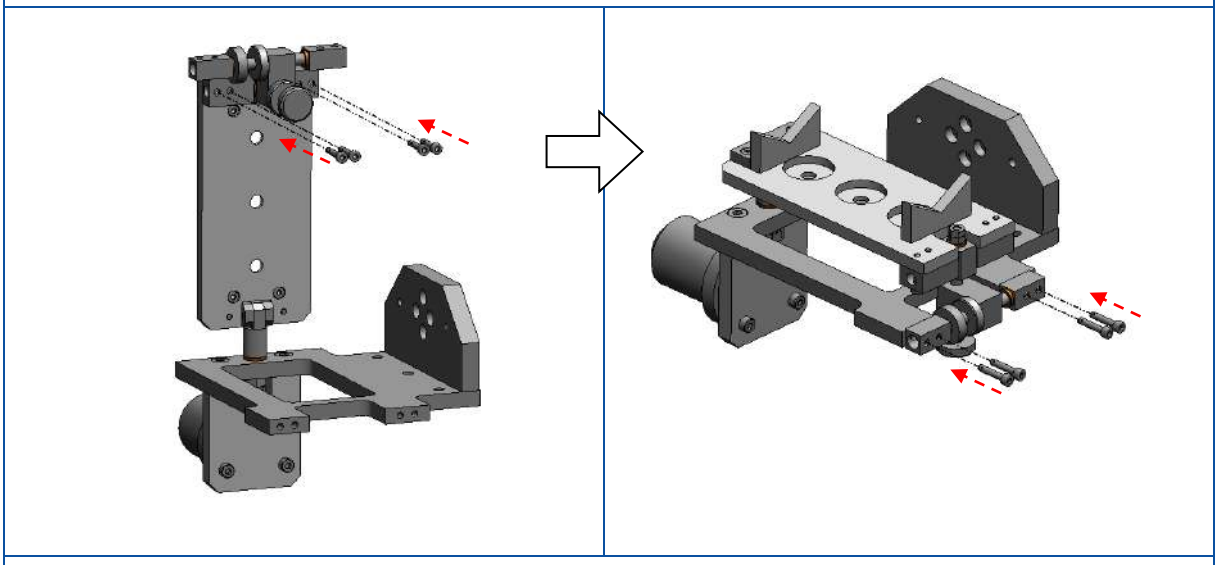


(4) Remove 2 fixing screws (M3 x 15mm) for mounting plate. Detach the mounting plate from the Sun Tracker Arm, and remove the fixing screws on both V-Blocks (M3 x 5mm in 2 places on each V-Block).

Disassembling is completed and the 2-hole mounting plate is replaced with 3-hole mounting plate.



(5) Attach the V-Blocks on the 3-hole mounting plate with fixing screws (M3 x 5mm in 2 laces for each V-Block) then attach the 3-hole mounting plate on the Sun Tracker Arm with 2 fixing screws. (M3 x 15mm)



(6) Attach the X/Y-Axis adjustment unit on the 3-hole mounting plate with the fixing screws (M3 x 15mm in 4 places) then attach the X/Y-Axis adjustment unit on the Sun Tracker Arm with the fixing screws (M3 x 15mm in 4 places)

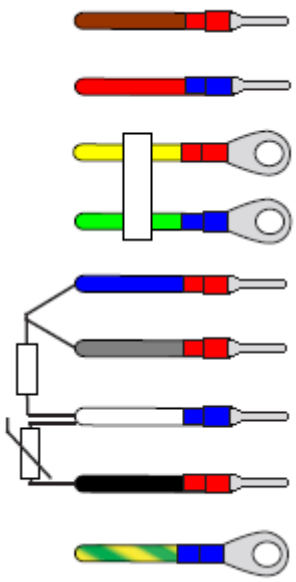
Check to make sure all the screws are placed back in their positions.

3. Electrical Connection

Connect the MS-57 cable to the logger or recoding equipment.

The wire color codes are shown in the table below.

