



# INSTRUCTION MANUAL

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## Radiometer Shadow Ring

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### RSR-01

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Manual Version Number: 1.0



**EKO** EKO INSTRUMENTS CO., LTD.

# 1. 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:

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## 2-1. Contact Information

### EKO INSTRUMENTS CO., LTD.

Asia, Oceania Region

<a href="http://www.eko.co.jp">www.eko.co.jp</a>	EKO INSTRUMENTS Co., Ltd.	
<a href="mailto:info@eko.co.jp">info@eko.co.jp</a>	1-21-8 Hatagaya, Shibuya-ku	Tel: +81 (3) 3469-6713
	Tokyo, 151-0072 Japan	Fax: +81 (3) 3469-6719

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Europe, Middle East, Africa Region

<a href="http://www.eko-eu.com">www.eko-eu.com</a>	EKO INSTRUMENTS Europe B.V.	
<a href="mailto:info@eko-eu.com">info@eko-eu.com</a>	Lulofsstraat 55, Unit 32,	Tel: +31 (0)70 3050117
	2521 AL Den Haag, The Netherlands	Fax: +31 (0)70 3840607

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North & South America Region

<a href="http://www.eko-usa.com">www.eko-usa.com</a>	EKO INSTRUMENTS USA Inc.	
<a href="mailto:info@eko-usa.com">info@eko-usa.com</a>	95 South Market Street, Suite 300	Tel: +1 408-977-7751
	San Jose, CA 95113 USA	Fax: +1 408-977-7741

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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.

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## 2-3. About Instruction Manual

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This manual was issued: 2012/10/01

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## 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. 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.



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



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### 3-1. WARNING/CAUTION

- Do not use these instruments for any other purpose than the intended use
- Do not disassemble, modify or touch inside of these instruments unless instructed in the manual.

## 3. Introduction

The EKO Instruments RSR-01 shadow ring is an economic solution to measure diffuse irradiation at any location on earth. The static Radiometer Shadow Ring RSR-01 can be used with all EKO Pyranometers (MS-802/402/410/602). Dedicated mounting adapters are available for other types of solar sensors (MS-212, other brands).

The shadow ring in combination with one of those pyranometers provides high quality diffuse solar radiation measurements on site. The shadow ring ensures that the radiation sensor always remains in shade for several days before it requires re-adjustment.

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### 3-1. Main features

- Cost effective solution to make diffuse radiation measurements
- Installation in tilted plane

## 4. Getting started

In the following paragraphs the shadow ring components are illustrated to be used for easy assembly and setup.

### 3-1. Content

- 1 Base plate
- 2 Longitudinal pillar
- 3 Longitudinal pillar cover
- 4 Crossbar
- 5 Crossbar fixation
- 6 Crossbar-detector connection
- 7 Shadow ring
- 8 Shadow ring sliding bars, 2x
- 9 Detector-adjusting bar
- 10 Detector-adjusting rail
- 11 Detector-adjusting fixation
- 12 Detector base plate
- 13 Clamping screws, knurled, 4x

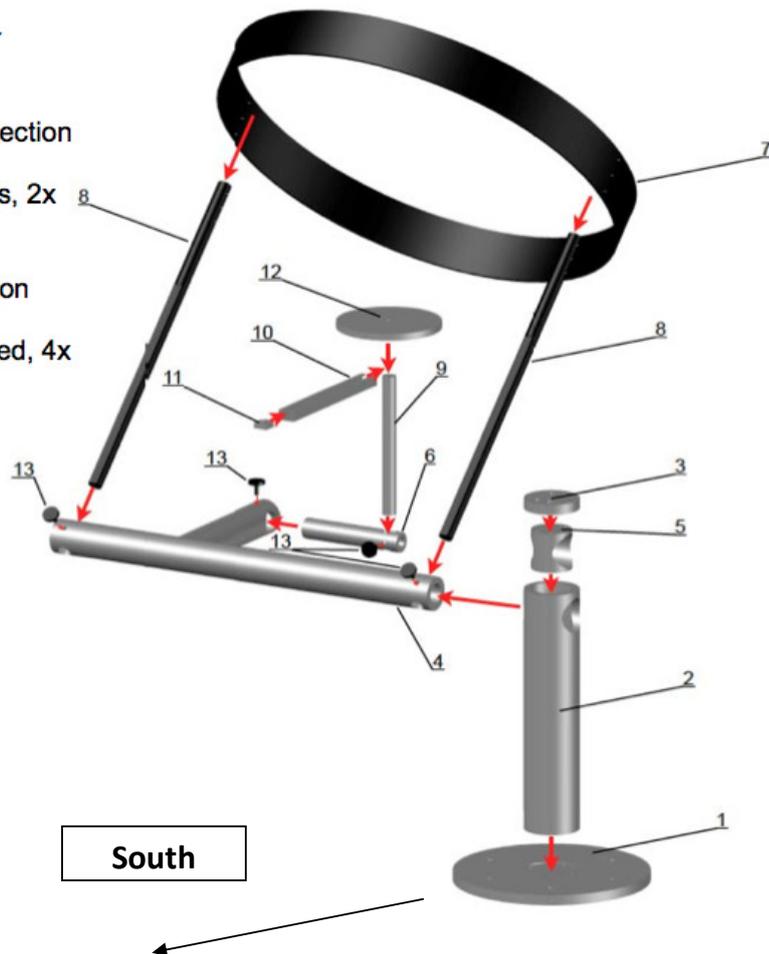


Figure 1 Content & Assembly

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## 3-2. Assembly

For logistic reason the shadow ring can be supplied as a compact kit or as a service can be fully pre-assembled.

