

SR20/SR20-D1 for PV system monitoring

SR20 secondary standard pyranometers: why PV system asset managers prefer a high-accuracy pyranometer with the right paperwork

SR20 is a solar radiation sensor of the highest category in the ISO 9060 classification system: secondary standard. SR20 pyranometer should be used where the highest measurement accuracy is required. SR20-D1 is the digital equivalent of the regular SR20 with analogue output. A unique feature of the SR20 series is that every instrument is individually tested and supplied with the right paperwork.

- Hukseflux secondary standard pyranometers offer the highest accuracy and are supplied with the right paperwork. High-accuracy measurement records of PV system performance increase the value of a PV plant by narrowing down risk profiles.
- A record of instrument performance according to the requirements of the GUM and ISO 9060 standards is essential as proof of instrument measurement accuracy. Only Hukseflux includes this.

Executive summary



Figure 1 SR20 secondary standard pyranometer



Figure 2 accurate PV system performance monitoring

Introduction

PV power plants are increasingly treated as a commercial investment. Traditionally system performance was monitored to allow operators to optimise system performance. Nowadays, in the process of monitoring and selecting measurement equipment, the investment-related considerations often dominate over operational aspects. For asset managers, high-accuracy measurements during PV system operation lead to a narrower specification of proven performance. This increases the value of the power plant, which is relevant in case the plant is financed with borrowed money or if it is sold. Accurate data allow investors to borrow a higher percentage of the total investment or borrow at a lower interest rate. This creates leverage; i.e. potentially multiplied financial gains.

Why it pays off to have improved measurement accuracy

The opportunity to get a better risk-rating justifies a higher investment in measurement equipment.

Why SR20 pyranometer

- The right paperwork: including certificates of temperature response and directional response
- Directional response at 4 azimuth angles
- Best in class calibration uncertainty
- Best in class temperature response (characterised up to + 50 °C, while competitors typically stop at + 40 °C)

What is the right paperwork, and why does it matter

The ISO/IEC Guide 99:2007 International Vocabulary of Metrology states that "type B evaluation of measurement uncertainty may be evaluated based on information obtained from the accuracy class of a verified measuring instrument" [1]. The ISO 9060:1990 standard, which covers pyranometer classification, demands for secondary standard pyranometers that "all specifications are tested for every individual instrument" [2]. In practice, the leading manufacturers of pyranometers test their secondary standard instruments, but not all supply these instruments with test certificates for the most critical specifications. These critical specifications are temperature dependence (this should be at least up to +50 °C for PV applications) and directional response (this should be up to 80 ° zenith angle in the extreme east and west directions for PV applications). Having the right certificates matters. By having these, you avoid any issues of liability.

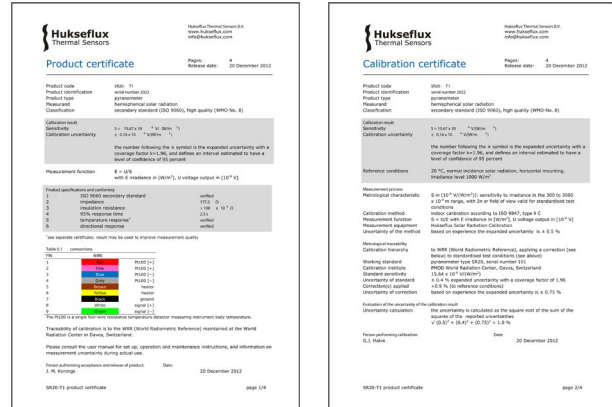


Figure 4 Hukseflux product and calibration certificates

Uncertainty evaluation

The uncertainty of a measurement under outdoor conditions depends on many factors. Guidelines for uncertainty evaluation according to the "Guide to Expression of Uncertainty in Measurement" (GUM) can be found in our manuals. We provide spreadsheets to assist in the process of uncertainty evaluation of your measurement.

Hukseflux Thermal Sensors B.V.
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Temperature response

Pages: 4
Release date: 20 December 2012

Product code: SR20- T1
Product identification: serial number 2022
Product type: pyranometer
Measurand: hemispherical solar radiation
Classification: secondary standard (ISO 9060), high quality (WMO-No. 8)

Characterisation result

Temperature response: $\pm 0.9 \%$

Temperature coefficients:
 $a = -1.1385 \times 10^{-4} \text{ } ^\circ\text{C}^{-1}$
 $b = -0.0529 \times 10^{-4} \text{ } ^\circ\text{C}^{-1}$
 $c = 1.0047$

Measurement process: dependence of sensitivity to ambient temperature
 Characterised parameter: $S(T) = S_0(aT + bT^2 + c)$
 Measurement function: with $S(T)$ sensitivity in [$10^{-8} \text{ V}/(\text{W}/\text{m}^2)$] at an instrument body temperature T , S_0 sensitivity at 20 °C instrument body temperature, T the instrument body temperature in [°C], a , b and c the temperature coefficients determined from a second order polynomial fit
 Hukseflux Temperature Response Characterisation

Measurement equipment: Hukseflux Temperature Response Characterisation

Conformity assessment: Temperature response is the percentage deviation in sensitivity due to change in ambient temperature within an interval of 50 K
 Definition of measurand: -10 to +40 °C
 Temperature interval: ISO 9060 specifies a limit on the temperature response for a secondary standard pyranometer of 2 %
 Acceptance interval: Conformity verified
 Conclusion: Conformity verified

Table 0.3 temperature dependence test result

TEMPERATURE DEPENDENCE TEST									
T [°C]	50	40	30	20	10	0	-10	-20	-30
relative signal	-2.4%	-1.4%	-0.6%	0	+0.4%	+0.5%	+0.5%	+0.2%	-0.2%

Please refer to the user manual for an explanation of the measurement procedure.