Table 5-1 Wire Color Codes



Color	Wires	
Brown	Sensor output	+
Red	Sensor output	-
Yellow	Heater Input (12V DC)	+
Green	Heater Input (12V DC)	-
Blue	PT100 (A) 3-wire (Internal Temperature)	
Gray		
White	PT100 (B) 3-wire or Thermistor (B)	
Black	Thermistor (A) (Internal Temperature)	
Yellow / Green (Stripe Color)	Ground (Shield)	

Note:

It is recommended to keep the cable length between data logger and the sensor as short as possible. Depending on how the cable is lined, unwanted noise is caused; thus, keep the cable away from the noise cause, such as AC cable or high voltage line. Also in some cases, more noise is seen depending on the type of data logger used.

When installing on the Sun Tracker, make sure to have enough cable length for Sun Tracker rotational movement.

Connect the output cable to the pyrheliometer by inserting the cable connector to the connector on the body then turn the screw cap. Make sure to connect the cable connector; otherwise, the moisture enter to the inside the plug and cause the contact failure.

When installing in area where condensation occur on the Quartz window, it is recommended to use window heater to prevent abnormal output due to condensation. To use the heater, 12V (0.5W) DC power supply is required.

When installing in a site where the distance between MS-57 and the data logger is more than 50m, it is recommended to use voltage/current transducer.

Always connect the shield cable. Otherwise, it will cause the noise and possibly cause the malfunction by the electrostatic or lighting surge.

The pyrheliometer housing is connected to the shielded cable (yellow/green stripe). To avoid 2-point grounding, when the shielded cable is connected to the data logger ground, the pyrheliometer should be electrically isolated from the sun-tracker system or the sun tracking system should not be connected to ground.

To avoid measurement errors use a measuring device with input impedance more than 30MΩ.

4. Sight Spot Adjustment

In order to take an accurate measurement, MS-57 has to be aligned with the sun properly. When the sky is clear, the sunlight will go through the sight and a spot of light is shown on the sight spot surface of body top. Adjust the X/Y-Axis adjustment unit (Zenith and Azimuth angles) so the center of this light spot will hit the dot engraved on the sight spot surface.

When the MS-57 is installed on an automated sun tracking system, like the EKO Sun Tracker and taking a long-term measurement, check the sight spot on the next day after installation to make sure the spot is still in the place, and continue checking the sight spot periodically.

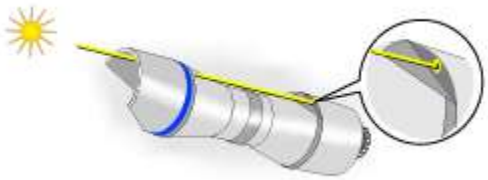


Figure 5-2 Sight Spot Adjustment

5-3. Operation

After installing and connecting MS-57 to the measurement device, MS-57 can be operated and is ready to collect solar radiation data.

It is recommended to use the window heater to prevent dew deposition at the Quartz window. Turn on the heater at least 30 minutes before sunrise. After sunrise, the window heater might be switched off to save energy.

1. Calculate Direct Normal Incidence Solar Irradiance

The direct normal incidence solar irradiance is calculated from the measured output voltage according to the following linear expression.

$$I = E / S$$

I	[W/m^2]:	Direct Normal Incidence solar irradiance
E	[µV]:	Output voltage of the sensor
S	[µV/W·m^{-2}]:	Sensitivity (Indicated on the calibration certificate)

2. Calculate Direct Horizontal Incidence Solar Irradiance

The direct horizontal incidence solar irradiance is calculated from the measured output voltage according to the following linear expression.

$$I_{hor.} = I \cdot \sin\theta$$

θ	[°]:	Solar Elevation Angle

3. Calculate Detector Temperature

When a thermistor temperature sensor (44031 10kΩ) is used, the detector temperature T[℃] can be converted from resistance R[Ω] by using the following formula. The temperature conversion table is also shown in Appendix A-2.

