

Calibration Certificate

Requester : EKO INSTRUMENTS Europe B.V.
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ISO 17025 / ISO 9847



Manufacturer : EKO Instruments Co., Ltd.
Description : Pyranometer
Model : MS-802F
ISO Classification : Secondary Standard
Serial Number : F15508FR
Accessories : Cable/Fanunit
Product Conditions :

Certificate Number : F15508FR-EX16-044
Issue date : April 26, 2016
Calibration Date : April 26, 2016
Calibration Procedure : LM-10

Calibration Conditions

Temperature	25±3	[°C]
Irradiance	1000±50	[W/m ²]
Solar Simulator in-stability	0.3	[%]

Calibration Results

Sensitivity	7.05	[μV/W·m ⁻²]
Uncertainty	0.63	[%] (Coverage factor $k = 1.96$)

The above product is calibrated and traceable to the reference pyranometer in compliance with ISO/IEC9847 Direct beam calibration (type IIc). Measurement uncertainties at the time of calibration are consistent with the Guide to the Expression of Uncertainty in Measurement (GUM).

Reference Instruments	Model	S/N	Sensitivity [μV/W·m ⁻²]	Calibration due
Pyranometer	MS-802	PRN-REF.04	7.033	2016/11/22
Digital Multimeter	34401A	MY41014381		2016/8/5

EKO Instruments Co., Ltd.

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S.Yoshida / Calibration responsible

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Calibration Results

<i>n</i>	Ref. Irradiance [W/m ²]	Pyranometer Output [mV]	Sensitivity [μ V/W·m ⁻²]	<i>n</i>	Ref. Irradiance [W/m ²]	Pyranometer Output [mV]	Sensitivity [μ V/W·m ⁻²]
1	1006.50	7.09	7.04	6	1006.50	7.09	7.05
2	1006.50	7.09	7.05	7	1006.50	7.10	7.05
3	1006.50	7.10	7.05	8	1006.50	7.09	7.05
4	1006.50	7.09	7.05	9	1006.50	7.09	7.04
5	1006.50	7.09	7.05	10	1006.50	7.09	7.04
Σ Mean (<i>n</i> = 10)		7.09	7.05				
Std. deviation			0.0025				

Calibration Procedure

The pyranometer was calibrated against a calibrated reference pyranometer using a 1000 W/m² (AM1.5 class AAA) sun simulator as source. The pyranometer is situated on a horizontal table and aligned to the optical axis of a normal incidence light source. By alternating the position of the calibrated reference pyranometer with the test pyranometer the output signal of both pyranometers are recorded and used to solve the equation of the unknown sensitivity variable. The operating conditions are maintained constant (e.g. ambient temperature and normal incidence irradiance), hence the pyranometer uncertainty figure from 10 readings (*n*) is determined by taking into account the sensitivity uncertainty (*Us*), uncertainty of temperature (*Ut*), normal distribution (*d*), and repeatability (*Ur*) of the reference pyranometer and the max. deviation of the incident irradiance between the measurement intervals.

Uncertainty

The expanded calibration uncertainty associated with the pyranometer sensitivity figure is calculated as the square root of the sum of the squares of the reported uncertainties:

1) Uncertainty of reference (<i>Us</i>)	0.31%
2) Uncertainty of temperature (<i>Ut</i>)	0.07%
3) Repeatability (<i>Ur</i>)	0.04%
4) Distribution (<i>d</i>)	0.04%
Total uncertainty (<i>Uc</i>)	0.32%
Expanded uncertainty (<i>U</i>)	0.63% (Coverage factor <i>k</i> = 1.96)

$$\text{Expanded Uncertainty} = 1.96 \times \sqrt{((Us^2 + Ut^2 + Ur^2 + d^2))}$$

Traceability

Annually the reference pyranometer MS-802 is calibrated against the primary standard PMO-6 according to the sun-and-shade method under ISO9846. The primary standard is directly traceable to the WRR (World Radiometric Reference) and maintained in the group of standard radiometers calibrated every 5 years during the IPC. The data logger is traceable to JEMIC (Japan Electric Meters Inspection Corporation).

