

Manual

Mini-Quantum/Temp.-Sensors

2060-M and 2065-M

Arabidopsis Leaf Clip 2060-B

Fiberoptics Holder for Surfaces 2060-A

2.164/07.2019

3rd Edition, October 19

2060-M_2065-M_03.docx

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Contents

1	Safety Instructions	2
2	Extent of Delivery	3
3	Introduction	5
4	Components	6
4.1	2060-M and 2065-M Light and Temperature Sensors	6
4.1.1	Mini-Quantum-Sensor.....	8
4.1.2	Thermocouple	9
4.1.3	Sensor Calibration.....	10
4.2	2060-B Arabidopsis Leaf Clip.....	11
4.3	2060-A Fiberoptics Holder for Surfaces	12
5	Mounting Sensors on Leaf-Clips	13
5.1	2060-B Arabidopsis Leaf Clip.....	13
5.2	2060-A Fiberoptics Holder for Surfaces	13
5.3	2060-A and MINI-PAM-II Internal Light Sensor	14
6	External LED Light Source 2054-L	15
7	Specifications	16
7.1	Mini Quantum/Temp.-Sensor 2060-M.....	16
7.2	Mini Quantum/Temp.-Sensor 2065-M.....	16
7.3	Arabidopsis Leaf Clip 2060-B.....	17
7.4	Fiberoptics Holder for Surfaces 2060-A	17
8	Guarantee	18
8.1	Manufacturer's Guarantee.....	18
8.2	Conditions.....	18
8.3	Instructions	19
8.4	Applicable law	20
9	Index	21

1 Safety Instructions

- Read safety instructions and the operating instructions prior to operation of the device.
- Pay attention to all safety warnings.
- Keep electronic amplifier unit away from water or high moisture areas.
- Keep the device away from dust, sand and dirt.
- Do not put the device near sources of heat.
- Connect the device only to the power source indicated in the operating instructions.
- Ensure that neither liquids nor foreign bodies get inside the device.
- The device should only be repaired by qualified personnel.

2 Extent of Delivery

Table 1: Extent of Delivery

	Part number	Device
<input type="checkbox"/>	2060-B	Arabidopsis Leaf Clip
<input type="checkbox"/>	2060-A	Fiberoptics Holder for Surfaces
<input type="checkbox"/>	2060-M	Analog version of Mini Quantum/Temp.-Sensor. For DUAL-PAM-100/DUAL-PAM/F, MINI-PAM, MULTI-COLOR-PAM, PAM-2500, ULM-500
<input type="checkbox"/>	2065-M	Digital version of Mini Quantum/Temp.-Sensor. For MINI-PAM-II, DIVING-PAM-II
	Date	Signature

3 Introduction

- The present manual introduces the 2060-M and 2065-M PAR and temperature sensors. Both devices possess the same sensors, but they differ in signal processing: the 2060-M produces an analog signal, but the 2065-M signal is digital. The 2060-M device can be connected to PAM fluorometers with analogue input (see Table 2, page 7) or to the ULM-500 data logger. The 2065-M is compatible with the MINI-PAM-II and the DIVING-PAM-II, where an adapter cable is needed in the latter case.
- This manual further introduces two devices which hold the light and temperature sensors of the 2060-M or 2065-M devices in defined positions: (1) The 2060-B Arabidopsis Leaf Clip which is designed for very small leaves, and (2) 2060-A Fiberoptics Holder for Surfaces which is suited for bulky samples.
- The light sensor records photosynthetically active radiation (PAR) which is the flux density of quanta in the visible spectral range (400 to 700 nm). The sensor is particularly well suited for light incident at angles between -30° and $+30^\circ$ to the surface normal (see Fig. 3, page 9).
- Temperature is measured by a flexible thermocouple. When in contact with a leaf, the leaf surface temperature is recorded.

4 Components

4.1 2060-M and 2065-M Light and Temperature Sensors

PAR and temperature sensors are connected by 30 cm cables to an amplifier unit (Fig. 1, page 6). The amplifier unit of the 2060-M device puts out analogue data via a 110 cm cable and a 7-pole plug. The amplifier unit of the 2065-M device puts out digital data via a 110 cm cable and a 4-pole plug. Table 2 (page 7) gives an overview on Walz devices and the socket to which the 2060-M or 2065-M device can be connected.

