

INSTRUCTION MANUAL

Low-Profile Pyranometer

ML-02



EKO

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2. Important User Information

Thank you for using EKO Products

Make sure to read this instruction manual thoroughly and to understand the contents before starting to operate the instrument. Keep this manual at safe and handy place for whenever it is needed.

For any questions, please contact us at one of the EKO offices given below:

2-1. Contact Information

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2-2. Warranty and Liability

For warranty terms and conditions, contact EKO or your distributor for further details.

EKO guarantees that the product delivered to customer has been verified, checked and tested to ensure that the product meets the appropriate specifications. The product warranty is valid only if the product has been installed and used according to the directives provided in this instruction manual.

In case of any manufacturing defect, the product will be repaired or replaced under warranty. However, the warranty does not apply if:

- Any modification or repair was done by any person or organization other than EKO service personnel.
- The damage or defect is caused by not respecting the instructions of use as given on the product brochure or the instruction manual.

2-3. About Instruction Manual

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Version Number: 2

2-4. Environment

1. WEEE Directive 2002/96/EC [Waste Electrical and Electronic Equipment]



In August of 2005, the European Union [EU] implemented the EU WEEE Directive 2002/96/EC and later the WEEE Recast Directive 2012/19/EU requiring Producers of electronic and electrical equipment [EEE] to manage and finance the collection, reuse, recycling and to appropriately treat WEEE that the Producer places on the EU market after August 13, 2005. The goal of this directive is to minimize the volume of electrical and electronic waste disposal and to encourage re-use and recycling at the end of life.

EKO products are subject to the WEEE Directive 2002/96/EC. EKO Instruments has labeled its branded electronic products with the WEEE Symbol [figure Trash bin] to alert our customers that products bearing this label should not be disposed of in a landfill or with municipal or household waste in the EU.

If you have purchased EKO Instruments branded electrical or electronic products in the EU and are intending to discard these products at the end of their useful life, please do not dispose of them with your other household or municipal waste. 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. CE Declaration



IMPORTANT USER INFORMATION



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: Silicon Pyranometer
Model No.: ML-01, ML-02

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

Harmonized standards:

EN 61326-1:2006 Class B (Emission)
EN 61326-1:2006 (Immunity)

Following the provisions of the directive:

EMC-directive : 89/336/EEC
Amendment to the above directive:93/68/EEC

Date: May. 21, 2017

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. WARNING/CAUTION

1. Setup

When installing ML-02 use a proper base to mount the ML-02 with attached bolts and nuts. If the mounting plate and/or mast do not have enough strength, it can break and lead to unexpected accidents and/or injury due to strong wind or earthquake.

2. Resin Diffuser

Giving strong impact to the resin diffuser may cause damage to the sensor. To clean the resin diffuser, use soft cloth without using any organic solvent, such as alcohol.

4. Introduction

The ML-02 is a low-profile pyranometer. The more compact dimensions and height of the sensor body than the conventional sensor make it easy to install anywhere else.

The Silicon detector with UV resistant diffuser will give a proper cosine response to the incoming radiation also at low solar elevation angles. This shape also minimizes soiling effects which could alter the quality of the measurement.

Compared to the reference cells, the ML-02 has a proper cosine response and it is more compact. Moreover, it also benefits from the same characteristics as a PV module (response time, spectral and temperature response).

4-1. Main Features

1. Excellent Characteristics

The ML-02 has excellent cosine response characteristics due to an enhanced diffuser detector construction. The temperature dependency, spectral response and time response function are equivalent to PV modules.

2. Low-Profile and Light Weight

Compared to the existing product(ML-01), the ML-02 has been low profile.(ϕ 20x7.5mm,10g), it is convenient to install ML-02 with products which people care about the appearance of because it is inconspicuous.

4-2. Package Contents

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

Table 4-1. Package Contents

Standard Items	Qty.	Remarks
Sensor	1	With cable already attached to the sensor
Calibration Certificate	1	
Quick Start Guide	1	
Fixing screw	2	[M2.6] x2 [Screw Length: 8mm] service goods Refer to "5-2 Setup 1. Installing on Horizontal or Tilted Position " when using this screw.

5. Getting Startd

5-1. Parts Name and Descriptions

Each part name and its main function are described below.