Person performing characterisation: R. Hartveld
 Date: 02 November 2012

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Figure 3 The right paperwork. Test certificate of temperature response supplied with every individual instrument

Hukseflux Thermal Sensors B.V.
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Directional response

Pages: 4
Release date: 20 December 2012

Product code: SR20- T1
Product identification: serial number 2022
Product type: pyranometer
Measurand: hemispherical solar radiation
Classification: secondary standard (ISO 9060), high quality (WMO-No. 8)

Characterisation result

Directional response: $\pm \pm 7.7 \text{ W}/\text{m}^2$

Measurement process: dependence of sensitivity resulting from the direction of irradiance (a measure of the deviations from an ideal cosine response and its azimuthal variation)
 Characterised parameter: $C_{dir} = S(\theta)/(S(0) \cdot \cos(\theta) - 1) \cdot 100 \%$
 Measurement functions: with C_{dir} the deviation from an ideal cosine response at zenith angle θ in [%], $S(\theta)$ the sensitivity to beam irradiance at zenith angle θ in [$10^{-8} \text{ V}/(\text{W}/\text{m}^2)$], $S(0)$ the sensitivity to beam irradiance at normal incidence, θ the incoming angle from zenith in [°]
 $C_{dir} = (S(\theta)/(S(0) \cdot \cos(\theta) - 1)) \cdot \cos(\theta) - 1000$
 with C_{dir} the directional response as defined below in [W/m^2]
 Measurement equipment: Hukseflux Directional Response Characterisation

Conformity assessment: The directional response is the error caused by assuming that the reported sensitivity is valid when measuring from any direction a beam whose normal incidence is 1000 W/m^2 .
 Definition of measurand: ISO 9060 specifies a limit on the directional response for a secondary standard pyranometer of $\pm 10 \text{ W}/\text{m}^2$
 Acceptance interval: Conformity verified
 Conclusion: Conformity verified

Table 0.2 directional response test result

azimuth	North		East		South		West	
	C_{dir} [%]	C_{dir} [W/m^2]	C_{dir} [%]	C_{dir} [W/m^2]	C_{dir} [%]	C_{dir} [W/m^2]	C_{dir} [%]	C_{dir} [W/m^2]
zenith								
40°	-7.7	-1.0	-3.7	-0.5	-4.0	-0.5	-6.9	-0.9
60°	-4.7	-0.9	-1.8	-0.4	-2.0	-0.4	-4.5	-0.9
70°	-4.1	-1.2	-2.2	-0.6	-2.1	-0.6	-4.8	-1.4
80°	-3.9	-2.3	-2.1	-1.2	-2.7	-1.6	-4.6	-2.7

Please refer to the user manual for an explanation of the measurement procedure.

Person performing characterisation: R. Hartveld
 Date: 03 October 2012

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Figure 5 The right paperwork. Test certificate of directional response supplied with every individual instrument

Standards

Applicable instrument classification standards are ISO 9060 and WMO-No. 8. Calibration is according to ISO 9847. PV related standards are ASTM E2848 and IEC 61724.

Demanding applications

SR20's low temperature dependence makes it an ideal candidate for use under very cold and very hot conditions. The temperature dependence of every individual instrument is tested and supplied as a second degree polynomial. This information can be used for further reduction of temperature dependence during post-processing.



Figure 6 SR20 pyranometer side view

See also

- **SR20** secondary standard pyranometer – analogue output
- **SR20-D1** digital secondary standard pyranometer – Modbus protocol
- **SR20-TR** secondary standard pyranometer with 4-20 mA transmitter
- **VU01** ventilation unit for ventilated SR20 / SR20-D1 pyranometer measurements
- alternative instruments: **SR11** and **SR05** for lower accuracy measurements
- **SR12** first class pyranometer for solar energy testing applications
- the making of SR20 **documented**
- view our complete **product range of solar sensors**

SR20 specifications

Measurand	hemispherical solar radiation
ISO classification	secondary standard pyranometer
Calibration uncertainty	< 1.2 % (k = 2)
Calibration traceability	to WRR
Rated operating temperature range	-40 to +80 °C
Temperature response test of individual instrument	report included, with second degree polynomial from -30 to +50 °C
Directional response test of individual instrument	report included, with measurements at all 4 azimuth angles up to 80 ° zenith angle
Temperature response SR20	<± 1 % (-10 to +40 °C) <± 0.4 % (-30 to +50 °C) with correction in dataprocessing
SR20-D1	<± 0.4 % (-30 to +50 °C)

About Hukseflux

Hukseflux Thermal Sensors makes sensors and measuring systems. We also provide services: calibration and material characterisation. Our main area of expertise is measurement of heat transfer and thermal quantities such as solar radiation, heat flux and thermal conductivity. Hukseflux is ISO 9001 certified. Hukseflux products and services are offered worldwide via our office in Delft, the Netherlands and local distributors.

Referenced documents

- [1] ISO, (2007), **ISO/IEC Guide 99:2007 International Vocabulary of Metrology – Basic and general concepts and associated terms (VIM)**, published by ISO, www.iso.org
- [2] ISO, (1990), **ISO 9060:1990 Solar energy – Specification and classification of instruments for measuring hemispherical solar and direct solar radiation**, published by ISO, www.iso.org

Interested in this product?
E-mail us at: info@hukseflux.com