PENDOTECH
Leading Process Analytics

PENDOTECH® PM2 PHOTOMETER FOR UV/VIS ABSORBANCE AND TURBIDITY MEASUREMENTS

USER'S MANUAL

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Safety Instructions

Definition of Equipment and Documentation Symbols and Designations

⚠ **WARNING:** POTENTIAL FOR PERSONAL INJURY

⚠ **CAUTION:** Possible instrument damage or malfunction

☞ **NOTE:** Important operating information

⚠ **On the transmitter or in this manual text indicates** Caution and/or other possible hazards, including the risk of electric shock (refer to accompanying documents).

Each prospective user must test the measurement unit for its proposed application to determine its suitability for the purpose intended prior to incorporating the sensor to any process or application. Proper safeguards must be put into place for the process in which the unit is used.

The functioning and operational safety of the product can only be ensured if the user observes the usual safety precautions as well as the specific safety guidelines stated in these operating guidelines:

⚠ The PM2 Photometer must only be operated under the specified operating conditions.

⚠ The PM2 Photometer should be installed and operated only by personnel familiar with the Photometer and who are qualified for such work.

⚠ Before connecting the device to a supply unit, ensure its output voltage cannot exceed 48 VDC. Do not use alternating current or a main power supply!

⚠ **Warning:** Only use a power supply with double insulation or reinforced insulation to supply this product.

⚠ **Warning:** Do not submerge this product. Protect the product before cleaning with any liquids by covering openings that expose the internal components.

⚠ Install equipment as specified in this instruction manual. Follow appropriate local and national codes.

⚠ Power supply must be disconnected before servicing.

⚠ The safety of the user may be endangered if the instrument:

- is visibly damaged
- no longer operates as specified
- has been damaged in transport

⚠ **Process upsets:** because process and safety conditions may depend on the consistent operation of this transmitter, provide appropriate means to maintain operation during sensor cleaning, replacement, or sensor or instrument calibration.

⚠ Except for routine maintenance and cleaning procedures, the PM2 Photometer must not be tampered with or altered in any manner.

⚠ Maintenance and repair work must only be carried out by PendoTECH.

⚠ METTLER TOLEDO/PendoTECH accepts no responsibility for damage caused by unauthorized modifications to the Photometer.

⚠ Follow all warnings, cautions, and instructions indicated on and supplied with this product.

⚠ Electrical installation must be per the National Electrical Code and/or any other applicable national or local codes.

⚠ If this equipment is used in a manner not specified by the manufacturer, its protection against hazards may be impaired.

⚠ **Relay action:** the PM2 Photometer relays will always de-energize on the loss of power, equivalent to a normal state, regardless of the relay state setting for powered operation. Configure any control system using these relays with fail-safe logic accordingly.

⚠ The terminals are suitable for single wires / flexible leads 0.2 mm2 to 1.5 mm2 (AWG 16 – 24).

Optical Safety

⚠ **Warning:** The photometer can emit light in the range of 200 nm – 1100 nm. Hazardous UV and IR radiation are emitted from the unit. Never directly stare into the source/return ports on the photometer or the fiber optic cables, as this can cause eye damage. The viewer-related risk depends on how the users install and use the product.

⚠ The photometer should always be powered off when handling the fiber optic cables. Protective eyewear must be worn if you must handle the fibers when the unit is powered on.

⚠ Ensure that both ends of the fiber optic cables (photometer and flow cell connections) are properly secured (firmly hand-tight) before powering on the photometer.

⚠ In the event of product failure, do not attempt to open the unit or replace the LED. There are no user-serviceable parts.

