MQS-B/A

Adapter Set for Thin Fiberoptics

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1 Introduction

The MQS-B/A Adapter Set is designed to measure the light intensity of a spot that is smaller than the light-receiving area of a light sensor. More specifically, the MQS-B/A Adapter Set permits measurements of the light intensity emitted by thin fiberoptics (typically ≤ 4 mm diameter) using an MQS-B light sensor having a diffusing disk of 5.5 mm diameter as the light-receiving area.

The MQS-B light sensor was originally calibrated by exposing its entire diffusing disk to light. Consequently, the entire diffusing disk must be exposed to correctly measure light intensity, and partial exposure results in false results. To enable light measurements of spots < 5.5 mm diameter, a second calibration was performed in which circular areas of either 1.2 mm or 3 mm diameter were exposed. The MQS-B/A Adapter Set reproduces the latter calibration conditions so that the light intensity of small light spots can be measured.

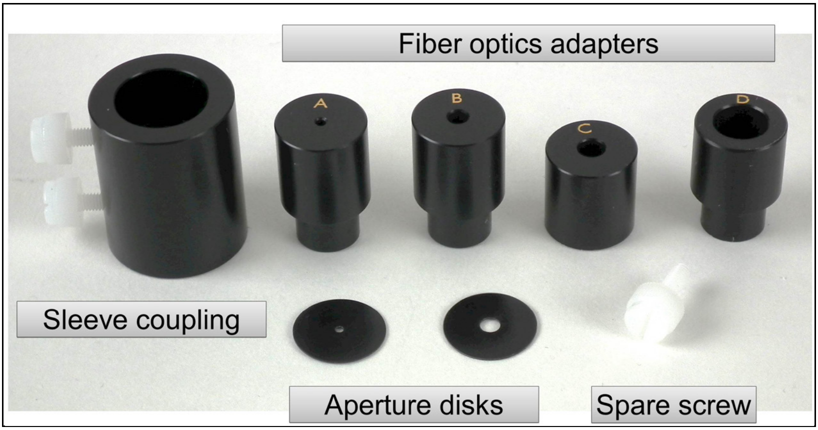

Fig. 1: MQS-B/A adapter set

2 Extent of Delivery

The MQS-B/A adapter set comprises a symmetrically designed sleeve coupling (Fig. 1, page 1). Further included are four fiber optics adapters with a central hole for fiberoptics (Fig. 1, A to D). From fiber optics adapter A to D, the diameter of these holes is 1.6 mm, 3.1 mm, 4.1 mm and 8.1 mm, respectively. The MQS-B/A adapter set also includes two disks (polyoxymethylene) with central apertures of 1.2 mm and 3.0 mm, plus a spare screw.

3 Setup

Each fiber optics adapter A, B and D consist of two cylinders, one of which with 10 mm outer diameter and the other with 14 mm outer diameter cylinder (Fig. 1, page 1). The narrower cylinder is 7 mm high and fills completely the narrow central

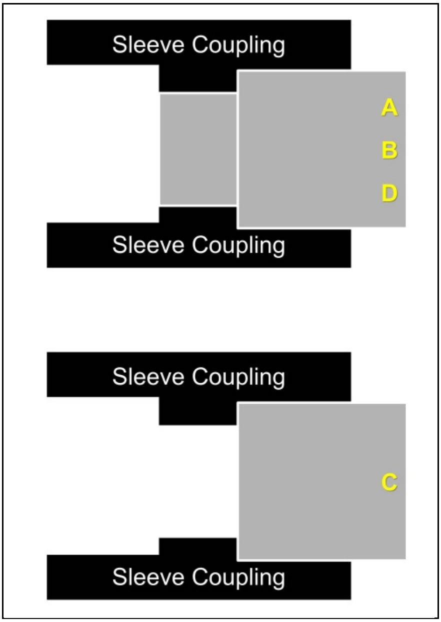

Fig. 2: Positioning of fiberoptics adapters in sleeve coupling of MQS-B/A adapter set.

Top, fiber optics adapter A, B, and D. Bottom, fiber optics adapters C. Sleeve couplings and fiber optics adapters are drawn in black and grey, respectively.

part of the sleeve coupling when the fiber optics adapter is fully inserted (Fig. 2, page 2). Adapter C has an outer diameter of 14 mm throughout and only adjoins to the central part of the sleeve coupling when fully inserted. Depending on fiberoptics outer diameter, one of the four fiber optics adapters is selected to position the fiberoptics centrally inside one end of the sleeve coupling (Table 1, page 4).

Considering that aperture diameter < active diameter of fiber-optics, one of the two aperture disks is selected and put inside the sleeve coupling on the opposite side of the fiber optics adapter (confer Table 1, page 4). For instance, the light guides of the WATER-PAM and the JUNIOR-PAM fluorometers (1.5 mm active diameter) and the Miniature Fiberoptics MINI-PAM/F1 of the MINI-PAM fluorometer (2 mm active diameter) require the 1.2 mm aperture disk. Theoretically, the light intensity emanated from the light mixing rod of the PHYTO-EDF fluorometer (4 mm active diameter) can be measured with both aperture sizes but the 3 mm aperture is preferred over the 1.2 mm aperture because of higher accuracy of measurements.