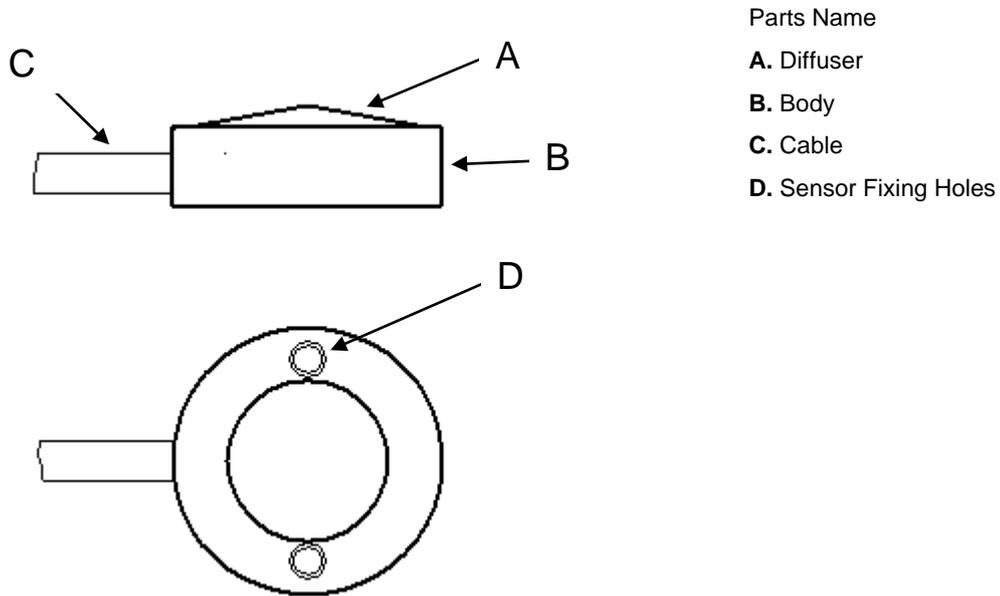


Figure 5-1. Parts Name and Descriptions

1. Diffuser

The special diffuser design gives a proper cosine response and reduces the effects of soiling, remaining water and dust. A durable UV resistant resin is used to perform reliable measurements over time.

2. Body

ML-02 has sensor mounting holes on the bottom of itself. Install the ML-02 using M2.6 screws depending on the situations. ML-02 can be mounted by using double-sided tapes.

3. Signal Cable

ML-02 comes with a sensor signal cable which is already attached and can be used right away. At the end of signal cable is untreated. Please attach a crimped terminal as necessary.

Standard length of the signal cable is 5m. With regards to change of the cable length and the tip of signal cable, please contact EKO.

5-2. Setup

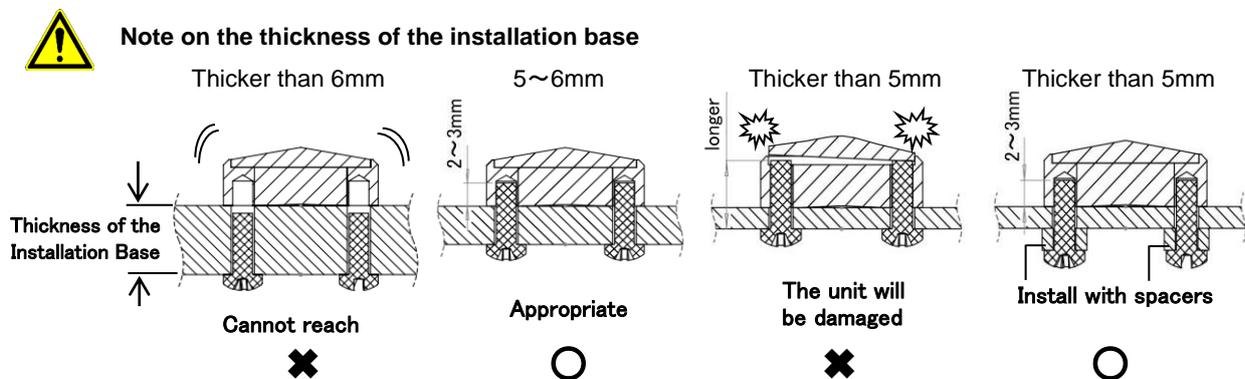
In order to obtain representative measurements working with the ML-02, several criteria with respect to setup and mounting of the instruments have to be considered:

The ideal mounting position for solar sensors is a location which has a full hemispheric field-of-view without any obstructions (such as buildings, trees, and mountain). In practice, it might be difficult to find such locations. Therefore, some practical recommendations on how to minimize undesired effects of reflecting or obstructing surfaces are given next:

- Select a mounting position which it is free from obstructions at 5° above horizon.
- The setup location should be easily accessible for periodic maintenance (glass dome cleaning, desiccant replacement, etc.).
- Avoid surrounding towers, poles, walls or billboards with bright colors that can reflect solar radiation onto the pyranometer.
- A strong physical impact to the pyranometer can lead to product damage and/or may cause changes to the sensitivity.