[Thermistor (44031 10kΩ)]

$$T = (\alpha + \beta\ (\ln(R)) + \gamma(\ln(R))^3\ )^{-1} - 273.15$$

$\alpha = 1.0295 \cdot 10^{-3}$

$\beta = 2.3910 \cdot 10^{-4}$

$\gamma = 1.5680 \cdot 10^{-7}$

When using a platinum resistance temperature sensor (Pt100, Class A), see the temperature conversion table shown in Appendix A-3.

6. Maintenance & Troubleshooting

6-1. Maintenance

Once the MS-57 is installed, it is essentially free of any maintenance although care must be taken to keep the instrument in the best condition for accurate measurement.

1. Data Verification

By analyzing the measurement data (such as irradiance and temperature), user can verify the condition of the instrument. When abnormal data is found, either the sight of the pyrheliometer is not aligned or the instrument has some defect. Check the condition of cable at the same time checking on the pyrheliometer setup condition.

2. Cleaning of Quartz Window

Clean the quartz window with a soft cotton cloth and alcohol or demineralized water when it gets soiled. Since soiling will have an effect on the performance of the radiometer by means of reduced optical transmission of the solar radiation and consequently leads to a reduced detector output. Despite no proper indication can be given on the required cleaning interval since it is strongly depending on the local environmental conditions affected by Rain, Snow, Ice, Dust, Sand, or Salt. Environmental factors like frequent rainfall can also have a positive effect on cleaning by washing off any sand or dust particles. For specific cases it might be an advantage to remove the Rain Cap and benefit from this effect. The success of this approach can be determined empirically.

3. Desiccant Inspection

Periodically the desiccants need to be exchanged to maintain a dry environment inside the pyrheliometer. The frequency of replacement varies with the operating conditions on location but annual replacement is recommended. The section at the next page shows how to replace desiccant.

4. Pyrheliometer Alignment

The measurement performance can also be inspected by carefully analyzing the measurement data (e.g. irradiance and temperature). Any abnormality found in the data might be caused by misalignment of the sensor or defect. At regular intervals, the quality of the cables can be checked like the alignment of the pyrheliometer.

5. Clean the Sight

Sometimes rain and dirt maybe collected in the through-hole for the sight and the sight spot cannot be confirmed. Clean and remove the water and/or dirt by using a small diameter pin.

6. Recalibration

EKO Instruments recommend to recalibrate the sensor every 2 years (*).

(*) When there is no condensation inside of the body.

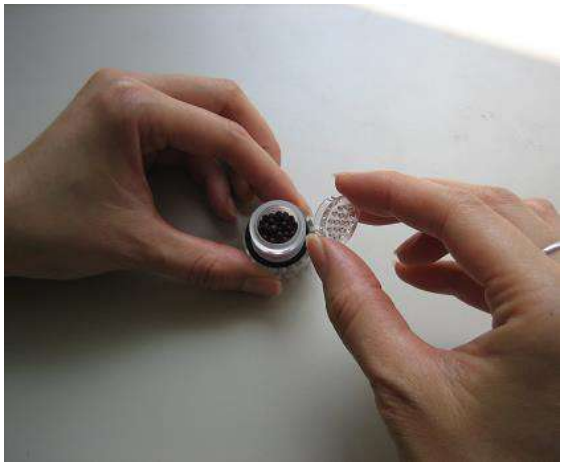
Table 6-1 Maintenance check List

Check List	Action
Data verification	Check the wiring connections
Cleaning of Quartz window	Use soft cotton cloth and alcohol or demineralized water
Desiccant inspection	Change in case the silica gel color turned from blue to reddish color
Pyrheliometer alignment	Check sights for alignment. When the sight spot cannot be confirmed, clean the through-hole with a pin to remove the water and/or dirt.
Recalibration	Every 5 years (*)

[How to Replace Desiccant]

1) Turn the drying cartridge in anti-clockwise. No tools are required.

2) The drying cartridge can be removed easily by hand.



3) Take off the inner lid.

4) Exchange the desiccant then put the inner lid back on the cartridge. Place the drying cartridge back on the MS-57 body and secure it gently.

6-2. Calibration and Measurement Uncertainty

It is recommended to recalibrate the instrument once every 5 years (*). For further information about the calibration and recalibration, please contact EKO.