Then, an MQS-B Cosine-Corrected Mini Quantum Sensor (not part of delivery) with its diffusing disk first is put inside. Consequently, the completely inserted MQS-B sensor will only be exposed to light falling through the aperture.

Note that the light intensity measured depends on the distance between fiber optics end and diffusing disk of the PAR sensor. For example, light intensity directly at the end of a fiber optics is measured when fiberoptics adapters A, B, and D are used, the fiber optics adapter chosen is flush with the fiber optics, and both the fiber optics adapter and the MQS-B sensor are fully inserted into the sleeve coupling. Under similar conditions, the light mixing rod of the PHYTO-EDF inserted into fiber optics adapter C results in 7 mm distance between light source and sensor. This distance is reduced to 2 mm if the light mixing rod with holder is maximally inserted into fiber optics adapter C.

Table 1: MQS-B/A measuring configurations

(A) JUNIOR-PAM				
MQS-B sensor	1.2 mm aperture disk	Sleeve coupling	Fiber adapter **A**	Fiber with 1.5 mm active diameter
(B) FIBER version of WATER-PAM				
MQS-B sensor	1.2 mm aperture disk	Sleeve coupling	Fiber adapter **B**	Fiber with 1.5 mm active and 3 mm outer diameter
				
(C) FIBER version of PHYTO-PAM				
MQS-B sensor	3 mm aperture disk	Sleeve coupling	Fiber adapter **C**	Perspex rod with 4.0 mm active diameter plus rod holder
				
(D) Miniature Fiberoptics MINI-PAM/F1				
MQS-B sensor	1.2 mm aperture disk	Sleeve coupling	Fiber adapter **D**	Fiber with 2.0 mm active diameter plus leaf clip adapter

When needed, the measuring setup must be adjusted to match the experimental setup, for example, by varying the position of fiber optics adapter or the degree of insertion of fiber optics into the fiber optics adapter.

4 The MQS-B Cosine-Corrected Mini Quantum Sensor

The sleeve coupling of the MQS-B/A adapter set has been designed to receive a MQS-B Cosine-Corrected Mini Quantum (to be ordered separately). This cylindrical sensor possesses at one end a diffusing disk of 5.5 mm diameter (Fig. 3, page 5) which transmits light to a photodiode inside the sensor.

The MQS-B sensor is called “cosine-corrected” because light impinging perpendicular to the diffusing disk (angle of incidence = 0 degree) is measured with highest sensitivity. For non-perpendicular light, sensitivity decreases with the cosine of the angle of incidence to eventually reach the value of 0 at 90 degrees. The MQS-B sensor measures “Photosynthetically

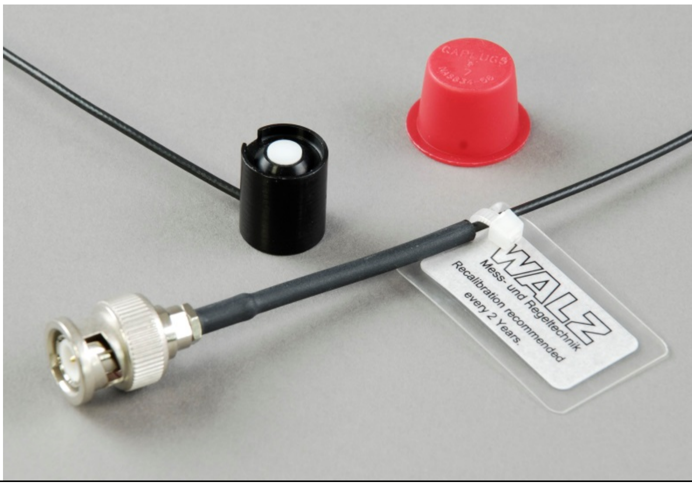

Fig. 3: MQS-B Cosine-Corrected Mini Quantum Sensor

Active Photon Flux Density" (PPFD). To be photosynthetically active, photons must be absorbed by photosynthetic pigments. Frequently, light absorption by photosynthetic pigments is considered to be effective within the wavelength borders of 400 and 700 nm, it is considered as inefficient outside of this interval. Accordingly, the sensitivity of the MQS-B sensor is close to zero at wavelengths < 400 nm and > 700 nm (Fig. 4, page 6). Within the 400 to 700 nm range, the sensitivity based on photon flux density (µmol photons m^{-2} s^{-1}) is rather constant so that PPFD is measured relatively independently of the wavelength of photons.