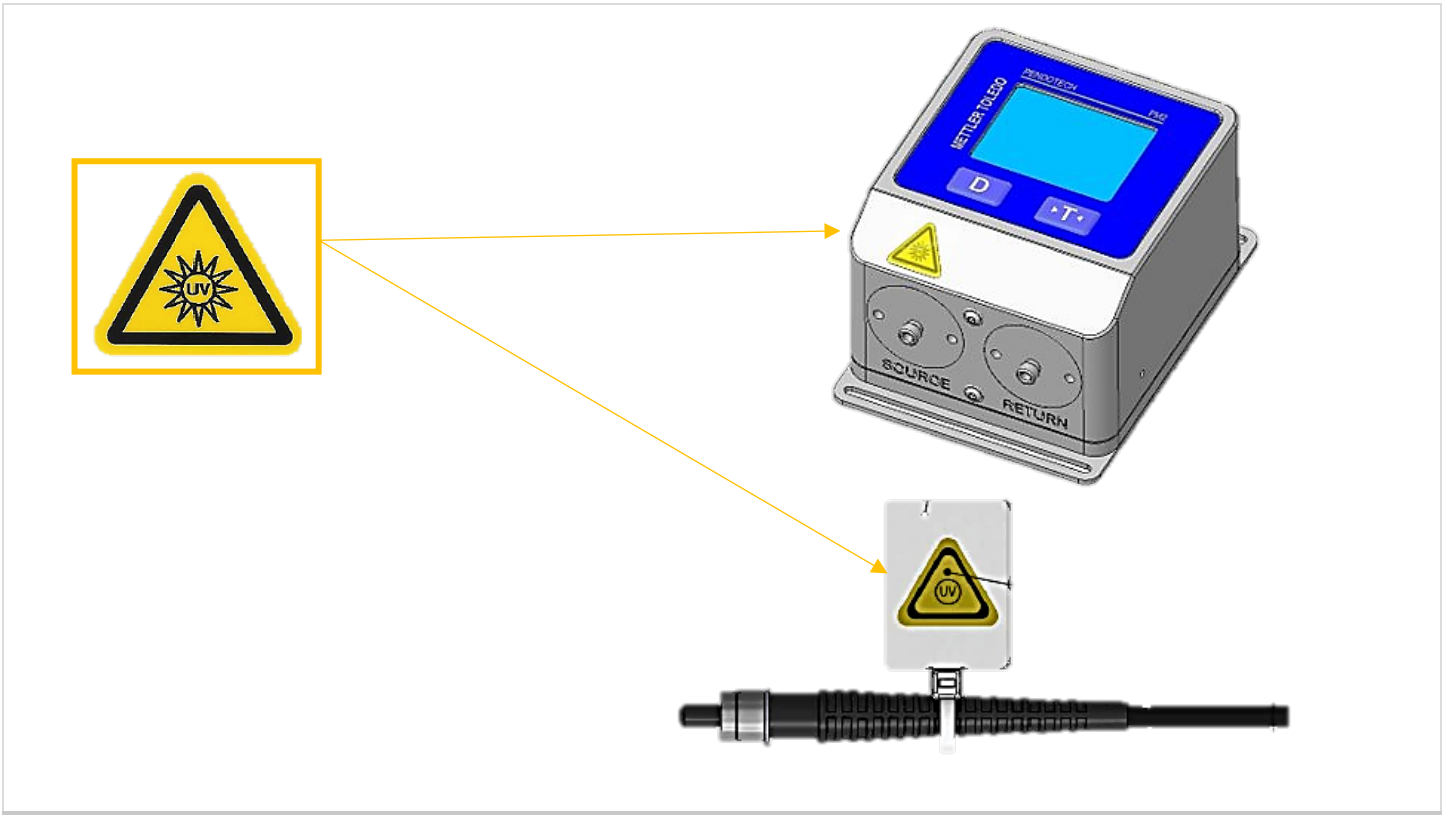


Fig 1: Warning label, PM2, Fiber cable.

Contents

1 Disclaimer

The information in this User Guide is believed to be accurate and reliable for the use and operation of the monitor; however, PendoTECH assumes no responsibility for the use of this product except for what is covered in the Limited Warranty and Terms and Conditions of Sale.

NOTE: *"NOTE" is used to notify the user of installation or operation information that is important but not hazard-related.*

2 Introduction and Unpacking

The PendoTECH UV PM2 Photometer is a versatile measuring and monitoring device that allows users to measure absorbance and turbidity in bioprocess fluid streams. The device uses a collimated beam of light that passes through a sample with a defined path length to determine the absorbance of the sample. The photometer can measure UV absorbance at 260nm, 280nm, or 300nm to identify the presence or absence of a molecule of interest and at 880nm to measure turbidity and filter performance.

The photometer also functions as a transmitter with a 4-20mA output scaled 0-3 AU, making it easy to integrate with other monitoring and control systems. The photometer is available in a dual-wavelength version, which allows users to make two measurements of multiple wavelengths simultaneously in the same sample.

To make measurements in-line, the photometer uses PendoTECH Single Use UV/Turbidity Flow Cells, which contain a special silica glass lens and compartments for optical couplers. The flow cells can be repeatedly cleaned and reused but are designed for single use. PendoTECH Flow Cell Stand is an accessory that can be used to house or mount these flow cells as an alternative to optical couplers. The stand is recommended for improved usability and accessibility when changing flow cells and for blocking out ambient light in turbidity applications.

Overall, the PendoTECH UV PM2 Photometer and Single Use Flow Cells provide a reliable and convenient solution for measuring and monitoring bioprocess fluid streams.

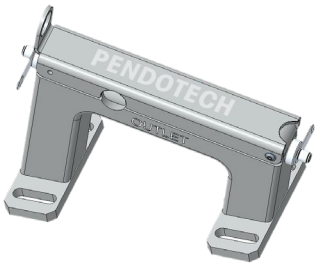
2.1 Identify the following components

Note: All the parts listed below are to be ordered individually.

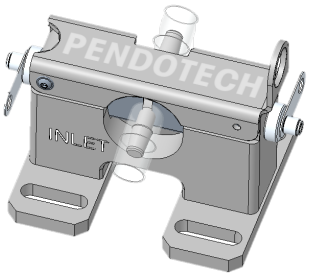
Photometer PM2

Fiber Optic Cable

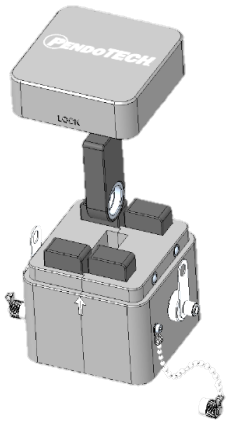
Coupler(s)



Flow cell Large Stand

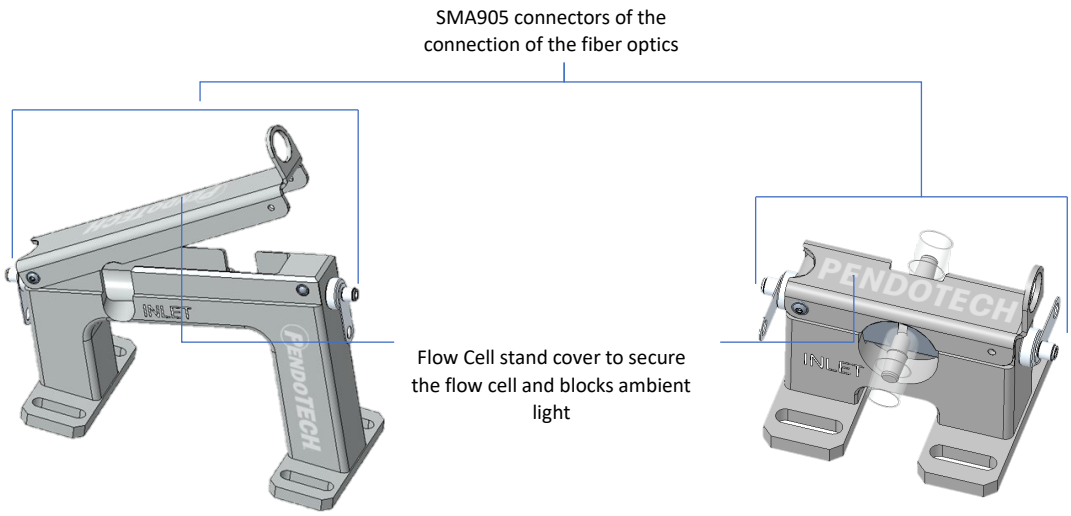


Flow cell Small Stand



Calibration Kit

3 Flow Cell and Flow Cell Stand



Flow Cell stand for 6.5cm flow cell
Material #: 30849504

Flow Cell stand for 1cm flow cell
Material #: 30849505

Note: *For Turbidity, a Flow Cell stand is required to block ambient light at 880nm from interfering with the measurement*