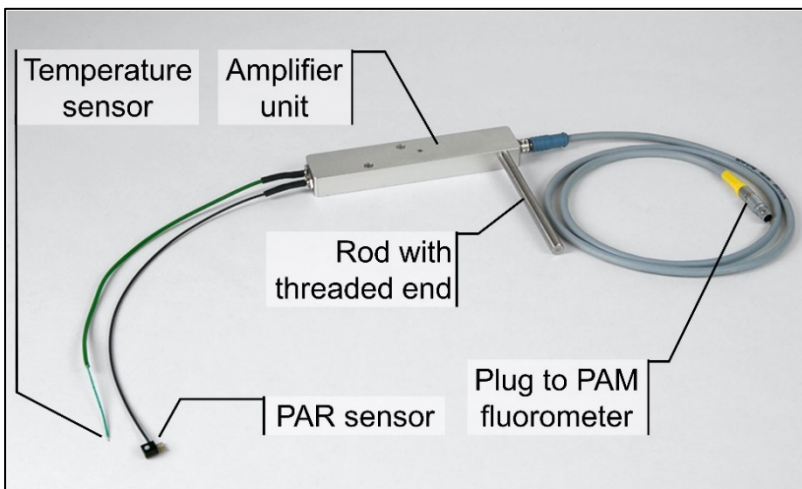


Fig. 1: Mini Quantum/Temp.-Sensor 2065-M.

Note Great caution should be exercised to prevent dirt or foreign matter from entering the plugs and sockets. Do not force a plug into the wrong socket. Orientate each plug so that the red dot on the plug coincides with the red dot of the socket. Do not try to disconnect a plug by pulling at the cable. Disconnect plug by pulling at the rippled bushing of the plug.

Table 2: Connection to Walz Devices

Sensor	Walz Device	Socket	Comment (PAR Offset)
2060-M	DUAL-PAM-100 DUAL-PAM/F	AUX	Cover light sensor, right-click on numeric PAR display of DualPAM software, carry out "Auto Zero".
2060-M	MULTI-COLOR-PAM	EXT. SENSOR	Cover light sensor, select "Light Calibration" from "Options" menu of PamWin software and carry out "Auto Zero".
2060-M	PAM-2500	LEAF CLIP	Same as MULTI-COLOR-PAM
2060-M	MINI-PAM	LEAF CLIP	Standalone operation: Cover light sensor, go to menu item 40 "LIGHT-OFFS." and manually set offset until PAR=0. WinControl-3 operation. Cover light sensor, go to System Settings and manually set offset until PAR=0.
2060-M	ULM-500	4-pole female socket	Select "Sensor Settings" = Leaf Clip and "Leaf Clip Type"=Mini-PAM LC. Requires adapter cable.
2065-M	MINI-PAM-II	LEAF CLIP	Offset adjustment normally not required, factory offset stored on the 2065-M.
2065-M	DIVING-PAM-II	AUX1/AUX2	See line above. Requires adapter cable.

4.1.1 Mini-Quantum-Sensor

The sensor's typical spectral response is depicted below (Fig. 2, page 8): its sensitivity to quantum flux density is constantly high in the 400 to 700 nm range, but low at shorter and longer wavelengths, respectively. The wavelength range of high sensitivity matches well the wavelengths of natural photosynthetically active radiation. Hence, the quantity measured by the light sensor is called photosynthetic active radiation (PAR) or photosynthetic photon flux density (PPFD), calibration is in the unit of $\mu\text{mol quanta}/\text{m}^2 \text{ s}^{-1}$.