According to figure 1, the red arrows illustrate the correct way to assemble the individual parts. The recommended mounting sequence is as follows:

- Attach items 1 and 2, insert 5 and loosely fix 3 on 5.
- Push 4 through the opening in 2 until it reaches the central position (or the scale on 4 meets 2) and temporarily tighten the screws on 3 to fix it.
- Rotate 4 until the local latitude is set on the scale
- Insert 6 into 4a (perpendicular extension of 4) until it is flush with 4a's outside. Again rotate it to the local latitude. The hole in 9 should now face exactly upwards. Finally use 13 to fix the position of 6.
- Push 9 into 6 so that the flattening on 9 faces the mounting hole in 6. Temporarily fix 9 using 13.
- Place 10 centrally on 9 and screw it down (when the RSR-01 is going to be installed outside mid latitude regions the central placement will be insufficient. See section '*Detector base setting*' in the next chapter for details).
- Loosely attach 12 with 11 and push it into 10.
- Screw together 7 with 8 twice and insert them into 4. Use two 13s to fix them temporarily.
- Displace the detector-mounting-unit (9 to 12) as described in section '*Detector base setting*' (next chapter).
- Install the detector and level.

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### 3-3. Setup

Prepare a setup base with fixing holes for the anchor bolts. Make sure that the mounting base can hold total weight of the RSR-01 and the sensor to be mounted. To avoid unexpected accidents or damage due to strong wind or gale, make sure to fasten the base plate on the stage or ground securely.

The ideal mounting position for the RSR-01 is a location which has a free 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 (Sensor cleaning, check for level and cable condition, etc.) of the Sun Tracker and mounted instrument(s).
- Avoid to place the RSR-01 in the area of surrounding objects e.g. towers, poles, walls or billboards with bright colors that can reflect solar radiation onto the pyranometer.

The shadow ring must be installed orientated in North / South direction. By determining the direction of north/south, prepare the setup base to pace the shadow ring.

#### **How to determine the True-North/South:**

True-North/South is a direction to the North/South Pole of the Earth. The North/South pointed by magnetic needle of compass is called magnetic north/south. Magnetic north/south has a deviation from a few degrees to more than ten degrees from True-North/South. Since this deviation differs by areas, it is recommended to check the deviation of magnetic north at your measurement site in advance. When installing the RSR-01, search for True-North/South by correcting the deviation of magnetic north/south.

Apply the following method to setup in the True North-South line:

Using a geographical Map by determining the direction by referencing an object on an accurate terrain map. By referencing a mountain, a building, or a tower which can be seen in far location from the installation site, figure out the direction of the object from the site on an accurate terrain map (such as Google Map), the accurate north/south direction can be determined by using protractor.

Another way to establish this alignment is to observe the sun at 12:00 True solar time (= Local Apparent Time). At this time the sun is exactly south (or north) and hence can serve as exact orientation. Therefore just align the highest point of the shadow ring with the imaginary extension of the sunbeam (do not forget eye protection!). This is a onetime adjustment.

For installation and connection of the pyranometer the sensor manual provides further instructions.

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### 3-4. Adjust to polar axis

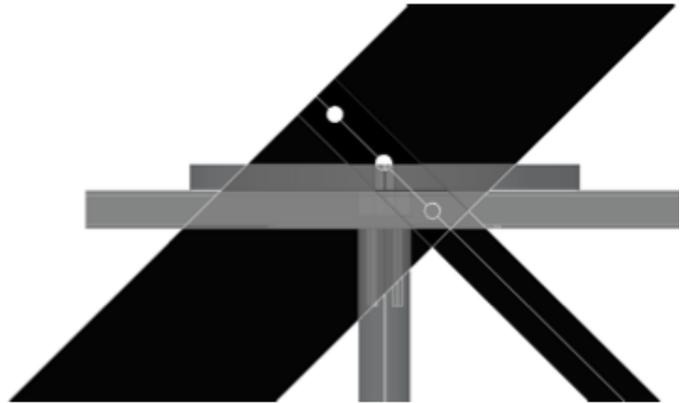
The purpose of this step is to bring the shadow ring sliding bars parallel to the polar axis. Therefore the crossbar has to be rotated in the required tilted position. First make sure the crossbar fixation and the fixing screw for the crossbar- detector connection are unscrewed. Rotate the crossbar in the desired position by watching the attached degree scale. Simply set the observation site latitude. To ensure a horizontal detector position the latitude adjustment has to be done for the crossbar-detector connection also. Now tighten the crossbar fixation and the fixing screw for the crossbar-detector connection again. This installation needs to be done only once, unless the observation site is not changed.