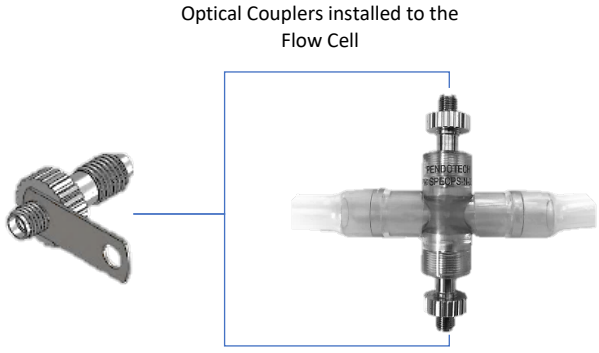
3.1 Flow Cells

The combination of the UV PM2 photometer and the PendoTECH Single Use Flow Cells allows the measurements to be made in line. The flow cells contain a special silica glass window and compartments to insert optical couplers, which attach to the fiber optic cables from the photometer. The flow cells can also be used with PendoTECH's Flow Cell Stand with integral couplers in place of the optical couplers to connect the fiber optic cables. The flow cell stand is optional but recommended because it blocks out ambient light that could otherwise affect the absorbance readings. Additionally, the flow cell stand improves accessibility and makes it easier to change flow cells. Although designed for single use, the flow cells may be repeatedly cleaned and reused.

Flow Cell with tubing installed

6.5cm Single-Use Turbidity Clow Cell

3.2 Optical Couplers



4 Unit Overview

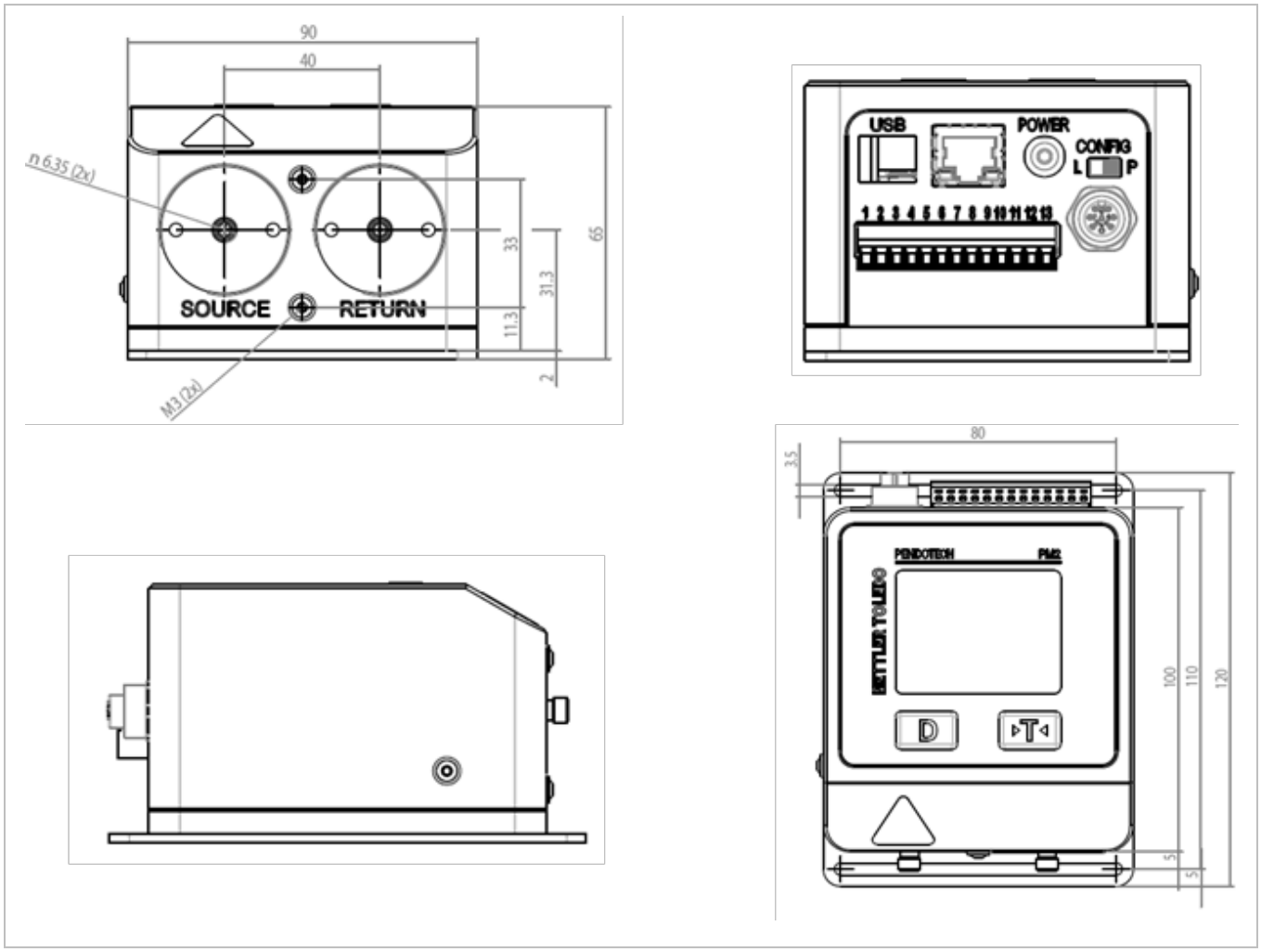


Fig 2: PM2 (Photometer) dimensions in mm.

1	4-20 mA +	**6**	RS485-A	**11**	ZERO -
2	4-20 mA -	**7**	RS485-B	**12**	ALARM +
3	4-20 mA +	**8**	GND	**13**	ALARM -
4	4-20 mA -	**9**	12-48 VDC POWER	4-20 mA = 0-3 AU	
5	RS485 Shield	**10**	ZERO +		

Note: For single channel units, only pins 1 and 2 are used. For dual channel units, pins 1 and 2 correspond to the photometer's first wavelength (lower), and pins 3 and 4 correspond to the second wavelength (higher).

5 Hardware installation

Please follow the outlined sections below as a guideline for installing the photometer and associated accessories. These guidelines apply for specific application installations or, in the case of OEM component installation onto a suitable panel.

DO NOT SUPPLY POWER TO THE UNIT UNTIL TOLD TO DO SO IN THE INSTRUMENT SETUP AND INITIALIZATION PROCEDURE IN SECTION 5

5.1 Environmental

The photometer is strongly recommended to be installed in a clean, dry area where the ambient temperature does not exceed 115F/46C. Systems mounted in enclosures can be purged with clean, dry, oil-free air (or nitrogen) to dissipate heat.

5.2 Physical

For permanent installations

Bolt the photometer, back panel, or enclosure (as appropriate) in place using mounting screws. The location should be secure, rigid, and strong enough to support the weight of the installed system.