1. Calibration Method

The MS-57 is calibrated under natural sunlight against the EKO instruments reference pyrheliometer which is traceable to the World Radiation Reference (WRR) maintained at the World Radiation Center (PMOD) in Davos (CH).

Both MS-57 and reference pyrheliometer are mounted on a Sun Tracker to capture the direct solar radiation. The direct solar radiation is measured based on 1 minute averaged value for total of more than 2 hours both in the morning and the afternoon on a clear day. The calibration value of the subjected pyrheliometer was obtained by multiplying the sensitivity value [$\mu V/W \cdot m^{-2}$] of the reference pyrheliometer with the averaged ratio of the measured total direct irradiance data. To improve the calibration accuracy and minimize the measurement uncertainty several operating criteria are applied.

(*) When there is no condensation inside of the body.

2. Calibration Uncertainty and Traceability

The criteria for the operating conditions like the indicated ambient temperature, minimum direct radiation and minimum solar elevation angle are applied to minimize the overall uncertainty in the calibration. The pyrheliometer uncertainty figure is statistically calculated based on a standard deviation of (1.96σ), which means that 95% of the measured direct irradiance values agree with the reference pyrheliometer.

The reference pyrheliometer will be calibrated at every 2 years against a primary standard pyrheliometer, called absolute cavity pyrheliometer. The absolute cavity pyrheliometer is directly traceable to the WRR (World Radiometric Reference) and maintained in the group of standard radiometers calibrated every 5 years during the IPC (International Pyrheliometer Comparison), as well as by NPC (NREL Pyrheliometer Comparison), which is held every year.

The data acquisition system is traceable to JEMIC (Japan Electric Meters Inspection Corporation).

6-3. Troubleshooting

This section contains information that can be used to make a failure diagnosis whenever the sensor does not function properly. Contact your distributor or EKO for any further technical support.

Table 6-2 Troubleshooting

Potential failure	Action
The sensor does not give any signal output	1. Measure the impedance across the sensor output wires. This sensor resistance should lie in the specified range (see 7.1 Specifications). If it is close to zero Ohms there is a short circuit (check the wiring). If it is infinite, there is a broken contact (check the wiring). 2. If no problem found from the above, check the output with another measurement device to make sure the actual data logger or measurement device is functioning properly.
The sensor signal is unrealistically high or low.	1. Check if the correct sensitivity is applied to the algorithm (see 5-3. Operation). Please note that each sensor has its own individual sensitivity. Check if the voltage reading is divided by the correct sensitivity value. 2. Check the sight spot and make sure the MS-57 is aligned to the direction of the sun.
The sensor signal shows unexpected variations.	Although the sensor is hardly susceptible to Electro Magnetic Interference (IME), it may pick up noise depending on the measuring environment. 1. Check the presence of strong EM sources of radar, radio, etc.. 2. Check the grounding condition (shielding). Check the condition of the sensor cable.

7. Specification

7-1. Specifications

Table 7-1 Specification: Specifications are indicated as typical values.

Characteristics	ISO9060: 2018	MS-57
		Class A
	(ISO9060: 1990)	(First class)
	Spectrally flat	Compliant
	Fast response	Compliant
Response time 95% output	＜10 Sec	＜0.2 Sec
Response time 99% output	---	＜0.5 Sec
Zero off-set a) 5K/hr	±1 W/m^2	±1 W/m^2
Total zero off-set b)	±2 W/m^2	±1 W/m^2
Non-stability	±0.5 %/1yr	±0.5 %/5yrs
Nonlinearity	±0.2 %	±0.2 %
Spectral error	±0.2%	±0.2%
Spectral selectivity	±3 %	±1 %
Temperature response -10 to +40℃	±0.5 %	±0.5 %
Temperature response -20 to +50℃	---	±1 %
Tilt response	±0.2 %	±0.2 %
Expected Daily Uncertainty	---	±1%

The content of the characteristic item is partly changed from ISO 9060: 1990. Please also refer to "A-3. Pyrheliometer Characteristics"

