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**USER'S GUIDE**  
**for**  
**MIDDLETON SOLAR**  
**EQ09-A, EQ09-AE**  
**CLASS A PYRANOMETER**  
**(and EQ18-A & EQ18-AE Pyrano-albedometer)**

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Middleton Solar, Australia.

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## 1 GENERAL

The EQ09-A Pyranometer is for measuring solar Global Horizontal Irradiance (GHI). It exceeds the requirements for an ISO 9060 Spectrally Flat Class A Pyranometer, and for a WMO High Quality Pyranometer. ISO Class A is the highest accuracy Class<sup>1</sup>. The EQ09-AE version has an in-built signal amplifier.

## 2 CONSTRUCTION

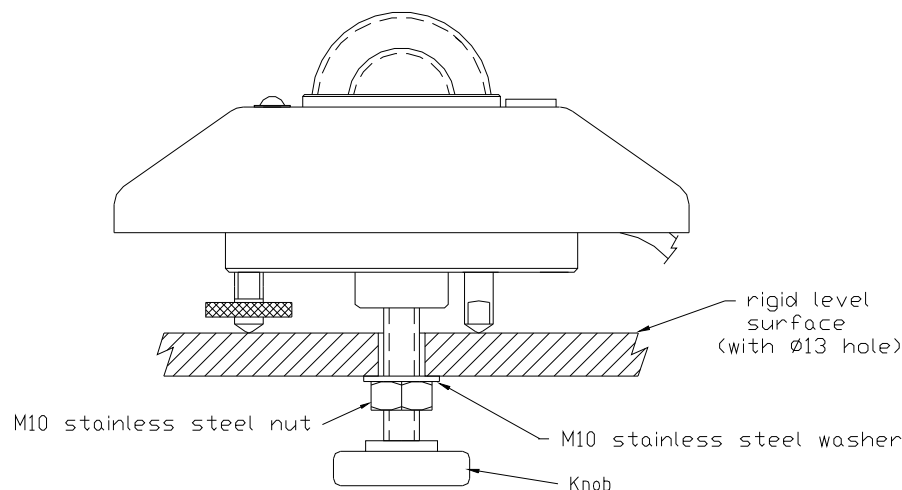
The EQ09-A series is made from anodised marine-grade aluminium to provide a durable corrosion-resistant instrument. It has a blackened thermal sensor shielded by two glass domes<sup>2</sup>. The sensor incorporates a precision thermoelectric element that generates a passive microvolt output proportional to the intensity of the incident radiation. It is equally receptive to all radiation wavelengths and therefore its response to solar radiation is non-selective spectrally. The sensor has been designed to give exceptionally low directional error without compromise to signal strength or response time.

## 3 INSTALLATION

### 3.1 SITE SELECTION

For global radiation measurement, select a site where obstructions do not exceed 5° of elevation, in the path followed by the sun, between earliest sunrise and latest sunset during the year. Avoid positioning the instrument near light coloured objects (eg. painted walls) which can cause errors due to reflection of radiation onto the instrument; also avoid siting near sources of artificial light.

### 3.2 MOUNTING



The EQ09-A should be mounted on a rigid level surface. The instrument has a central M10 x 1.5p hole in its base. The mounting knob supplied should be screwed into this hole and the instrument mounted, as shown above, using the washer & nut provided. Adjust the height of the feet so the circular level is centred. Secure the knob & nut finger-tight only (do not over-tighten).

<sup>1</sup> ISO 9060:2018 'Class A' roughly corresponds to superseded ISO 9060:1990 'Secondary Standard'

<sup>2</sup> carbon nanotube (CNT) is used for the black sensor surface

### 3.3 ELECTRICAL CONNECTION, EQ09-A

The EQ09-A has a shielded output cable. The cable shield can be grounded at the measurement end.

The cable cores are:

red = output +ve (typically  $17\mu\text{V}$  per  $\text{W}/\text{m}^2$ )

blue = output -ve

(option: yellow & green = sensor temperature thermistor; Appendix C)

The measurement equipment should range up to 50mV and have an input impedance of at least  $1\text{M}\Omega$ .