1. Installing on Horizontal or Tilted Position

- 1) Fasten the main unit to the installation base with two M2.6 screws. The thread depth of the body is 3mm. Note that if the screw penetrates more than 3mm deep into the body, the sensor will be damaged. The screws supplied with the product are 8mm long, which is the optimal length for an installation base 5mm to 6mm thick. If the installation base is thinner than 5mm, use spacers to adjust so that the screws do not protrude into the main unit more than 3mm, as shown in the diagram below. If the installation base is thicker than 6mm, please prepare longer screws that are appropriate for your base separately.



- 2) Check the installation base where the sensor has to be mounted and make sure it has two fixing holes with the appropriate pitch. (See [7-3. Dimension])

2. Wiring

To extend the cable life time, make sure that the cables are not exposed to direct sun light or rain/wind by lining the cable through a cable conduit. Cable vibrations will potentially cause noise on the output signal.

Fasten the cable so that the cable does not swing or move by wind blowing.

Exposure of the signal cable to excessive electromagnetic sources can cause noise on the output signal.

Therefore, the cable should be lined at a safe distance from a potential source generating EM noise, such as a power electronics, high voltage lines or telecom antenna.

Strongly pulling the signal cable will break the cable connections; make sure the cable is not forcibly pulled during the installation.

5-3. Cable Connection

1. Connecting to Measuring Device

- 1) Connect the ML-02 signal cable ends to a measurement device or data logger. Polarities are as follow:

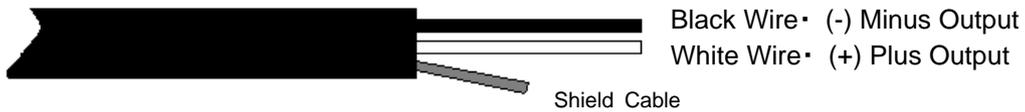


Figure 5-4. Signal cable Ends Polarity

- 2) Check the output voltage. If some noise is seen on the output voltage, connect the shield cable and minus (-) input terminal together.
- 3) Make sure to connect the cable with correct polarities to the measuring device input terminals. White wire is (+), black wire is (-). (It is recommended to use a measurement device with minimum 100k Ω input impedance).

2. Notes for Handling Cables

The sensor signal cable comes with standard length of 5m (directly connected to ML-02 body). In case the cable length is insufficient for your application, please request for desired length at the time of ordering. In case you want to extend the cable length use a shielded low noise cable.

5-4. Measurement

1. Calculation

The global solar irradiance in Watts per meter squared [W/m^2] is obtained when the output voltage E [μV] is divided by the sensitivity of the pyranometer S [$\mu\text{V}/\text{W}\cdot\text{m}^{-2}$]. This calculation is expressed by the following formula:

$$I = \frac{E}{S}$$

I : Measurement Value [W/m^2]

E : Sensor Output Voltage [$\mu\text{V}(\text{mV})$]

S : Sensor Sensitivity [$\mu\text{V}/\text{W}\cdot\text{m}^{-2}$]

* The sensitivity S for the sensor is stated on the calibration certificate and the product label.

2. Measuring Device Requirements

Measurement range settings: If the measurement range can be selected on the data acquisition system, select the measurement range which can accurately measure the signal over a range of 0 to 100mV under the assumption that the global broad-band solar irradiance does not exceed $1,400\text{W}/\text{m}^2$ (in both horizontal and tilted measurement positions) the signal level of the pyranometer output Voltage will remain below 70mV.

This maximum output Voltage can be calculated by multiplying the maximum solar irradiance with the calibration factor (e.g. when the sensitivity of the ML-02 pyranometer is about $50\mu\text{V}/\text{W}\cdot\text{m}^{-2}$ or $0.050\text{mV}/\text{W}\cdot\text{m}^{-2}$, the maximum output voltage is about $1,400\text{W}/\text{m}^2$ times $0.050\text{mV}/\text{W}\cdot\text{m}^{-2} = 70\text{mV}$).