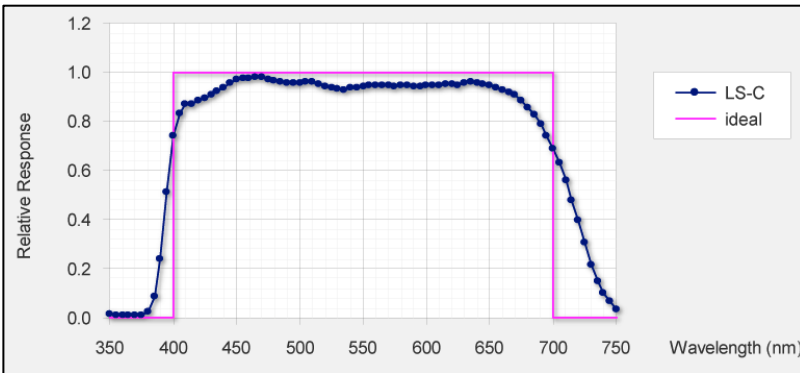


Fig. 2: Typical spectral response against photosynthetically active radiation (quantum flux density between 350 nm and 750 nm) of the mini quantum sensor. Solid line, ideal response. Dots, actual response.

Essential optoelectronic elements of the mini-quantum-sensor are:

- A 3 mm \varnothing diffusing disk.
- High stability silicon photovoltaic detector with filter set for PAR correction.
- Cosine response characteristics (Angular dependence: Error < 3 % for angle between -30° and $+30^\circ$ from normal axis). See below (Fig. 3, page 9), for a typical angular response curve

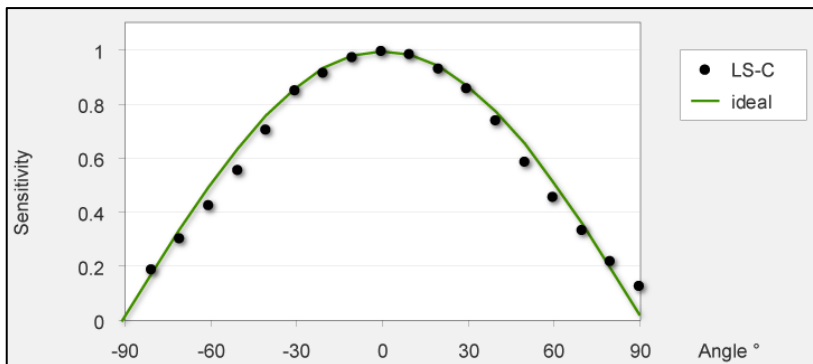


Fig. 3: Typical angular response curve of the mini quantum sensor. The mini quantum sensor uses a plastic diffuser to obtain an angular response error of less than $\pm 3\%$ ($-30\dots 30^\circ$ angle). Dots, actual angular response. Line, ideal cosine response.

4.1.2 Thermocouple

Temperature is sensed by a NiCr-Ni thermocouple. A reference couple is located on the circuit board of the amplifier unit. With

decreasing temperatures, the voltage created by the thermoelectric effect at the thermocouple declines. The relationship between thermovoltage and temperature is almost linear, and the thermovoltage is used to measure temperature.

4.1.3 Sensor Calibration

Temperature calibration of the analogue 2060-M Mini-Quantum/Temperature-Sensor was performed at 25 °C and the amplifier was adjusted so that Gain=1 and Offset=0. In case of the digital 2065-M Mini-Quantum/Temp.-Sensor, calibration uses measurements at 2, 25, and 50 °C to calculate gain and offset of the temperature sensor. These calibration data are stored on the flash memory in the amplifier box.

PAR sensors are calibrated against a standard light source. In case of the of the 2060-M unit, the amplifier box is adjusted so that PAR slope=1. The PAR slope is also denoted as “Calibration Factor”, “Gain” or as “Calibration Constant”. The PAR Offset, should be adjusted at first use of the 2060-M unit and later at regular intervals: the column “Comment” of Table 2 (page 7) provides corresponding instructions. The digital 2065-M unit stores all calibration data in the amplifier box.

Generally, the stability of light calibration depends on keeping the sensor’s diffuser disk clean. Calibration can be checked by comparison with a standard quantum sensor. Any deviation can be corrected by adjusting calibration factors. A substantial increase of the calibration factor “PAR slope” may indicate dirt deposition on the diffuser, which may be removed by gentle cleaning using a cotton tip applicator moistened with mild detergent.