### 3.4 ELECTRICAL CONNECTION, EQ09-AE

The EQ09-AE is supplied with a 4-core lead:

red = supply +V (5 to 15VDC, < 6mA),

blue = supply 0V

yellow = output +ve ( $1\text{mV}$  per  $\text{W}/\text{m}^2$ ),

green = output -ve

The EQ09-AE can be powered from a 6V, 9V, or 12V battery. Alternatively it can be connected to a small power supply or datalogger. The typical fullscale output is <2V. The measuring equipment impedance should exceed  $3\text{K}\Omega$ . The settling time of the amplifier is 50ms from power-up.

Avoid ground loop induced interference in your measurement setup by ensuring there is only one ground point for the sensor and measurement system.

## 4 MAINTENANCE

Keep the outer glass dome clean. Use only water and mild detergent to gently wash the surface. If the outer dome is cracked or pitted it must be replaced. Periodically inspect the sensor plate to ensure that the black surface is intact.

The EQ09-A sensor is hermetically sealed and contains a desiccant sachet to ensure that the interior remains dry and free from condensation. The desiccant is orange silica gel (non-toxic). The desiccant should be replaced when the instrument undergoes periodic calibration. The silica gel changes from orange to clear if moisture has entered the instrument.

To gain access to the dessicant sachet remove the three socket screws that hold the body to the top (it is not necessary to remove the shade disk). When refitting the body take care to locate the O-ring in its groove before securing the three socket screws.

## 5 CALIBRATION

Each pyranometer is individually calibrated during manufacture, according to ISO 9847. It is recommended that the instrument calibration be checked periodically.

## 6 TECHNICAL SPECIFICATION

Performance Specification	ISO 9060:2018 Spectrally Flat Class A	EQ09-A & EQ09-AE
Response time (to 95%)	< 10 sec	8 ±1 sec
Zero off-set a) -200 W.m <sup>-2</sup> thermal rad.	± 7 W.m <sup>-2</sup>	< 3 W.m <sup>-2</sup> (unventilated)
Zero off-set b) 5 K.h <sup>-1</sup> ambient temp.	± 2 W.m <sup>-2</sup>	< ± 1.5 W.m <sup>-2</sup>
Zero off-set c) total response	± 10 W.m <sup>-2</sup>	< ± 5 W.m <sup>-2</sup>
Non-stability (1 year interval)	± 0.8 %	< ± 0.5 %
Non-linearity (100-1000 W.m <sup>-2</sup> )	± 0.5 %	< ± 0.5 %
Directional response (w.r.t. 1000 W.m <sup>-2</sup> )	± 10 W.m <sup>-2</sup>	< ± 10 W.m <sup>-2</sup>
Spectral error (280 to 4,000 nm)	± 0.5 W.m <sup>-2</sup>	< ± 0.4 W.m <sup>-2</sup>
Spectral selectivity (350 to 1,500 nm)	< 3 %	< 3 %
Temperature response (-10 to +40 °C)	± 1 %	< ± 1 %
Tilt response (0-90°)	± 0.5 %	< ± 0.2 %
Additional signal processing errors	± 2 W.m <sup>-2</sup>	EQ09-A, not applicable EQ09-AE < ± 2 W.m <sup>-2</sup>