A Si photodiode detector is integrated in the ML-01 which generates a current proportional to the received solar radiation. A shunt resistor is applied across the detector junctions to convert the current output into a voltage.

Note: Make sure to use a measuring device with input impedance more than $100\text{k}\Omega$ and resolution of $50\mu\text{V}$ to detected radiation values of $1\text{W}/\text{m}^2$

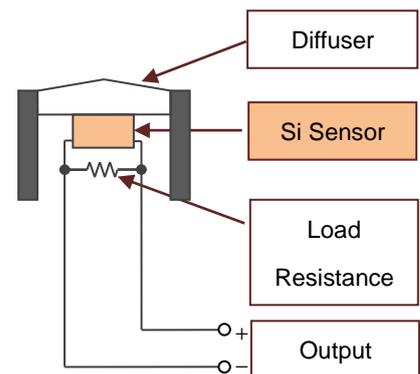


Figure 5-5. ML-02 Construction

6. Maintenance & Troubleshooting

6-1. Maintenance

EKO sensors will provide accurate measurement results if the diffuser and the condition of the instrument are maintained properly. Furthermore, regular maintenance and scheduled re-calibrations can extend the lifetime and precision. However, environmental conditions, such as for instruments mounted near highly frequented traffic lanes or airports, chemical industry, may have a deteriorating effect on the materials. Therefore, proper maintenance is needed and has to be adapted to the local environmental conditions.

The following table describes the common maintenance tasks that should be performed on a regular basis:

Table 6-1. Maintenance Items

Items Maintenance Item	Frequency	How to	Effect
Clean Diffuser	Several times per week (at least once per week)	Keep the diffuser clean by wiping it with a soft cloth.	If the diffuser gets soiled (by accumulation of dirt) the detector output will be affected due to a change in transmittance. This dirt can either be removed manually (not using alcohol) or it is washed off by rain (self cleaning effect).
Check Diffuser Condition	Weekly	Check for cracks and scratches on the diffuser and the rim.	May lead to water leakage due to rain/dew which causes damage of the detector inside the pyranometer.
Check Cable Condition	Weekly	Verify if the cable is properly connected, and how cable is lined; make sure the cable is not swinging by wind.	A disconnected cable will cause sporadic reading errors or failure of operation. If the cable is damaged, it may lead to noise or electric shock (ventilator AC power cable).
Check Setup Base Condition	Weekly	Check if the instrument is tightened properly to the mounting base plate and the base plate and/or table is securely fastened in a proper condition.	Loose instruments and/or mounting plates can lead to damages of the instruments and/or injury.

6-2. Calibration Method

EKO calibrated the ML-02 by the following procedure.

[Indoor Calibration Procedure]

The ML-02 was calibrated to conform the international secondary calibration methods applied to PV reference cells. It was calibrated at 25 °C against an AM1.5G / 1000W/m² radiation source provided by AAA Solar Simulator (IEC 60904-3 Spectral distribution). During the calibration sequence, the incidence irradiance [W/m²] is alternately measured with a calibrated ML-01 sensor (EKO standard) which is used as reference.

The sensitivity figure of the ML-02 product is determined by calculating the output ratio multiplied by the sensitivity figure of the reference model.

Traceability

The ML-01 reference sensor maintained at EKO is traceable to the international radiation scale called WRR (World Radiometric Reference) maintained at PMOD (Davos, Switzerland). The ML-01 reference sensor is calibrated by direct comparison against the secondary standard reference pyranometer MS-802 and 2 units of internal reference pyranometers, which were calibrated against the PMO-6 absolute cavity according to the continuous sun-un-shade method [according to ISO 9846 Calibration of a pyranometer using a pyrhelimeter).

The absolute cavity (PMO6) maintained at EKO is directly traceable to WRR by comparing against WRR every 5 years.

See Appendix A-2 for traceability diagram.

6-3. Troubleshooting

Check the following items in case of trouble with the instrument. If any questions should remain, contact EKO for further technical support.

Table 6-2. Troubleshooting

Failure	Action
There is no output	Make sure that the sensor cable is connected properly to the measurement device. To verify the sensor connection, measure the impedance of signal cable (between the "+" and the "-" wires) and check if the measured impedance is within the proper range as shown on the specification.
	Check whether the measurement range setup on the measuring device is appropriate.
Output value is too low	The diffuser maybe covered by rain drops or got soiled. Clean the diffuser with a soft cloth.

7. Specification

7-1. Main Unit

The spectral response for ML-02 is shown in graph in the Appendix A-1 section.