Temperature Response Measurement Test Report ISO 9060

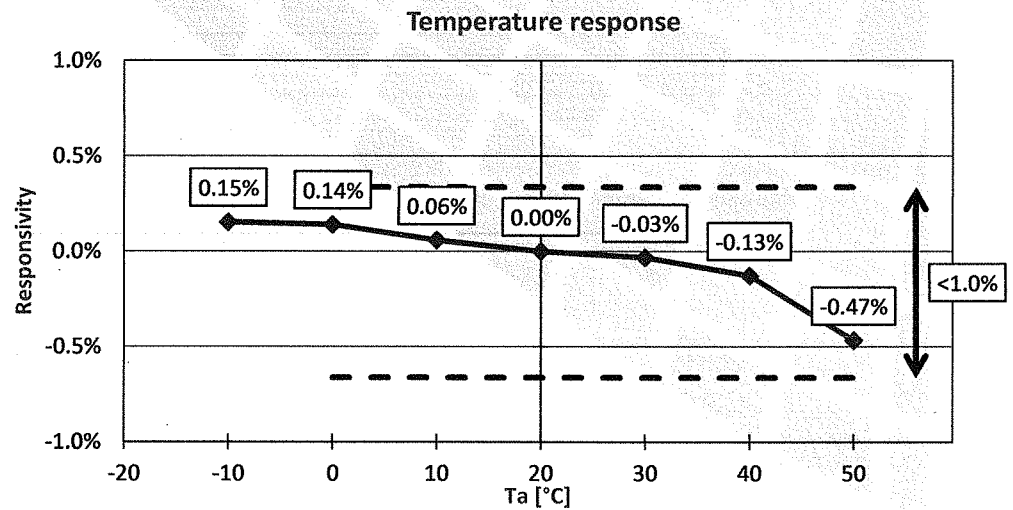
Manufacturer : EKO Instruments Co., Ltd. **Issue date :** April 26, 2016
Description : Pyranometer
Model : MS-802F
ISO Classification: Secondary Standard
Serial Number : F15508FR

Specification : Pyranometer output signal is sensitive to temperature. The pyranometer temperature response characteristics are defined by ISO9060 as "the maximum tolerable error within the temperature range when the ambient temperature is changed by 50°C".

Pass Criteria : <1% ΔT=50°C

Conclusion : Pass

Measurement result



The detector temperature reponsivity was measured inside a climate chamber within the temperature range 50°C to -10°C. During the test the pyranometer was mounted in horizontal position and exposed to a constant radiation source (Solar Simulator AAA class / 1000 W/m² / IEC60904-9) while the climate temperature was changed. The measurement results are interpolated and plotted in steps of 10°C relative to 20°C.

(*) Absolute value

Directional Reponse Measurement Report ISO 9060

Manufacturer : EKO Instruments Co., Ltd.

Description : Pyranometer

Model : MS-802F

ISO Classification : Secondary Standard

Issue date : April 26, 2016

Serial Number : F15508FR

Measurement date : September 09, 2015

Specification : As defined ISO 9060 a pyranometer output signal is supposed to be proportional to the cosine of the light's angle of incidence. The pyranometer directional response characteristics are defined as the maximum tolerable error for zenith angles (0° to 80° at 1000W/m² irradiance) to the ideal cosine response.

Criteria : +/- 10W/m² / 0 - 80° zenith angle

Measurement procedure

The pyranometer was placed on an automated goniometer stage to simulate the directional response for different zenith and azimuth angles at constant irradiance (Solar Simulator AAA class / 1000 W/m² / AM1.5 / Degree of parallelism of the light <3°, temporal instability <0.3%). Subsequently the pyranometer output (mV) was measured at 5 zenith angles and 4 azimuth angles (40°, 70°).

Directional response

Zenith angle [°]	South [%]	East [%]	North [%]	West [%]
20	-0.34	-	-	-
40	-0.92	-0.25	0.38	-0.26
60	-1.55	-	-	-
70	-1.29	-1.64	-0.64	-0.23
80	0.94	-	-	-

Zenith angle [°]	South [W/m ²]	East [W/m ²]	North [W/m ²]	West [W/m ²]
20	-3.2	-	-	-
40	-7.1	-1.9	2.9	-2.0
60	-7.7	-	-	-
70	-4.4	-5.6	-2.2	-0.8
80	1.6	-	-	-