### General Specification

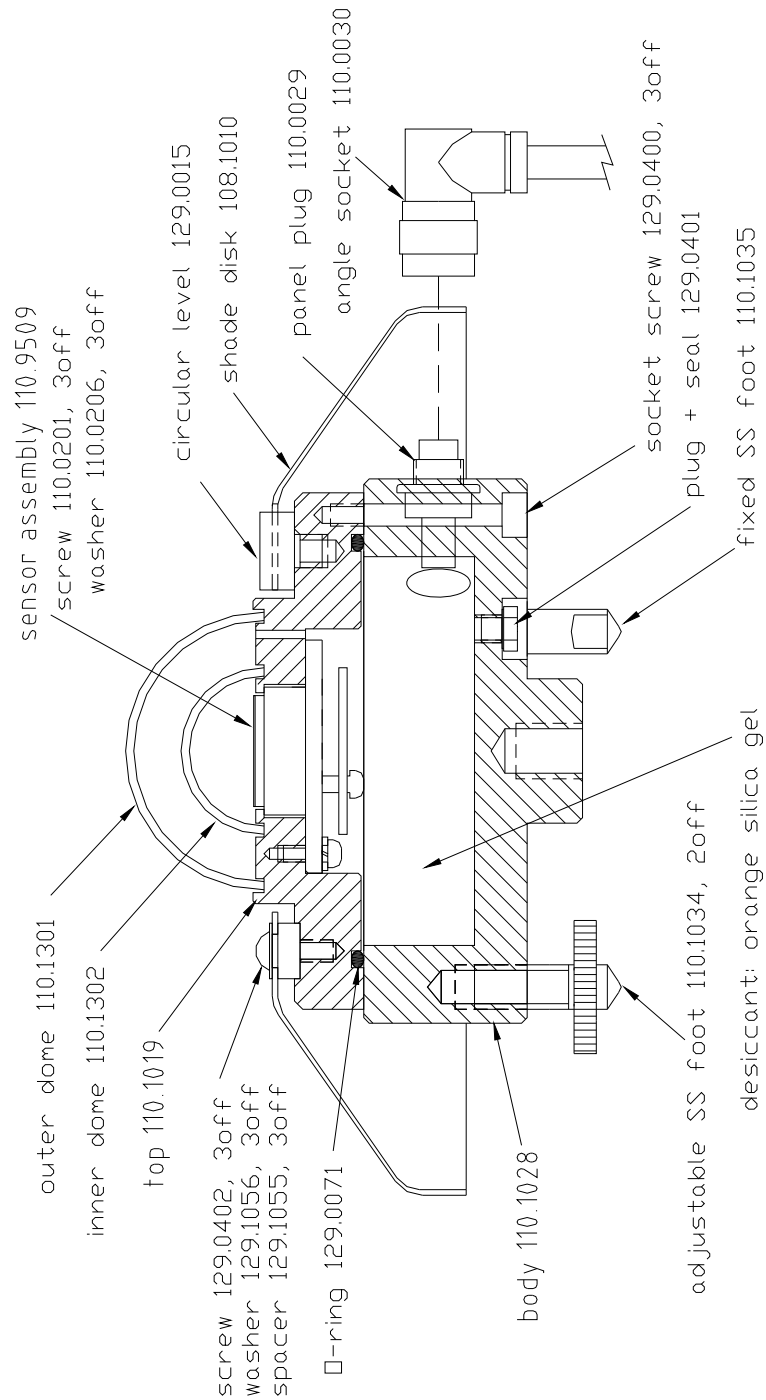
viewing angle	2π steradians
irradiance	0 – 4,000 W.m <sup>-2</sup>
spectral range	300 – 3,000nm (nominal) 305 – 2,700nm (50% points)
sensitivity (typical)	EQ09-A: 17 ± 1 μV/W.m <sup>-2</sup> EQ09-AE: 1.0 mV/W.m <sup>-2</sup>
calibration	outdoors to ISO 9847, traceable to WRR
achievable uncertainty (minute totals)	U <sub>95</sub> = 2% (RSS of instrument, calibration, measurement)
operating temperature	-40 to +80°C
operating humidity	0-100% RH
output impedance	20 Ω (EQ09-A); 65 Ω (EQ09-AE)
measurement input impedance	>1 MΩ
power requirement (EQ09-AE only)	5 to 15 VDC, 6mA
bubble level resolution	0.1°
level adjustment	one fixed foot, two adjustable feet
construction	anodised marine-grade aluminium & stainless steel
desiccant	orange silica gel (non-toxic)
IP rating	sealed to IP67

ISO 9060:2018 requires that Class A pyranometers be individually tested for Directional Response and for Temperature Response.