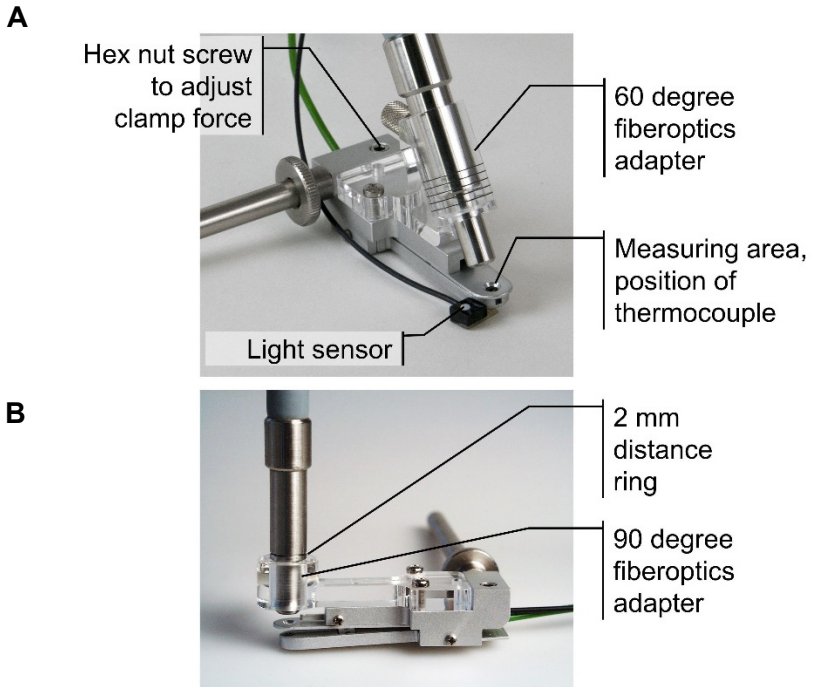


Fig. 4: 2060-B Arabidopsis Leaf Clip. (A) Leaf-Clip Holder 2060-B with standard 60° fiberoptics adapter and with (B) Fiberoptics Adapter 90° 2030-B90.

4.2 2060-B Arabidopsis Leaf Clip

The 2030-B clip has a narrow measuring area designed to position small leaves below the fiberoptics. The aluminum plate with the hole defining the measuring area and the aluminum part below are connected by a hinge and, thus, form a clip. The 60° fiberoptics adapter displayed in Fig. 4 (page 11) can be exchanged by a Fiberoptics Adapter 90° 2030-B90. To replace the

adapter, remove the two Phillips screws fixing the adapter to the aluminum body.

Supplied with the 2060-B clip are two stainless steel rings of 2 and 4 mm height, respectively. These rings increase the distance between fiberoptics tip and sample level, if the fiberoptics is inserted in one or both rings before putting it in the 60° or the 90° fiber optics adapter.

4.3 2060-A Fiberoptics Holder for Surfaces

The holder positions the fiberoptics of PAM fluorometers on bulky samples. As for the 2060-B Arabidopsis Leaf Clip, two stainless steel rings of 2 and 4 mm height, respectively, are provided. The device features a 60° fiberoptics adapter.

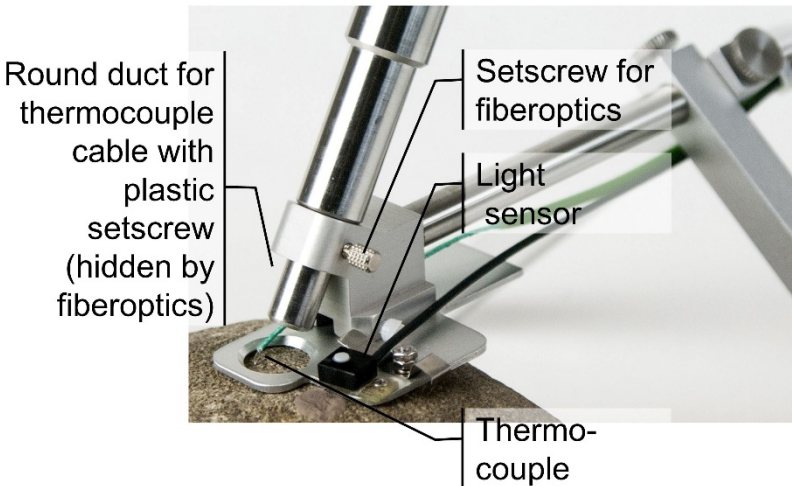


Fig. 5: 2060-A Fiberoptics Holder for Surfaces equipped with light and temperature sensors.