For laboratory use

Ensure sufficient space on the bench or tabletop to accommodate the hardware supplied.

For panel mount use

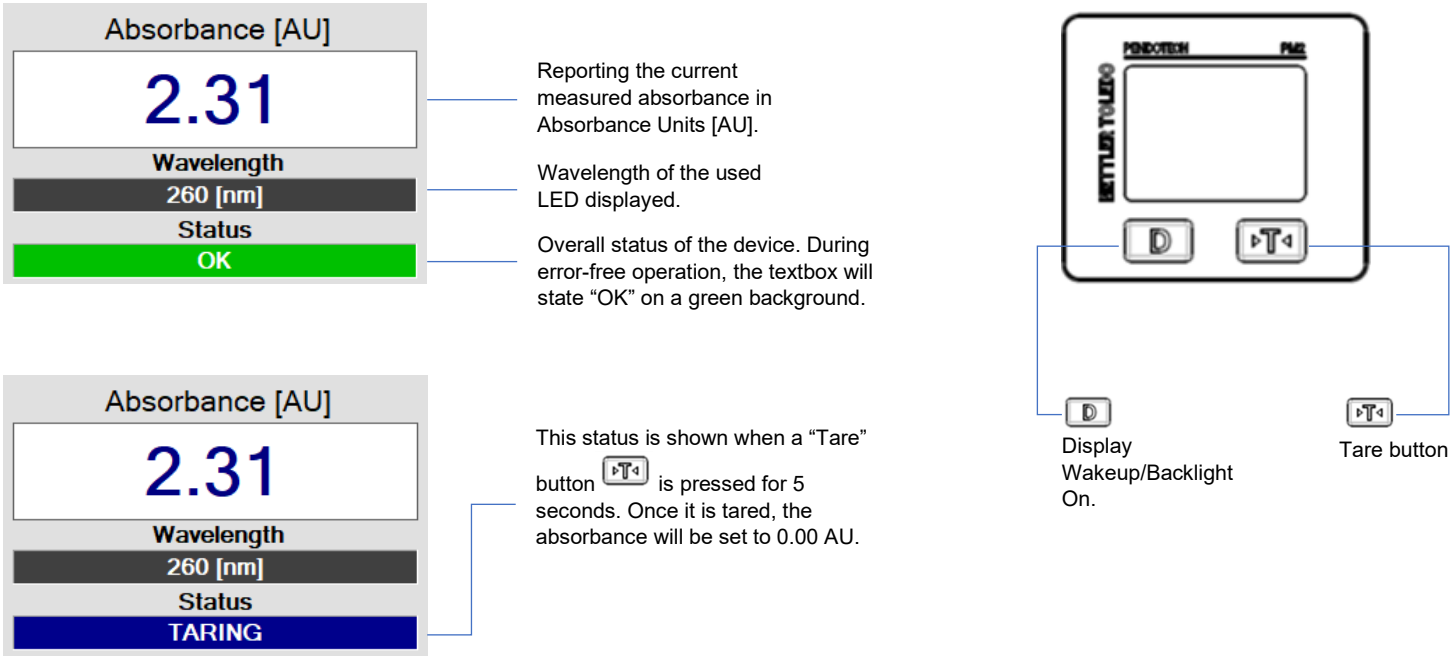
Ensure sufficient space on the bench or tabletop to accommodate the hardware supplied.

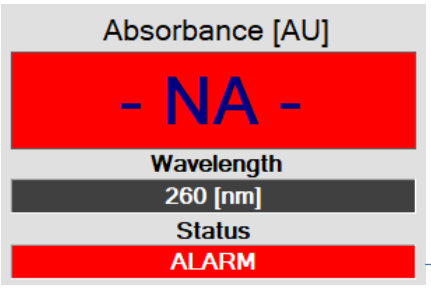
For all installations

Run the fiber optic cable(s) through conduit or other appropriate protective measures as desired. Refer to Section 5.3 below for optical component installation instructions.

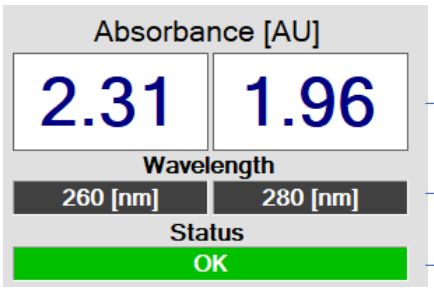
Run required electrical wiring for instrument power and output signals (4-20mA). Review Section 5.4 below before making electrical connections.

5.3 Panel Display and Buttons





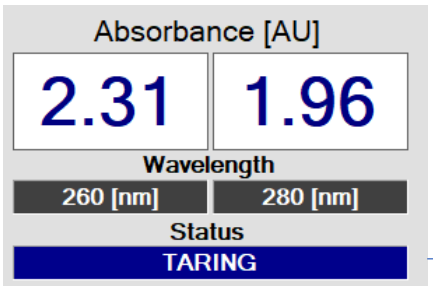
On errors the device enters the alarm mode. (See section alarms). The screen signals -NA- (Not applicable) on a red background in the [AU] textbox. The status textbox states "ALARM" and changes background to red.



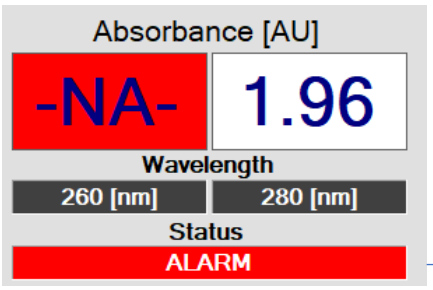
Reporting the current measured absorbance in Absorbance Units [AU]. Left side for channel 1 right side for channel 2.

Wavelength(s) of the used LED displayed.

Overall status of the device. During error-free operation, the textbox will state "OK" on a green background.



This status is shown when a "Tare" button is pressed for 5 seconds. Once tared, set the absorbance to 0.00 AU for both channels.



The screen signals -NA- (Not applicable) on a red background in the affected AU channels. The status textbox states "ALARM" and changes background to red.