Table 7-1. Sensor Specification

Characteristics	Details
Measurement Range	0 ~ 2000W/m ²
Spectral range	400 ~ 1100nm
Response time	<1ms
Sensitivity(approx.)	50μV/W·m ²
Output (0~100mV Range)	~100mV
Internal Resistance (approx.)	48Ω
Operating Temperature	-30 ~ +80°C
Temperature Dependency	<0.15%/°C
Directional Response (0°~80°)	<±5%
Field of View	180°
Non-Stability	<±2% per year
Dimension	φ20× 7.5mm
Weight(Not including cable)	10g

7-2. Cable Specifications

Table 7-2. Cable Specifications

Cables	Details	Wire	Output
Cable	Material: KPPV(Shield) Diameter: 0.08mm ² ×2 pins φ2.1mm Cable end: Bare(Untreated)	White Black	(+) Plus (-) Minus

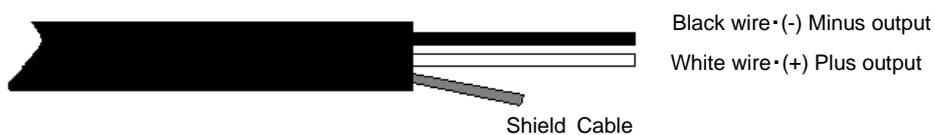


Figure 7-1. Signal Cable

7-3. Dimensions

1. ML-02 Dimensions

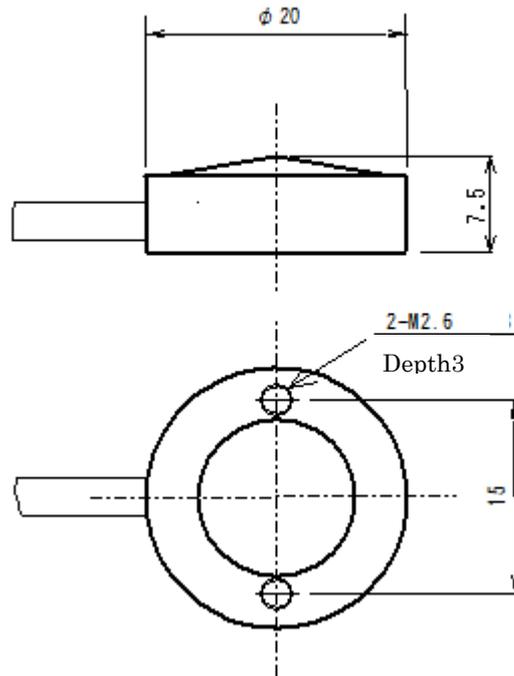


Figure 7-2. Outer Dimensions of ML-02

7-4. Accessories List

Table7-4. Accessories List

Option Items	Remarks
Cable length	5m (Optional 10m)

APPENDIX

A-1. Spectral & Directional Response Characteristics

Below are the typical values of the spectral response and directional response.

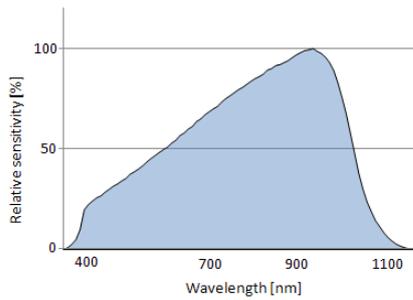


Figure A-1-1. Spectral Response (Typical Value)

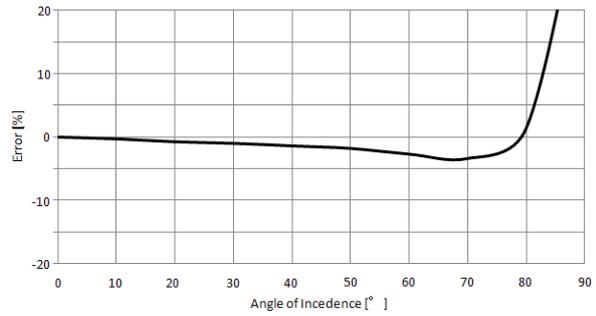


Figure A-1-2. Directional Response (Typical Value)