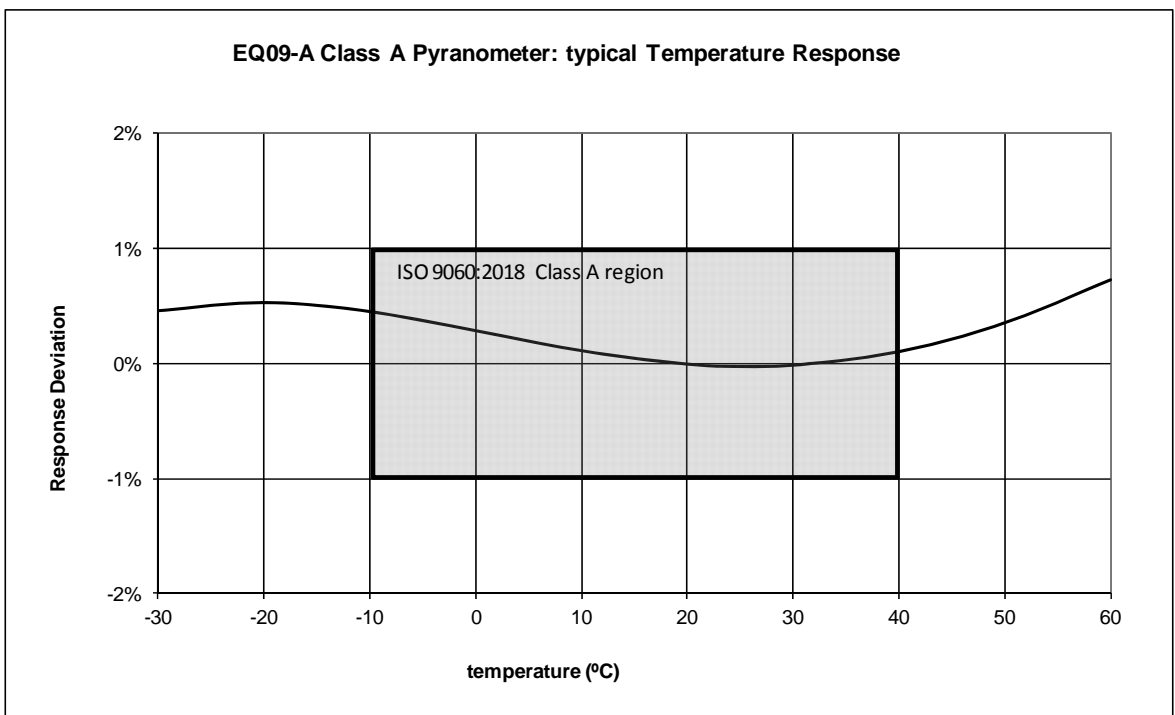
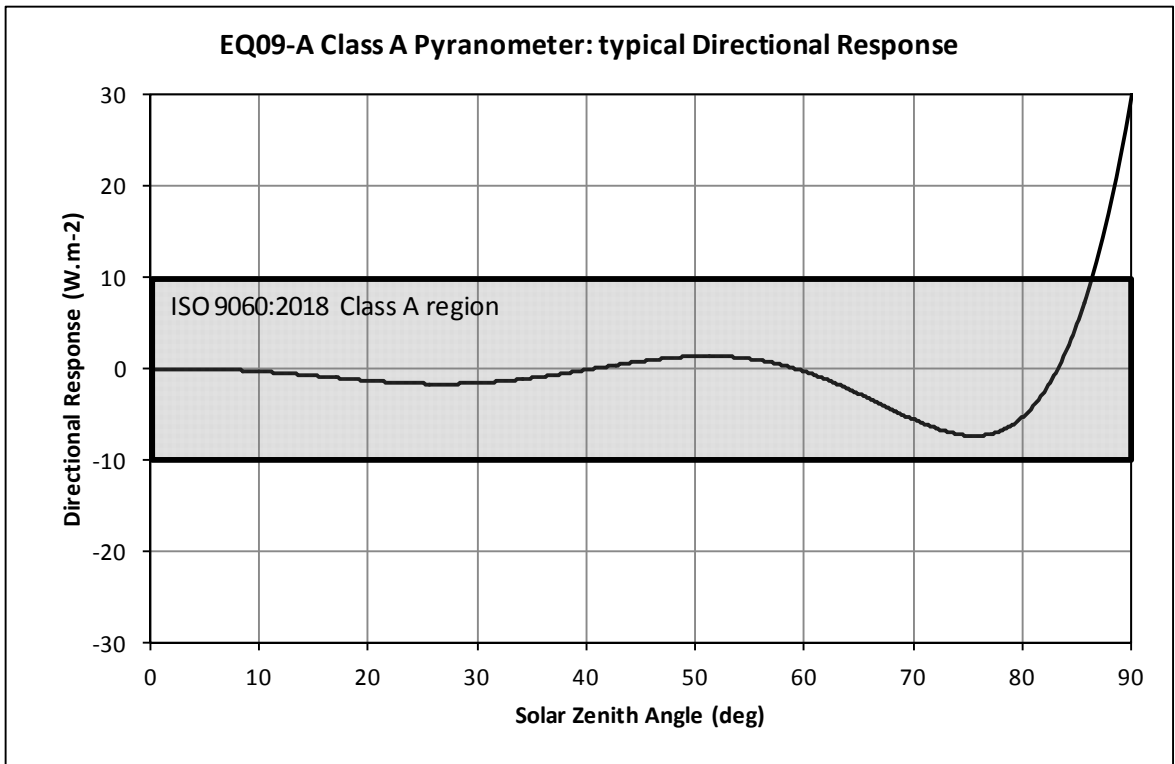
The EQ09-A & EQ09-AE can be optioned as ISO 9060:1990 Secondary Standard pyranometers, without individual Directional & Temperature tests.