Table 7-2. Other Specification

Characteristics	MS-57
Field of View	5°
Wavelength Range	200 –4000nm
Operating Temperature	-40 to +80 °C
Maximum Operational Irradiance	4000W/m^2
Sensitivity	Approx.7μV/W·m^{-2}
Detector Impedance @ 25°C	Approx.15 kOhms
Operating Temperature	-40 to +80 °C
Ingress Protection Rating	IP 67
Low Voltage Regulations	IEC 61326-1-2006
Compliance	CE Compliant
Outer Dimensions (Length x Diameter)	217mm x 55mm
Cable Length (Standard)	10 m
Weight (Including 10m cable)	0.6kg (1.6 kg)
Power for Window Heater to prevent dew deposition	DC12V / 0.5W
Calibration Traceability (ISO 9059)	World Radiation Reference
Recommended Recalibration Interval	Every 5 years
Sensor for Temperature Measurement (Internal Temperature Measurement)	Pt100 Class A, IEC751 Compliance Thermistor 44031, 10kΩ@25℃

7-2. Dimensions

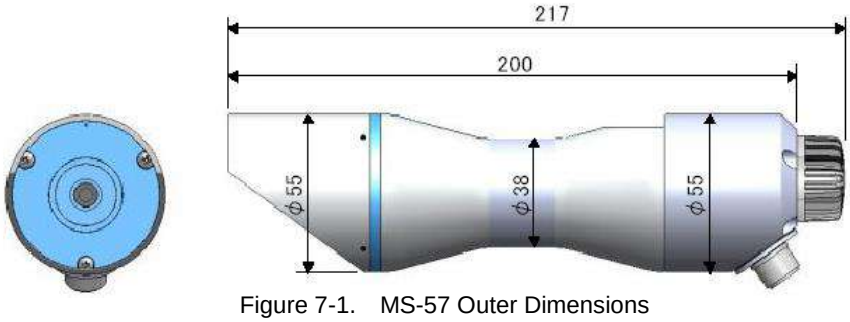


Figure 7-1. MS-57 Outer Dimensions

7-3. Specification Definitions

1. Response Time (Typical)

A response time of less than 0.5s to achieve 99% of the final measurement value is one of the unique features of the MS-57. The small thermopile detector having a low heat capacitance and high thermal conductivity responds quickly to changes of the solar radiation. To keep the detector-output stable and in perfect thermal balance during changing environmental and solar radiation conditions, the detector body is isolated from the sensor housing. When using a data logger with a sampling frequency of 1second, because of the fast responding detector the measurement data are stored without losses of the natural radiation changes.