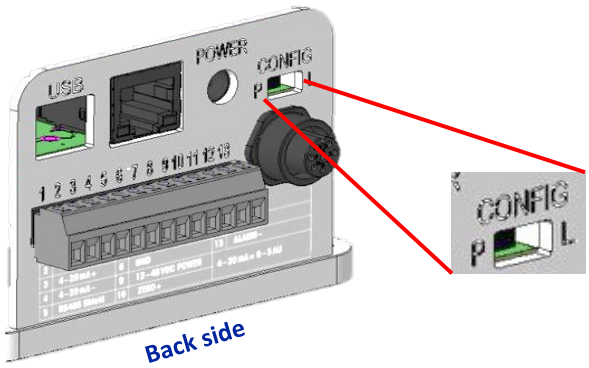
5.4 Alarms

Refer to the PM2 photometer's Display, indicating an alarm condition. For the 4-20mA outputs will indicate alarms (going to high-level).

Alarm Activator	Cause	Solution
The measurement detector is saturated at 100%.	Photometer outputting invalid absorbance values due to bad tare.	Re-tare flow cell with background solution or air.
The reference detector is saturated at 100%.	Extreme amount of ambient light entering flow cell/measure detector.	Use flow cell holder to block ambient light from entering flow cell; ensure fiber optic cable connections are firmly hand tight.
The reference light and dark signals are too close to each other.	LED is dead.	Send back to PendoTECH for repair.

5.5 Configuration of Unit for Laboratory or Panel Mount Installations

PM2 has dual functionality to operate as a laboratory benchtop unit or panel mount unit. By default the configuration switch is in the **L** position or laboratory unit. In this configuration the power connector and the 8-pin circular input/output connector are active. To change to the panel mount configuration where power, input/output functions are on the screw terminal connector, move the switch to the **P** position as shown.



5.6 Optical

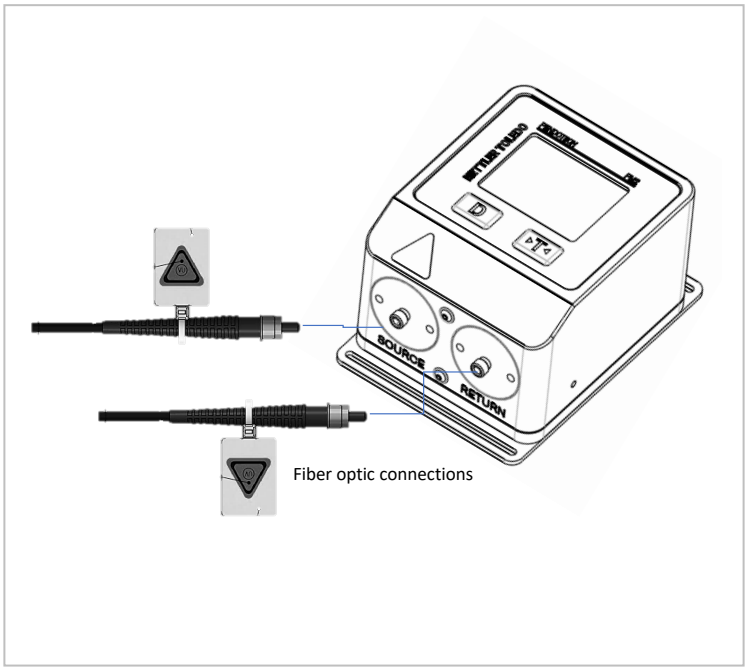


Fig 3: Front view of the PM2 Photometer with fiber optic cables for source and return.

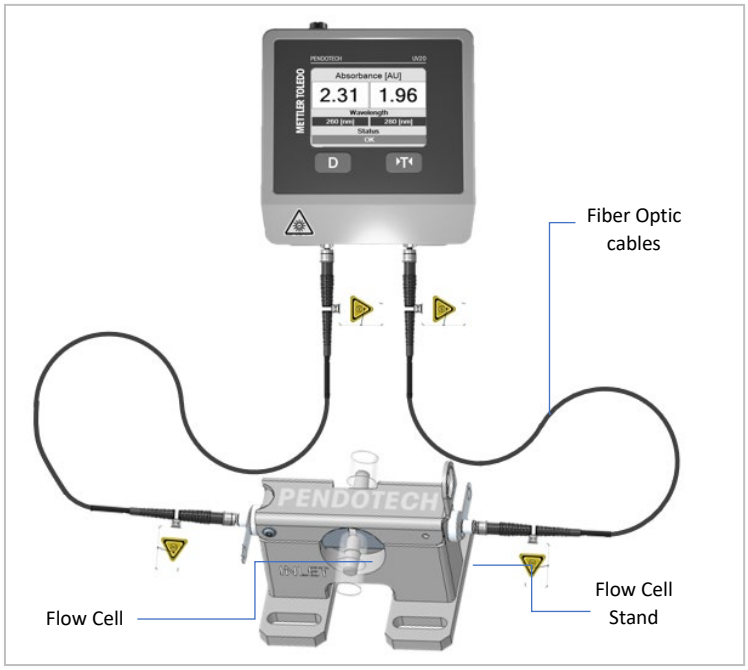
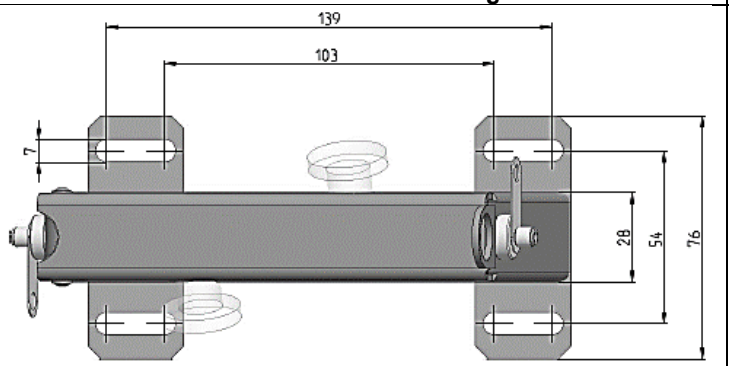
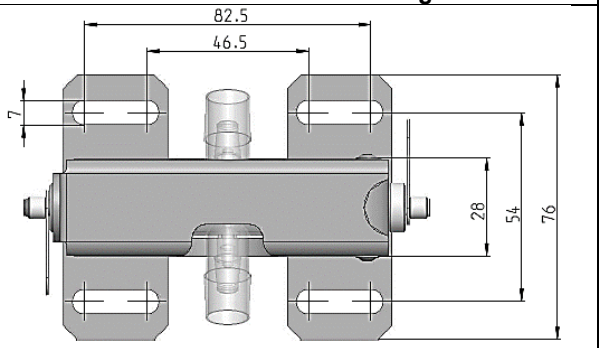


Fig 4: Complete system setup showing measure unit/PM 2 Photometer, flow cell stand/holder, and fiber optic cables

1. Remove the protective caps from the SMA-905 connectors on the fiber optic cables and the photometer.
2. Clean the fiber ends with spectroscopic-grade isopropyl alcohol (IPA, also known as 2-propanol) or methanol using a lint-free cotton swab or non-abrasive task wipe. Spectroscopic grade acetone can also be used, but separation of cotton from the swab might occur as the binding agent dissolves.
3. Properly mount the flow cell stand/holder (if applicable to system). The flow cell stand can be set directly flat on a lab bench or should be properly wall/panel mounted. Proper mounting of the flow cell stand facilitates the pass through of bubbles/air pockets in the fluid stream, which if trapped in the flow cell, can degrade system performance.