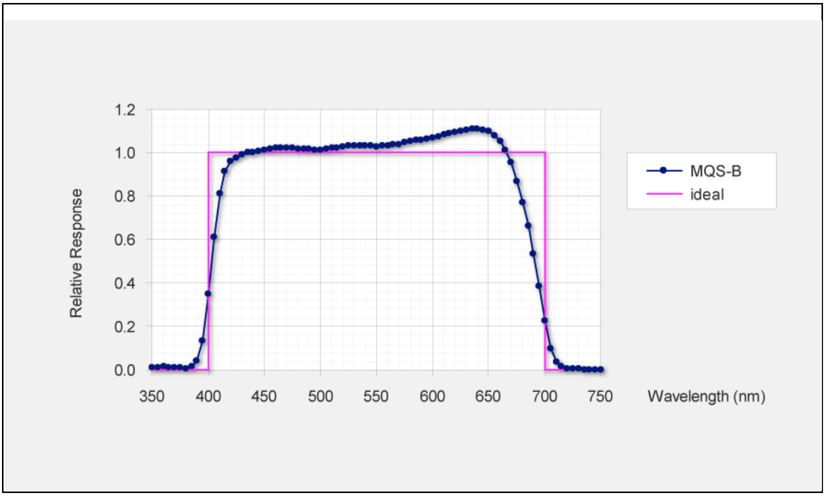

Fig. 4: Spectral response of MQS-B sensor

Typical response between 350 nm and 750 nm of a MQS-B sensor (blue line with dots). The pink line shows the ideal response of a photon flux sensor for photosynthetically active radiation.

4.1 Sensor Calibration

Standard calibration of the MQS-B sensor occurs by exposing its *entire* diffusing disk to a known PPFD emitted by a calibration lamp. The PPFD at disk surface divided by the photocurrent caused by this PPFD is the calibration factor in units of (µmol photons m^{-2} s^{-1})/µA. This calibration factor is printed on the tag attached to the sensor cable (preceded by "Mult.:" and given as negative value for historical reasons).

The MQS-B sensor can be connected to a high-impedance BNC input of a data logger as provided by the ULM-500 Universal Light Meter & Data Logger. To yield PPFD in units of µmol photons m^{-2} s^{-1}, the calibration factor must be entered into the data logger. PPFD measurements are valid only if the *entire* diffusing disk of the sensor is uniformly exposed to light.

Non-standard calibration was conducted with the sensor's diffusing disk covered by a black disk with centrally located aperture of either of 1.2 mm or 3.0 mm. These additional calibrations are needed for correct PPFD measurements when the diffusing disk of the MQS-B sensor can only partially illuminated.

Calibration with an aperture diameter of 1.2 mm increased the standard calibration factor by a factor of 13.8. With a 3.0 mm aperture, the calibration factor was increased 2.5-times.

4.2 Sensor Versions

In addition to directly connecting the sensor to the ULM-500 logger, the MQS-B sensor of versions US-MQS/WB and US-MQS/B is connected via an amplifier box to a PAM device (Table 2, page 8).

Each amplifier box is tuned to a specific sensor which means that the amplifier box takes account of the calibration factor of this particular sensor. As a consequence, the output of the amplifier box is independent of the original calibration factor and is replaced by the factor of 1.00.

The factor 1.00 is valid if the entire diffusing disk of the sensor is exposed to light. Note, however, if the US-MQS/WB version is purchased as accessory of the WATER-PAM FIBER Ver-

Table 2: Sensor Versions

MQS-B	**US-MQS/WB**	**US-MQS/B**
Sensor only	Sensor + amplifier box	Sensor + battery-powered amplifier box
		
Compatible with	**Compatible with**	**Compatible with**
ULM-500 Universal Light Meter & Data Logger	DUAL-PAM MINI-PAM (not MINI-PAM-II) MULTI-COLOR-PAM PAM Control Unit (WATER-PAM) PAM-2500	PHYTO-PAM

sion then the factor of 1.00 applies for light measurements with the 1.2 mm aperture placed in front of the MQS-B sensor. As a rule, the version US-MQS/B is acquired as accessory of the PHYTO-PAM and, in this case, the value of 1.00 applies for light measurements in which a 3 mm aperture is placed in front of the MQS-B sensor. Table 3 provides an overview of the effective calibration factors for various configurations.

Table 3: Effective calibration factors

MQS-B (sensor only)	
Diffusing disk fully exposed	Calibration factor(1)
3.0 mm aperture	Calibration factor(1) · 2.5
1.2 mm aperture	Calibration factor(1) ·13.8
(1) Calibration factor (µmol photons m^{-2} s^{-1}/µA) printed on tag attached to the sensor cable and on certificate for sensor	
US-MQS/WB (sensor and amplifier, configured for WATER-PAM FIBER Version, i.e., with 1.2 mm aperture in front of diffusing disk)	
Diffusing disk fully exposed, e.g., measurements of ambient PPFD	0.072 = 1 /13.8 (enter 0.07 in window "System Settings" of WinControl-3)
3.0 mm aperture	0.181 = 2.5/13.8 (enter 0.18 in window "System Settings" of WinControl-3)
1.2 mm aperture	1.0
US-MQS/WB (sensor and amplifier, configured for PHYTO-EDF, i.e., with 3 mm aperture in front of diffusing disk)	
Diffusing disk fully exposed, e.g., measurements of ambient PPFD	0.4 = 1/2.5 (calibration factor not adjustable, calculate manually)
3.0 mm aperture	1.0
1.2 mm aperture	5.52 = 13.8/ 2.5 (calibration factor not adjustable, calculate manually)

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