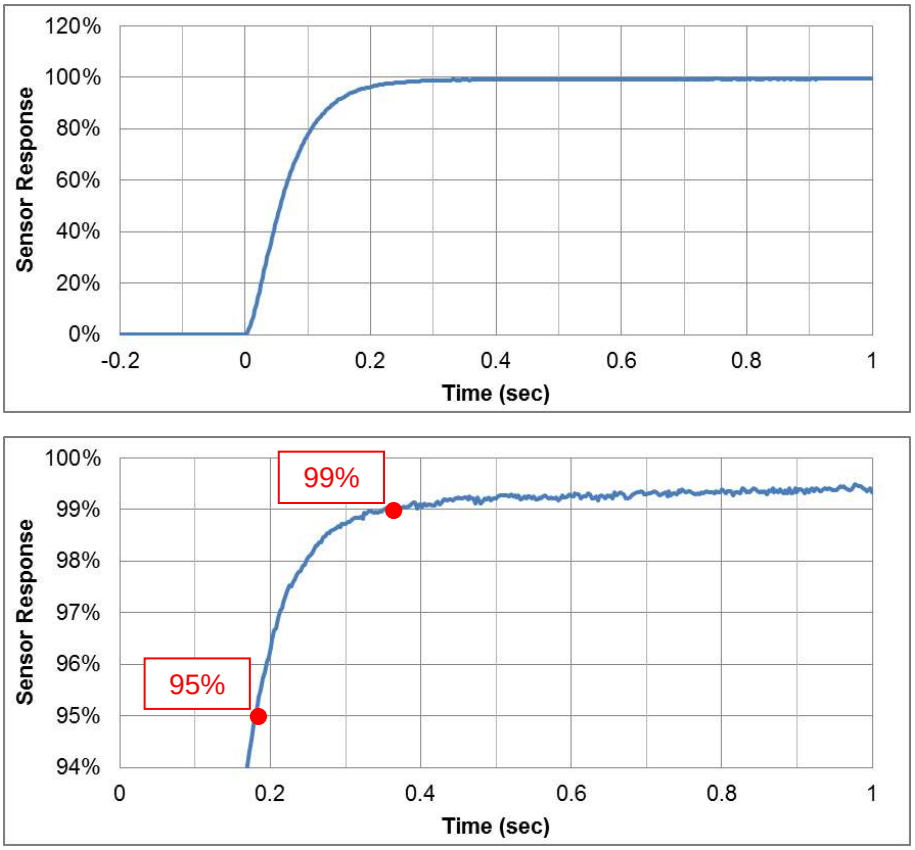


Figure 7-2. Response Time Measurement

2. Temperature Dependency (Typical)

In general the sensitivity of optical detectors depends on the temperature of the instrument because of material properties, known as the temperature coefficient (TC). However the MS-57 sensor construction has a built in special passive compensation network which reduces the temperature dependency to less than +/-0.5% between –20ºC and +50ºC. To achieve this low temperature dependency the sensitivity of each sensor is measured and compensated individually in manufacturing process. For the measurement of the temperature dependency a highly stable 1000 W/m^2 light source (<0.3% variance during total measurement sequence) is used. With each MS-57 measurement report (Temperature Dependency Test Report) is issued indicating the measured temperature dependency of responsivity in steps of 10℃ relative to the output at 20℃.

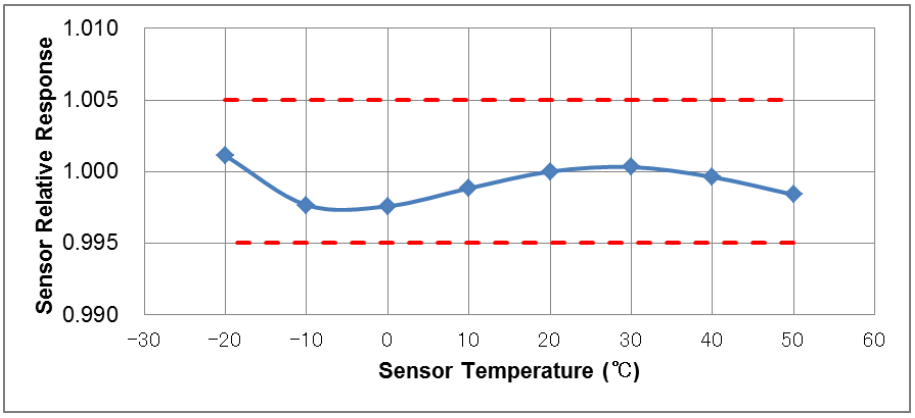


Figure 7-3. Temperature Dependency Measurement

3. Zero Offset (Typical)

Due to a well balanced and light weight detector construction the Zero Offset caused by changing instrument temperature is negligible. The typical Zero Offset was measured according to the ISO 9060 definition at a temperature response of 5K/h change in ambient temperature. A thermally balanced detector is important to guarantee the best measurement stability during variable environmental and solar irradiance conditions.