5 Mounting Sensors on Leaf-Clips

5.1 2060-B Arabidopsis Leaf Clip

Mostly, the Arabidopsis Leaf-Clip Holder 2060-B is ordered together with PAR and temperature sensors already mounted on the leaf clip. When the sensors are ordered separately, they must be attached by the customer.

The light sensor is mounted sideways of the viewing area by a tiny screw (cf. Fig. 4, page 11).

To fix the temperature sensor, remove the lower part of the clamp by removing its two small Phillips screws. Note position of the spring before taking apart! Then remove the small plate mounted on the lower part of the clamp. Place sensor cable in groove of lower part of the clamp so that the electrical junction (small metal droplet) is positioned in the center of the viewing area. Lock cable by screwing on the small plate. Bend upward the uninsulated wires at an angle of about 80° so that the thermocouple it will be gently pressed against the leaf, when the clamp is closed. Assemble clip.

5.2 2060-A Fiberoptics Holder for Surfaces

As for the 2060-B Arabidopsis Leaf Clip, the light sensor is attached sideways of the sample viewing area (Fig. 5, p 12).

The temperature sensor is inserted from behind through the round duct at the bottom of the metal block. (The rectangular duct, which is located parallelly to the round duct, is intended for

first generation light sensors.) Push forward until the thermocouple is in the sample viewing area. Lock cable of temperature sensor with the laterally located plastic screw. Bend cable end to bring the thermoelement in its desired position.

5.3 2060-A and MINI-PAM-II Internal Light Sensor

Calibration of the internal light sensor for the sample levels of the 2060-B Arabidopsis Leaf Clip or the 2060-A Fiberoptics Holder for surfaces requires correct positioning of the light sensor of the 2065-M device. In case of the 2065-B Arabidopsis clip, simply fix the sensor between upper and lower part of the clip. Make sure that the sensor is in the center of the viewing area so that the entire diffusing disk of the sensor is exposed to light from the MINI-PAM-II.

In case of the 2060-A Fiberoptics Holder, the light sensor is positioned using a special Perspex frame (Fig. 6, page 14). For light calibration, attach sensor to frame and place 2060-A Fiberoptics Holder so that the sensor's diffusing disk is entirely illuminated.

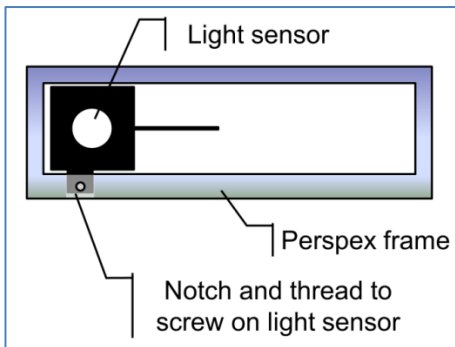


Fig. 6: Light Sensor Positioner for 2060-A Fiberoptics Holder for Surfaces.

6 External LED Light Source 2054-L

In the standard configuration, the External LED Light Source 2054-L illuminates at an angle of 60° to the sample plane. When this configuration is mounted on the 2060-B Arabidopsis Leaf Clip, the sample is incompletely exposed to light. Therefore, the LED panel must be repositioned to illuminate the sample directly from above (Fig. 7, p 15). To this aim, two additional holes are provided in the metal plate holding the LED panel. To avoid shading, the fiberoptics should not be fully inserted into the fiber-optics port of the 2060-B Arabidopsis Leaf Clip.