## 7 SPARE PARTS

Spare parts may be ordered from the manufacturer or through an approved distributor. For your convenience the part name and number is shown below. Please quote both when ordering. It is also important when ordering parts to include the Serial Number of the instrument, this is inscribed on the identification label of the unit.



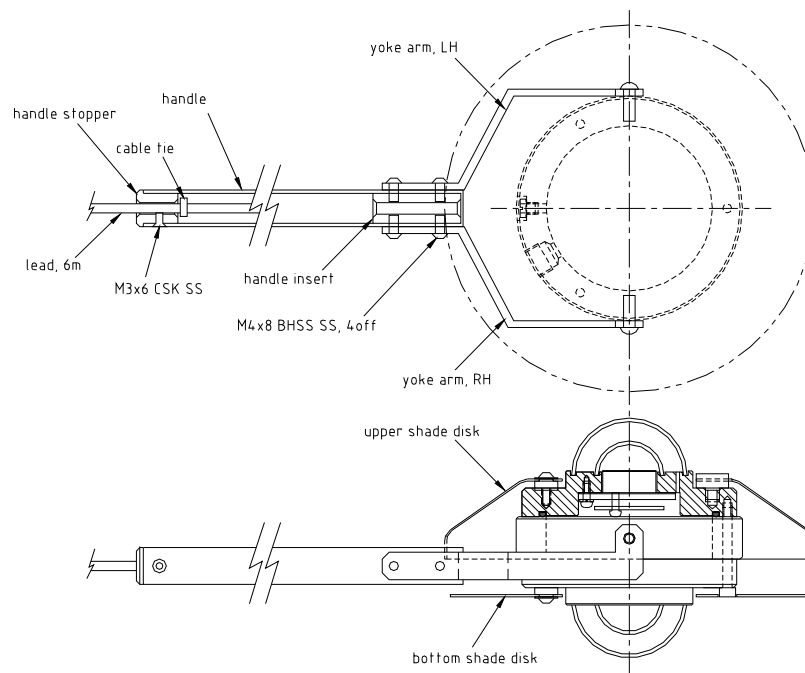
Appendix A: DIRECTIONAL RESPONSE & TEMPERATURE RESPONSE



## Appendix B: EQ18-A & EQ18-AE PYRANO-ALBEDOMETER

Albedo is the ratio of upward to downward flux densities of solar radiation. The EQ18-A Pyrano-albedometer consists of a modified EQ09-A pyranometer with an additional inverted sensor assembly. The dual sensors are matched for response and sensitivity and their collector surfaces are parallel. The EQ18-AE version has dual in-built signal amplifiers.

The EQ18-A is packaged with the handle separated from the instrument body. Screw together the in-line connectors on the lead, then screw the handle tube to the arms on the body using the four M4x8 screws provided.



The sensors have separate outputs.

