

**CALIBRATION CERTIFICATE**  
**PAR QUANTUM SENSOR**

**CERTIFICATE NUMBER** 10828140454  
**SENSOR MODEL** PQS 1  
**SERIAL NUMBER** 140454  
**SENSITIVITY** 8.40  $\mu\text{V}/\mu\text{mol}/\text{s}\cdot\text{m}^2$  at normal incidence and solar radiation at air mass 1.5  
**IMPEDANCE** 470  $\Omega$   
**TEMPERATURE** 22  $\pm$  2  $^{\circ}\text{C}$   
**REFERENCE PYRANOMETER** Kipp & Zonen PQS 1 sn REF 2  
**CALIBRATION DATE** 9 September 2014 (recalibration is recommended every two years)  
**IN CHARGE OF TEST** K.Lansbergen

**Calibration procedure**

The calibration procedure is an exact interchange of test PQS 1 and reference PQS 1 in a horizontal parallel beam of filtered light (NIR reducing filter) from a Xenon lamp. The photosynthetic photon flux density was approx. 400  $\mu\text{mol}/\text{s}\cdot\text{m}^2$ . The instrument temperature was approx. 25  $^{\circ}\text{C}$ . The calibration has an expanded uncertainty ( $k=2$ ) of 4%.

**Hierarchy of traceability**

The reference PQS 1 has been calibrated on 11 December 2012 against a standard of known spectral irradiance, the 1000 W DXW tungsten halogen lamp OL 200U, S/N: S-1243 supplied by Gooch and Housego. The standard lamp T-R 725 has been calibrated with a filter radiometer by the Metrology Research Institute of the Helsinki University of Technology (HUT) on October 19, 2012 for a vertical distance of 412.5 mm and a lamp current of 8.0000 A. The trap detector (UVFR-8) of the filter radiometer is traceable to the cryogenic electrical substitution radiometer of SP, Sweden.

The calibration of the reference PQS 1 was done at Kipp & Zonen with a lamp current of 8.0000  $\pm$  0.0005 A. The instrument was placed at a vertical distance of 412.5  $\pm$  1 mm between lamp filament and PQS 1 diffuser surface. The calculated PAR irradiance at the diffuser surface is 249.1  $\mu\text{mol}/\text{s}\cdot\text{m}^2$ . The instrument temperature was approx. 30  $\pm$  5  $^{\circ}\text{C}$ .

**Correction applied**

Correction for false NIR-response during calibration of the reference PQS 1 is necessary. With a RG780 cut-on filter, covering the PQS 1, the response to the abundant NIR radiation in the lamp spectrum was measured. The response on NIR is divided by 0.917 to correct for the reflection losses of the filter. During calibration of production instruments with a Xe lamp the NIR radiation is blocked with a filter. The three measured sensitivities were 4.484, 4.481 and 4.476  $\mu\text{V}/\mu\text{mol}/\text{s}\cdot\text{m}^2$ .

A second correction factor  $C = C_{\text{par1.5}}/C_{\text{xxx}} = 0.987$  is applied to the above reference sensitivity to derive the sensitivity for atmospheric global horizontal irradiance in the nominal pass-band of the instrument. The correction is calculated by convoluting the spectral response of an ideal PAR sensor and of this instrument with respectively the DXW lamp spectrum and the air mass 1.5 spectrum. The air mass 1.5 spectrum is taken from the SMARTS 2.9.5 program from NREL, a model based on the international standard ISO 9845-1. For this spectrum the false NIR response of the instrument is also negligible. The sensitivity of the reference PQS 1 for AM1.5 radiation is: 4.38  $\mu\text{V}/\mu\text{mol}/\text{s}\cdot\text{m}^2$ .

**Notice**

The calibration certificate supplied with the instrument is at the date of first use. Even though the calibration certificate is dated relative to manufacture, or recalibration, the instrument does not undergo any sensitivity changes when kept in the original packing. From the moment the instrument is taken from its packaging and exposed to irradiance the sensitivity may deviate with time. See the 'non-stability' value (% change in sensitivity per year) given in the radiometer specifications.