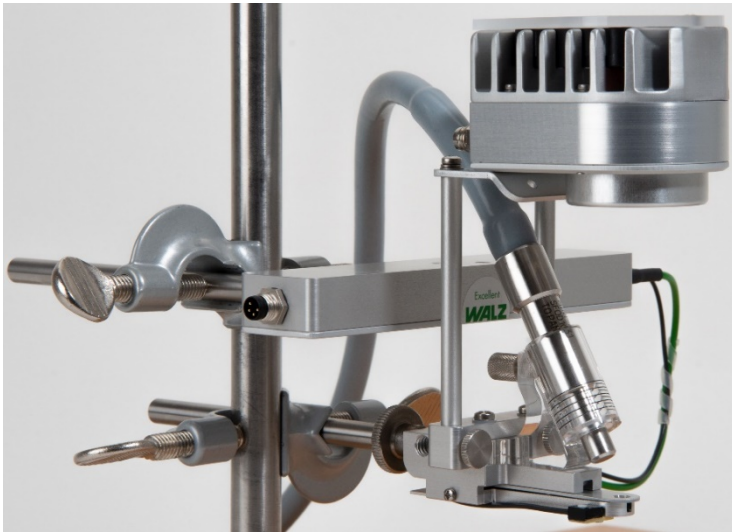


Fig. 7: 2060-B Arabidopsis Leaf Clip equipped with PAR and temperature sensors plus External LED Light Source 2054-L.

7 Specifications

7.1 Mini Quantum/Temp.-Sensor 2060-M

Mini quantum sensor: LS-C sensor, selective PAR measurement, 0 to 20000 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PAR

Thermocouple: Ni-CrNi, 0.1 mm diameter, -20 to +60 °C

Output: PAR, high sensitivity range: 0 to 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$; normal sensitivity range: 0 to 20000 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PAR (output 0 to 2.5 V for each range). Leaf temperature, -20 to +60 °C (0 to 0.8 V)

Power supply: PAM-2500 leaf clip socket (5 V/4 mA)

Length of power cable: 100 cm

Length of sensor cables: 30 cm

Dimensions: 16 cm x 3 cm x 1.7 cm (L x W x H)

Weight: 220 g

7.2 Mini Quantum/Temp.-Sensor 2065-M

Design: Mini quantum and temperature sensors connected by 30 cm cables to an electronic unit for signal amplification, digitization and storage of calibration factors. A 10 cm steel rod can be laterally screwed-on to the electronic unit. A 110 cm cable connects the 2065-M unit with the fluorometer

Mini quantum sensor: LS-C sensor for selective PAR measurement, range 0 to 7000 $\mu\text{mol m}^{-2} \text{s}^{-1}$, cosine corrected for light incident at angles between -30 ° to +30 from surface normal

Thermocouple: Ni-CrNi, wire diameter 0.1 mm, -20 to +60 °C

Dimensions of electronic unit: 15 cm x 3.3 cm x 2.5 cm (L x W x H)

Weight: 125 g (excluding cable)

7.3 Arabidopsis Leaf Clip 2060-B

Design: Aluminum clip with 3.2 mm diameter viewing area designed to position small leaves below the fiberoptics of the PAM-2500, prepared to accommodate PAR and temperature sensors of the Mini Quantum/Temperature-Sensor 2060-M

Dimensions: 7.6 cm x 3.0 cm (max.) x 5.2 cm (max.) (L x W x H)

Weight: 55 g

7.4 Fiberoptics Holder for Surfaces 2060-A

Design: Aluminum plate (6.0 x 3.3 cm max.) with 11 mm diameter circular hole (measuring area) and aluminum port to position fiber at an angle of 60° relative to the aluminum plate. With port for temperature sensor of 2060-M unit to measure surface temperature and thread to mount the PAR sensor of the 2060-M unit. Connected to a 10 x 0.8 cm (L x Ø) steal rod with two lateral aluminum supports (12 cm x 1 cm x 1 cm, L x W x H) which are lockable by knurled screws

Dimensions (without aluminum supports): 15 cm x 3.3 cm x 2.5 cm (L x W x H)

Weight: 125 g

- Subject to change without prior notice -

8 Guarantee

8.1 Manufacturer's Guarantee

Under this Manufacturer's Guarantee ("Guarantee"), subject to the Conditions and Instructions below, Heinz Walz GmbH, Germany ("Manufacturer"), guarantees (§443 BGB) to the end customer and user ("Customer") that all products supplied by it shall substantially conform in material respects to the Specifications for 24 months from the delivery date (date on invoice). In this Guarantee, "Specifications" means the product's features (as may be amended by Manufacturer from time to time), which are set out under the headings "specifications" and/or "technical specifications" within the product's respective brochure, data sheet, or respective tab on the Manufacturer's website for such product, and which may be included with the documents for the product when delivered. In case of an eligible guarantee claim, this Guarantee entitles the Customer to repair or replacement, at the Manufacturer's option, and this Guarantee does not include any other rights or remedies.