30849504 Panel Mounting	30849505 Panel Mounting
	

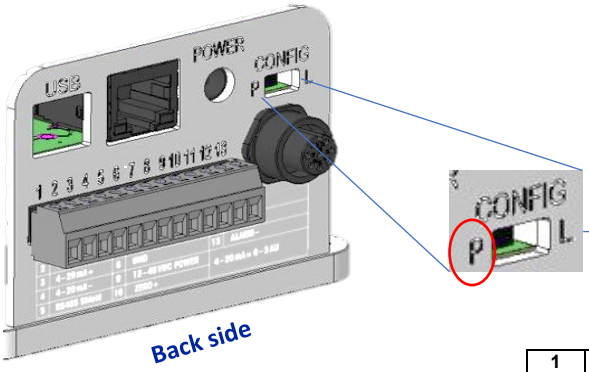
4. Connect the flow cell with optical couplers or flow cell stand to the photometer with the fiber optic cables. It does not matter which fiber connects to the source and return.
   NOTE: Ensure that both ends of the fiber optic cables (photometer and flow cell connections) are properly secured (firmly hand tight) before powering on the photometer.
5. Power on the unit. Refer to section 5.7 below for electrical connection and wiring.
6. Press the tare button (or perform dry contact closure over Tare/Zero +/- pins). This initiates the taring routine.
   NOTE: For best results, the unit should be tared with the process background fluid in the flow cell if possible. If not possible, then a tare with air in the flow cell may be used instead.
7. Wait at least 3 seconds for the taring routine to complete.
   NOTE: In a panel mount installation, the display is not visible. It is recommended to integrate a 3s indication display on the user interface that the unit is not ready for use (do not change fluid sate in the flow cells light path).
8. The unit is now ready for operation.

NOTE: The fiber optic cables must be secured so they are not free to move around, be stepped on, leaned against, or otherwise damaged during normal operations. The minimum bend radius for fibers UV PM2 Photometer is 8" (20.3cm).

Only hand tighten SMA-905 connections. Never use a wrench, pliers, or other tool. Over-tightening the SMA-905 connections may result in damage to the connector and the fiber optic cable, drastically reducing or prohibiting light transmission and requiring the replacement of the fiber optic cables.

5.7 Electrical

Panel mount version

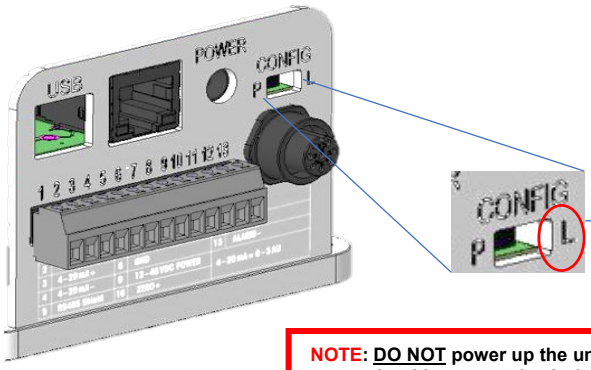


To change to the panel mount configuration where power, input/output functions are on the screw terminal connector, move the switch to the **P** position as shown.

1	4-20 mA +	**6**	RS485-A	**11**	ZERO -
2	4-20 mA -	**7**	RS485-B	**12**	ALARM +
3	4-20 mA +	**8**	GND	**13**	ALARM -
4	4-20 mA -	**9**	12-48 VDC POWER	4-20 mA = 0-3 AU	
5	RS485 Shield	**10**	ZERO +		

NOTE: For single channel units, only pins 1 and 2 are used. For dual channel units, pins 1 and 2 correspond to the photometer's first wavelength (lower), and pins 3 and 4 correspond to the second wavelength (higher).

Lab version



The default configuration switch is in the **L** position or laboratory unit. However, if the switch is in the panel mount configuration, move the switch from **P** position to **L** as shown.

NOTE: DO NOT power up the unit during installation. Ensure that all electrical connections are made with un-energized wires. It is recommended that an ON/OFF switch be employed for panel mounting.

I. Connect the power and ground to the system.

For laboratory systems, a 24VDC power brick is included with every PM2. However, the global use wall plug(s) must be ordered separately.

For panel-mounted systems, a 13-position terminal block connector is on the back of the PM2. Use a small flathead screwdriver to loosen the screw, insert a NON-ENGERGIZED 12-48VDC lead (with the end stripped so the metal wire is exposed) to position 9, and tighten the screw to secure the lead. Repeat the same procedure for securing the grounding lead to position 8.

II. Connect the 4-20mA output. For single-channel units, only pins 1 and 2 are used. For dual channel units, pins 1 and 2 correspond to the photometer's first wavelength (lower), and pins 3 and 4 correspond to the second wavelength (higher).

Pin	8-pos	Pin Function
1	WH	4-20 mA +
2	BN	4-20 mA -
3	GN	4-20 mA +
4	YE	4-20 mA -
5	GY	RS485 Shield
6	PK	RS485-A
7	BU	RS485-B
8	RD	GND

PendoTECH also has other pre-configured cables for connections to the PendoTECH Pressure MAT® Plus monitors, PendoTECH Control Systems, and other PendoTECH products.

6 Introduction to Absorbance Monitoring

6.1 Theory of Operation

Absorbance measures how much incident light is absorbed when it passes through a material. Light intensity decreases exponentially with distance as light passes through the material, so transmittance can be determined by measuring the intensity of both the incident and transmitted light. The value for transmittance can then be used to calculate the absorbance of the sample.