A-2. Traceability

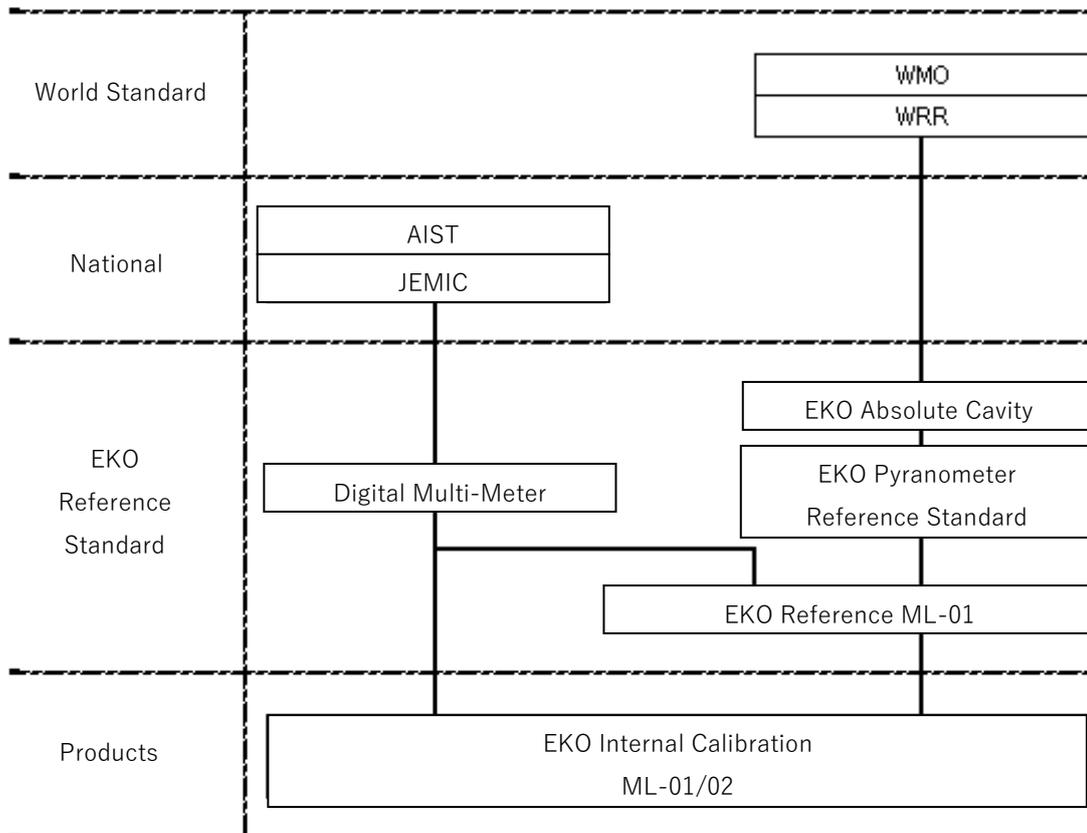


Figure A-2. Traceability Diagram

A-3. Radiometric Terms

Table A-3. Definitions of Terms

Hemispheric Solar Irradiance	Cosine-weighted solar irradiance received over a solid angle of 2π sr 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 circumsolar 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 Meteorological Organization (WMO)	It is a specialized organization of the International Union that carries out international standardization and coordination of meteorological work. WMO: Abbreviation for World Meteorological Organization
World Radiation Reference [WRR]	Radiometric reference instrument system which has an uncertainty of less than $\pm 0.3\%$, 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. Pyrliometer 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-4. Pyranometer Characteristics

Table A-4. Pyranometer 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 200W/m ² net thermal radiation [ventilated]
Zero Off-Set b	Response [dark-signal] to 5K per hour change in ambient temperature
Total Off-set c	[ISO 9060: 2018 added] Total zero off-set including the effects a), b) 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 1000W/m ² .
Directional Response	Also referred to as cosine error [W/m ²]; the range of errors caused by assuming that the normal incidence responsivity is valid for all directions when measuring, from any direction, a beam radiation whose normal incidence irradiance is 1000W/m ² [ISO 9060: 2018 modified] Include the zenith angle of zenith angle 90 ° or more.
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 to 1.5µm.
Spectrally flat Pyranometer	[ISO 9060: 2018 added] If the spectral selectivity is less than 3 %, "spectrally flat" is attached to the applicable class as a subcategory.
Temperature Response	[ISO 9060: 2018 modified] Percentage maximum output error due to any change of ambient temperature between -10 to 40°C against the output at 20°C.
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 1000W/m ² .
Additional processing errors	[ISO 9060: 2018 added] Error generated when converting the analog output of Pyranometer or Pyrhelimeter into a digital signal with a signal converter etc.



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