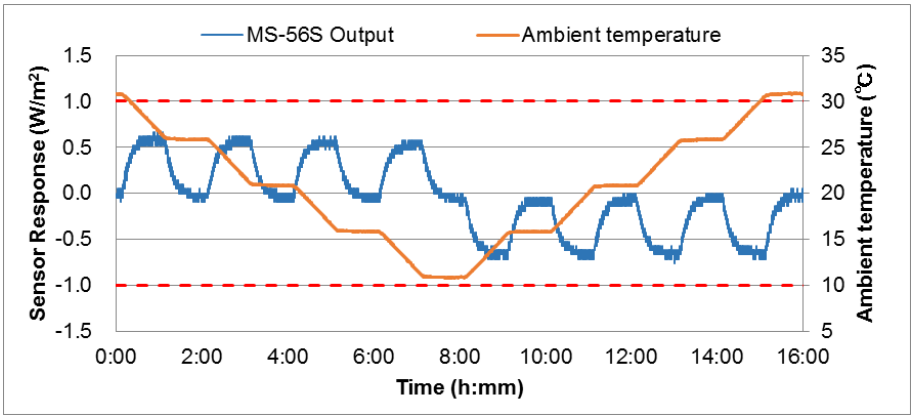


Figure 7-4. Zero Offset Measurement

7-4. Product Accessories

Table 7-3 Accessories List

Accessories	Details
Cable Length*	20, 30, 40, 50m
STR-21/22 Mounting Jigs	Fixing Ring
	Mounting Plate (3-holes)
Drying Cartridge	Drying Cartridge
Replacement Silica Gel	Replacement Silica Gel (desiccant) container (500g)

*Standard cable length: 10m

APPENDIX

A-1. Symbols

Table A-1 Definitions of Symbols

List of symbols	Definitions	Units
E	Output Voltage	μV
S	Sensitivity	$\mu V/W \cdot m^{-2}$
t	Time	s
τ	Response Time	s
T	Temperature	°C
I	Solar Irradiance	W/m^2

A-2. Radiometric Terms

Table A-2. Definitions of Terms

Hemispheric Solar Irradiance	Cosine-weighted solar irradiance received over a solid angle of 2πsr on a plane surface, expressed in units of W/m^2 or kW/m^2.
Global Solar Irradiance, Global Horizontal Irradiance (GHI)	Hemispherical solar irradiance received on a horizontal plane surface, expressed in units of W/m^2 or kW/m^2.
Direct Solar Irradiance, Direct Normal Irradiance (DNI)	Normal-incidence solar irradiance received over a small solid angle which includes the circum solar irradiance, expressed in units of W/m^2 or kW/m^2.
Diffuse Solar Irradiance, Diffuse Horizontal Irradiance (DHI)	Hemispherical solar irradiance without the direct solar irradiance, i.e. indirect irradiance of the scattered solar radiation (by air molecules, aerosol particles, clouds, etc.), expressed in units of W/m^2 or kW/m^2.
Pyranometer	A radiometer designed to measure the hemispheric solar irradiance over the wavelength range of about 300 to 3,000nm.
Pyrheliometer	A radiometer designed to measure the direct solar irradiance over a certain solid angle including the circumsolar irradiance.
World Radiation Reference (WRR)	Radiometric reference instrument system which has an uncertainty of less than +/-0.3%, expressed in SI units. This reference is maintained by the World Meteorological Organization (WMO), and it has been issued since January 1, 1980
ISO9060	An ISO norm (International Standard). The first edition was published in 1990, then the second edition was revised in 2018. Based on the performance of each characteristic, Pyranometer is classified into three classes A, B, and C, and specifications of "Spectrally flat radiometer" and "Fast response radiometer" are set as sub-categories. Pyrheliometer is classified into 4 classes of AA, A, B and C based on the performance of each characteristic, and specifications of "spectrally flat radiometer" and "Fast response radiometer" are set as sub-categories.

A-3. Pyrheliometer Characteristics

Table A-3. Pyrheliometer Characteristics (see also CIMO Guide, WMO No. 8, 2008)