The Beer-Lambert Law relates how absorbance is related to the concentration and the distance the light must travel through the sample (path length):

$$A = \varepsilon c l$$

Where A is absorbance, ε is the extinction coefficient, c is the concentration of the solution (in mol/L), and l is the path length traveled by light through the sample (in cm).

6.2 LED-Based Absorbance

Light emitting diode (LED)-based photometers are a desirable choice when qualitative measurements are desired. Additionally, using calibration standards and environmental control, an LED-based photometer is capable of quantitative determination of analyte concentration. When making quantitative measurements, it is critical that the LED-based photometer is accurately correlated to standard laboratory methods and solutions.

The LED provides a specific wavelength (or wavelengths for dual channel models) range for measurement, selected to coincide with analyte-specific molecular absorbance. The LED is located internal to the photometer and is specific to the application. Therefore, the PM2 UV photometer is a dedicated instrument for monitoring only one or two specific analytes of interest.

Shown below are three example LED spectrum profiles graphs for typical LED light source wavelengths 260/280/300/880nm (Figures 5-8).

Definitions

- **CWL (Center Wavelength):** The wavelength of an optical source that is considered its' middle. The wavelength of the peak of the spectral density curve.
    - **Watch-Out**: If measurements are attempted on a shoulder/slope of the molecule's absorption profile, the absorption measurement can change dramatically over the span of a few nanometers. Absorbance may never saturate as a portion of the LED's output is outside of the molecule's absorbance profile. Minute photometer unit-to-unit absorption variations exist due to CWL tolerance.

- **FWHM (Full Width Half Maximum)**: A measure of the range of light the LED generates. The width of an optical signal at half its maximum intensity
    - **Watch-Out**: If the light source FWHM width is wider than the molecule's absorption peak, which will produce false, low absorption values.

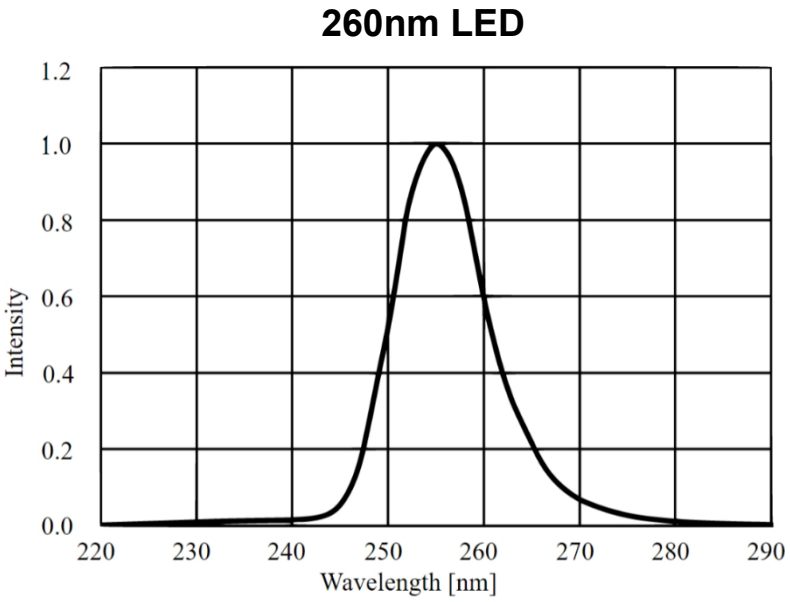


Fig 5: LED wavelength spectrum example for 260nm UV PM2 Photometer.

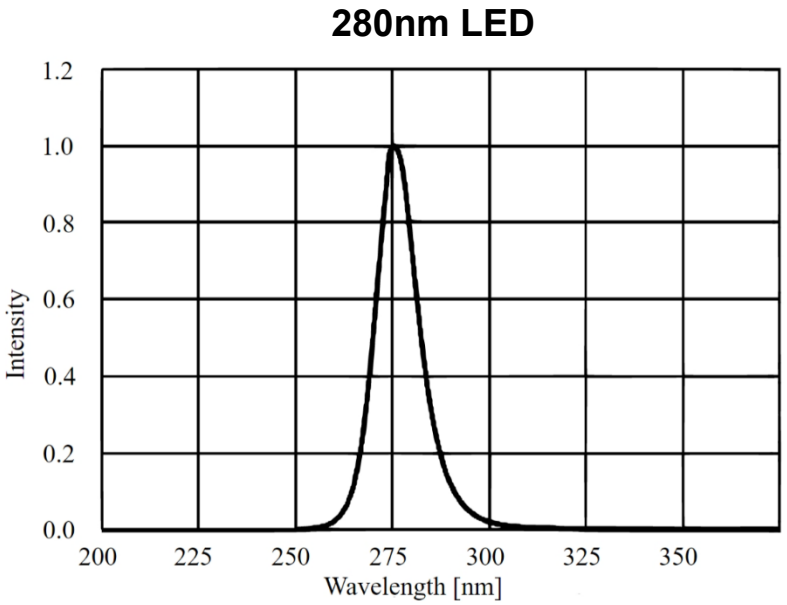


Fig 6: LED wavelength spectrum example for 280nm UV PM2 Photometer.

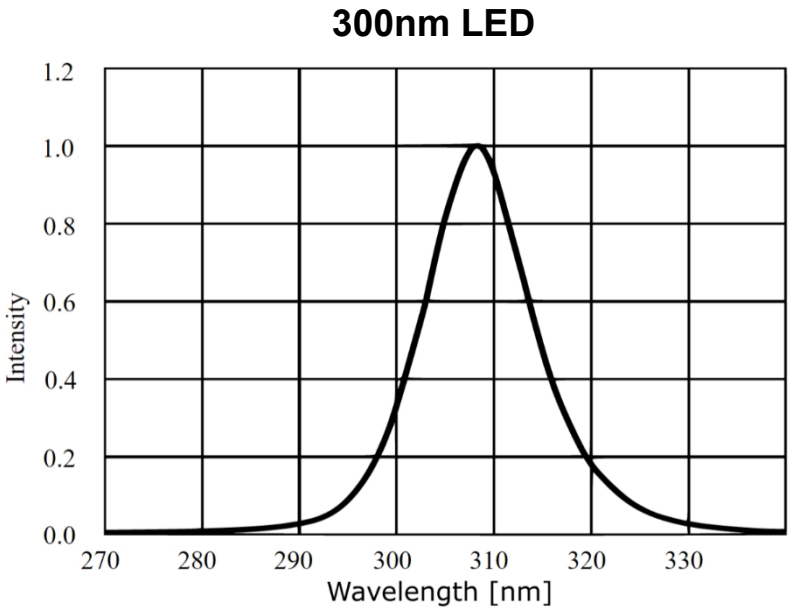


Fig 7: LED wavelength spectrum example for 300nm UV PM2 Photometer.