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## 3-5. Adjust detector base height

Before installing the detector itself the detector-adjusting bar has to be shifted to an initial position. The easiest way to achieve this is first to set the shadow ring sliding bars to equinoctial position (declination  $\delta = 0^\circ$ ) and second briefly remove the middle screws on both sides of the shadow ring. Now to enable the



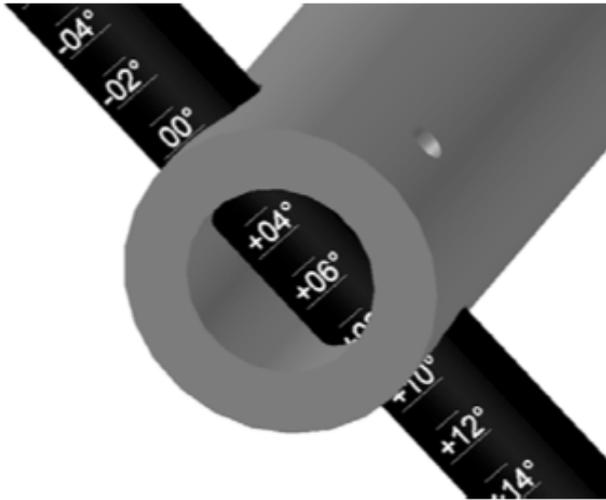
horizontal alignment, loosen the detector-adjusting fixation so the detector base plate is free to slide on the detector-adjusting rail (if the RSR-01 is used on a site near the equator or near the poles the possible displacement offered by the length of the detector-adjusting rail is not sufficient. In that case this rail has to be mounted eccentric in the necessary direction).

Additionally loosen the clamping screw, which fixes the detector-adjusting bar to enable vertical displacement. The next step is to unscrew the detector base plate mounting screw so that it protrudes slightly (or put any vertical extension on the screw). Now you can find the correct initial position by varying the horizontal and vertical displacement as long as the protruded obstacle intercepts the visible connection between the released holes in the shadow ring. Once the detector base plate has reached the initial position fix all screws which allows horizontal displacement and mount the detector. To finalize the detector base setting, displace the detector-adjusting bar downward accordingly the distance between detector base plate top and the detector sensor position. Finally fix the detector-adjusting bar again and return the shadow ring middle screws.

When the observation site is changed or another type of detector is installed, the detector base setting must be repeated.

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### 3-6. Slide bar settings



The correct shadow ring position is a function of the declination of the sun, which shows a trigonometric variation over the year.

To readjust the position of the ring the shadow ring sliding bar needs to be shifted corresponding the attached scale on the bars. The scale shows the declination and the

correct values have to be read out from the upper side of the crossbar according to the related figure.

Positive values refer to the period 21.03. to 23.09. and negative values concern the period 23.09. till 21.03.

The displacement follows the correlation:

$$L_{dist} \propto \tan(\delta)$$



To ensure shading over the measuring period a regular schedule would require readjustment approximately every two days.

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### 3-7. Diffuse Correction algorithm

The sensor on the shadow ring is able to measure the diffuse incoming solar radiation from the upper hemisphere (solid angle of  $2\pi$  – the obscured fraction of the ring).

To obtain an estimation of the incoming radiation ( $2\pi$ ) that would be received from the entire hemisphere and compensate for the obscured fraction of the shading ring, a correction can be applied.

The factor for uniform sky radiation can be calculated using following relation (derivation, see e.g. *Oliveira et al. 2002*), where  $b$  denotes the ring widths,  $R$  the ring radius,  $\delta$  the declination,  $z$  the zenith angle and  $\omega$  the hour angle with  $\omega_{z0}$  as half day.

$$F_c = \left\{ 1 - \left( \frac{2b}{\pi R} \right) [\cos(\delta)]^3 \int_0^{\omega_{z0}} \cos(z) d\omega \right\}^{-1}$$

Furthermore, in the absence of the earth's refractive atmosphere, the relations between the sun and a horizontal surface simplifies to (see e.g. *Iqbal 1983*)

$$\cos(z) = \sin(\delta)\sin(\phi) + \cos(\delta)\cos(\phi)\cos(w)$$

Therefore, the correction factor can be calculated for any latitude ( $\phi$ ) using the following equation.

$$F_c = \left\{ 1 - \left( \frac{2b}{\pi R} \right) [\cos(\delta)]^3 [w_{z0}\sin(\delta)\sin(\phi) + \cos(\delta)\cos(\phi)\sin(w_{z0})] \right\}^{-1}$$

#### References

- *Oliveira, A. P., A. J. Machado, and J. F. Escobedo, 2002: A New Shadow- Ring Device for Measuring Diffuse Solar Radiation at the Surface, Journal of Atmospheric and Oceanic Technology, 19, Issue 5, pp. 698-708.*
- *Iqbal M., 1983: An introduction to solar radiation, Academic Press, 390 pp.*

## 5. Specifications

Items	Specifications
Weight	10.5 kg
Ring outer diameter	634 mm
Ring width	73 mm
View angle seen from the detector	13,6 degrees
Max. detector position height	175 mm
Geographical application	Northern / Southern hemisphere



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