8.2 Conditions

This Guarantee shall not apply to:

- Any defects or damage directly or indirectly caused by or resulting from the use of unauthorized replacement parts and/or service performed by unauthorized personnel.

-
- Any product supplied by the Heinz Walz GmbH, Germany which has been subjected to misuse, abuse, abnormal use, negligence, alteration or accident.
 - Damage caused from improper packaging during shipment or any acts of God.
 - Batteries, cables, calibrations, fiberoptics, fuses, gas filters, lamps, thermocouples, and underwater cables.
 - Defects that could reasonably have been detected upon inspection of the product when received by the Customer and not promptly noticed within ten (10) days to Heinz Walz GmbH.
 - Submersible parts of the DIVING-PAM or the underwater version of the MONITORING-PAM have been tested to be watertight down to the maximum operating depth indicated in the respective manual. Guarantee shall not apply for diving depths exceeding the maximum operating depth. Further, guarantee shall not apply for damage resulting from improper operation of devices, in particular, the failure to properly seal ports or sockets.

8.3 Instructions

- To obtain guarantee service, please follow the instructions below:
- The Walz Service Information Form available at https://www.walz.com/support/repair_service.html must be completed and returned to Heinz Walz GmbH, Germany.
- The product must be returned to Heinz Walz GmbH, Germany, within 30 days after Heinz Walz GmbH, Germany has received written notice of the defect. Postage, insurance, and/or shipping costs incurred in returning equipment

for guarantee service are at customer expense. Duty and taxes are covered by Walz.

- All products being returned for guarantee service must be carefully packed and sent freight prepaid.
- Heinz Walz GmbH, Germany is not responsible or liable for missing components or damage to the unit caused by handling during shipping. All claims or damage should be directed to the shipping carrier.

8.4 Applicable law

- This Guarantee is governed by German law. Place of jurisdiction is Bamberg, Germany.

9 Index

- 2054-L 15
 2060-A..... 12, 13, 17
 2060-B..... 11, 13, 17
 2060-M..... 6, 16
 2065-M..... 6, 16
 Amplifier Box 2060-M..... 6, 10
 Angular response.....9
 Arabidopsis Leaf Clip 11, 13
 Calibration..... 10, 14
 Calibration Constant..... 10
 Components6
 Cosine response.....9
 Distance rings..... 12
 DUAL-PAM7
 Extent of Delivery.....3
 External LED Light Source... 15
 Fiberoptics Adapter 90° 12
 Fiberoptics Holder for Surfaces
 12, 13
 Figures
 01 Mini Quantum/Temp.-
 Sensor 2060-M..... 6
 02 Spectral Response Light
 Sensor 8
 03 Angular Response Light
 Sensor 9
 04 2060-B Arabidopsis Leaf
 Clip 11
 05 Fiberoptics Holder 2060-A
 12
 06 Light Sensor Positioner. 14
 07 External LED Light Source
 2054-L..... 15
 Gain.....10
 Guarantee 18
 Internal PAR Sensor..... 14
 Introduction 5
 Light Intensity..... 16
 MINI-PAM..... 7
 MINI-PAM-II.....7, 14
 Mini-Quantum-Sensor..... 8
 Mounting Sensors..... 13
 MULTI-COLOR-PAM..... 7
 PAM-2500 7
 PAR 8
 PAR Offset 10
 Photon Flux..... 8
 PPF 8
 Safety Instructions.....2, 7
 Sensor Calibration..... 10
 Specifications..... 16
 Arabidopsis Leaf Clip 2060-B
 17
 Arabidopsis Leaf Clip 2065-M
 16
 Fiberoptics Holder for
 Surfaces 2060-A... 17
 Mini Quantum/Temperature-
 Sensor 2060-M..... 16
 Spectral response..... 8
 Tables
 01 Extent of Delivery..... 3
 02 Connection to Walz
 Devices..... 7
 Temperature..... 9
 Temperature Sensor..... 10
 Thermocouple 9
 ULM-500 7