The output wires for the EQ18-A are:

Top Sensor: red, +ve	Bottom Sensor: yellow, +ve
blue, -ve	green, -ve

The output wires for the EQ18-AE are:

Top Sensor: yellow, +ve	Bottom Sensor: white, +ve
blue, -ve	green, -ve

The input wires for the EQ18-AE are:

red = supply positive (5.5 to 14.5VDC, 12mA)  
black = supply negative

The EQ18-AE can be powered as per the EQ09-AE (see Section 3.4).

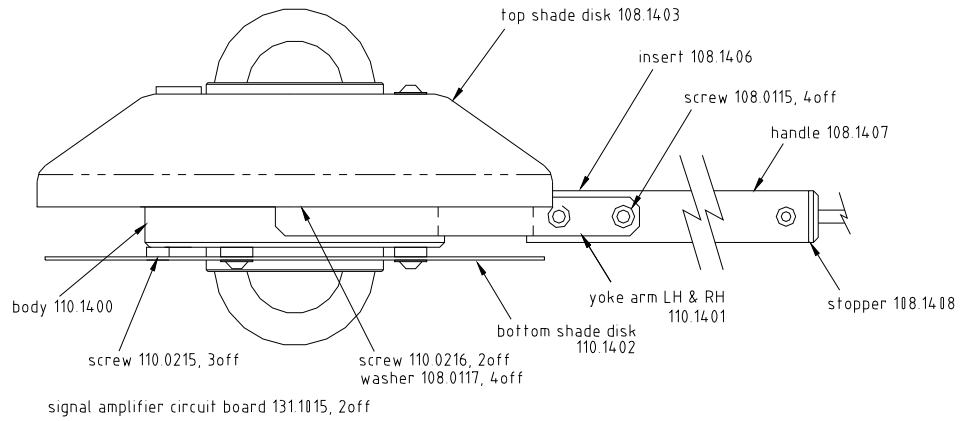
Take care to select a site that is level, as the directional nature of the solar beam means that a surface that slopes toward the sun will receive more radiation than a level surface and thus make the albedo appear too high. If the surface is rough or non-uniform then mount the Pyrano-albedometer as high as possible to integrate



the effect of the surface features. Avoid a site that is subject to shadows or reflected light from adjacent structures.

Mount the instrument horizontally, normally 1-2m above the ground, by clamping the handle to a suitable support.

The part numbers of items unique to the EQ18-A & EQ18-AE are identified below. Other parts are the same as the EQ09-A / EQ09-AE.



Appendix C: SENSOR TEMPERATURE vs THERMISTOR RESISTANCE  
For instruments fitted with optional sensor temperature output

YSI 44031 Thermistor (accuracy =  $\pm 0.2^{\circ}\text{C}$ )

Temperature ( $^{\circ}\text{C}$ )	Resistance ( $\Omega$ )	Temperature ( $^{\circ}\text{C}$ )	Resistance ( $\Omega$ )
-30	135,200	15	15,130
-29	127,900	16	14,500
-28	121,100	17	13,900
-27	114,600	18	13,330
-26	108,600	19	12,790
-25	102,900	20	12,260
-24	97,490	21	11,770
-23	92,430	22	11,290
-22	87,660	23	10,840
-21	83,160	24	10,410
-20	78,910	25	10,000
-19	74,910	26	9605
-18	71,130	27	9227
-17	67,570	28	8867
-16	64,200	29	8523
-15	61,020	30	8194
-14	58,010	31	7880
-13	55,170	32	7579
-12	52,480	33	7291
-11	49,940	34	7016
-10	47,540	35	6752
-9	45,270	36	6500
-8	43,110	37	6258
-7	41,070	38	6026
-6	39,140	39	5805
-5	37,310	40	5592
-4	35,570	41	5389
-3	33,930	42	5193
-2	32,370	43	5006
-1	30,890	44	4827
0	29,490	45	4655
1	28,150	46	4489
2	26,890	47	4331
3	25,690	48	4179
4	24,550	49	4033
5	23,460	50	3893
6	22,430	51	3758
7	21,450	52	3629
8	20,520	53	3504
9	19,630	54	3385
10	18,790	55	3270
11	17,980	56	3160
12	17,220	57	3054
13	16,490	58	2952
14	15,790	59	2854