Response Time	The time (seconds) of a pyranometer sensor to reach 95% of its final output signal. (ISO 9060: 2018 added) If the response time reach to 95% is less than 0.5 seconds, "fast response" is attached to the applicable class as a subcategory.
Zero Off-Set a	Response (dark-signal) to 5K per hour change in ambient temperature
Total zero off-set b	(ISO 9060: 2018 added) Total zero off-set including the effects a) and other sources
Non-Stability	Rate of change [%] of the pyranometer sensitivity per year.
Nonlinearity	Percentage deviation from the responsivity at 500W/m^2 due to any change of irradiance within the range 100W/m^2 to 1,000W/m^2.
Spectral error	(ISO 9060: 2018 added) Maximum spectral mismatch error of Pyranometer [%] with respect to spectral irradiance at AM 1.5 and AM 5 under multiple atmospheric conditions on fine weather against the reference standard spectral irradiance defined by IEC60904-3: 2016 Photovoltaic devices - ”Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data.”
Spectral Selectivity	Percentage deviation of the product of spectral absorptance and spectral transmittance from the corresponding mean within the range 0.35μm to1.5μm.
Temperature Response	(ISO 9060: 2018 modified) Percentage maximum output error due to any change of ambient temperature between -10 to 50℃ against the output at 20℃.
Tilt Response	(ISO 9060: 2018 modified) Percentage deviation from the responsivity at 0° tilt (horizontal) due to change in tilt from 0° to 180° at 1,000W/m^2.

A-4. Thermistor Temperature Conversion Table

Table A-4 Temperature Conversion table for the Thermistor (44031, 10kΩ@25℃)

T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]
-30	135200	0	29490	30	8194
-29	127900	1	28150	31	7880
-28	121100	2	26890	32	7579
-27	114600	3	25690	33	7291
-26	108600	4	24550	34	7016
-25	102900	5	23460	35	6752
-24	97490	6	22430	36	6500
-23	92430	7	21450	37	6258
-22	87660	8	20520	38	6026
-21	83160	9	19630	39	5805
-20	78910	10	18790	40	5592
-19	74910	11	17980	41	5389
-18	71130	12	17220	42	5193
-17	67570	13	16490	43	5006
-16	64200	14	15790	44	4827
-15	61020	15	15130	45	4655
-14	58010	16	14500	46	4489
-13	55170	17	13900	47	4331
-12	52480	18	13330	48	4179
-11	49940	19	12790	49	4033
-10	47540	20	12260	50	3893
-9	45270	21	11770	51	3758
-8	43110	22	11290	52	3629
-7	41070	23	10840	53	3504
-6	39140	24	10410	54	3385
-5	37310	25	10000	55	3270
-4	35570	26	9605	56	3160
-3	33930	27	9227	57	3054
-2	32370	28	8867	58	2952
-1	30890	29	8523	59	2854

A-5. Pt100 Class A Conversion Table

Table A-5 Conversion Table for Pt100 Class A (complying with JIS C 1604 1997)

T [°C]	R [Ω]	T [°C]	R [Ω]	T [°C]	R [Ω]
-30	88.2	0	100.0	30	111.7
-29	88.6	1	100.4	31	112.1
-28	89.0	2	100.8	32	112.4
-27	89.4	3	101.2	33	112.8
-26	89.8	4	101.6	34	113.2
-25	90.2	5	102.0	35	113.6
-24	90.6	6	102.3	36	114.0
-23	91.0	7	102.7	37	114.4
-22	91.4	8	103.1	38	114.8
-21	91.8	9	103.5	39	115.2
-20	92.2	10	103.9	40	115.5
-19	92.6	11	104.3	41	115.9
-18	92.9	12	104.7	42	116.3
-17	93.3	13	105.1	43	116.7
-16	93.7	14	105.5	44	117.1
-15	94.1	15	105.8	45	117.5
-14	94.5	16	106.2	46	117.9
-13	94.9	17	106.6	47	118.2
-12	95.3	18	107.0	48	118.6
-11	95.7	19	107.4	49	119.0
-10	96.1	20	107.8	50	119.4
-9	96.5	21	108.2	51	119.8
-8	96.9	22	108.6	52	120.2
-7	97.3	23	109.0	53	120.6
-6	97.7	24	109.3	54	120.9
-5	98.0	25	109.7	55	121.3
-4	98.4	26	110.1	56	121.7
-3	98.8	27	110.5	57	122.1
-2	99.2	28	110.9	58	122.5
-1	99.6	29	111.3	59	122.9

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