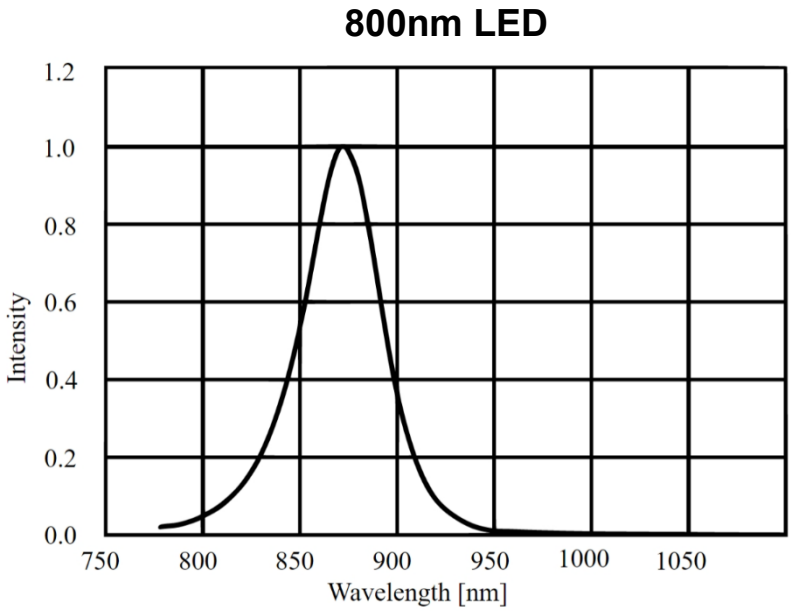


Fig 8: LED wavelength spectrum example for 800nm UV PM2 Photometer.

In brief, the photometer works as follows: The measuring system is in the detector block of the photometer. Light is provided by an LED, which produces a stable light output at a narrow wavelength range. The reference signal is measured directly from the light source by the reference detector, and light that passes through the sample is measured by the measure detector. The reference channel is used in order to cancel variations from light source intensity fluctuations, spectral change due to window fouling, or suspended particles in the process stream.

7 Glossary and definitions

Dynamic Range: Dynamic range refers to the range of concentrations an instrument can read, from the minimum to the maximum detectable concentration. The minimum detectable concentration is determined by the signal-to-noise ratio. The maximum detectable concentration is determined by the compound's chemistry and by factors such as instrument sensitivity ranges, optical pathlength, etc.

Linearity: Absorbance intensity is typically directly proportional (linear) to concentration. There are, however, many factors that affect this linear relationship. For example, stray light, turbidity, variation in the chemical composition of the background, etc., can affect the linearity of the absorbance response.

Measure Detector: A detector that measures the intensity of light after it has contacted the sample. The system is designed so that only absorbing wavelengths of light are measured by the measure detector.

Measure LED: The measure LED is the light-emitting diode (LED) used to select the measurement wavelength.

Measure Wavelength: The wavelength, or range of wavelengths, of light absorbed by the analyte(s) of interest.

Process Background: The liquid or gas used to transport or sustain the analyte of interest in the process. This includes all the chemical constituents found in the process except the analyte of interest.

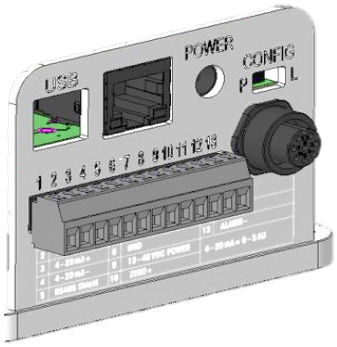
Reference LED: The reference LED is the light-emitting diode (LED) used to select the reference wavelength to be measured by the reference detector. The centre wavelength selected is a wavelength at which the analyte of interest does not absorb and is used to cancel variations from such effects as light source intensity fluctuations or spectral change due to window fouling or suspended particles in the process stream. Reference LED is an optional feature but is required through media referencing.

Sensitivity: The ability of the photometer to detect a given level of analyte based on the molecular absorbance of the analyte. The actual limits of detection depend on the properties of the analyte measured and the process conditions.

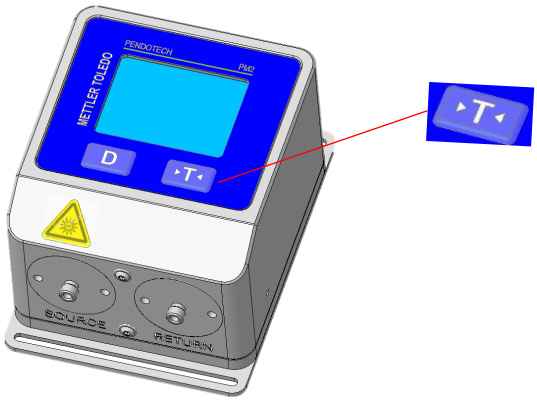
Specificity: The ability of the analyzer to monitor one specific analyte in a mixture of background materials without interference from the background materials.

8 Instrument Control

8.1 Zero



1	4-20 mA +	**6**	RS485-A	**11**	ZERO -
2	4-20 mA -	**7**	RS485-B	**12**	ALARM +
3	4-20 mA +	**8**	GND	**13**	ALARM -
4	4-20 mA -	**9**	12-48 VDC POWER	4-20 mA = 0-3 AU	
5	RS485 Shield	**10**	ZERO +		



NOTE: For best results, the unit should be tared with the process background fluid in the flow cell if possible. If not possible, then a tare/calibration with air in the flow cell may be used instead.

9 Absorbance Operations

NOTE: The 4-20mA output is correlated to absorbance intensity in AU (absorbance units). The 4-20mA output must be scaled using an external device to convert absorbance intensity to relevant engineering units. The photometer cannot be set to relevant engineering units and has a fixed range of 0.00-3.00AU = 4mA-20mA.

NOTE: Please reference Section 5 for hardware installation instructions (environmental specifications, physical mounting, optical connectivity, and electrical connectivity).

This procedure assumes that the hardware has been installed correctly and is ready for operation. For panel-mounted systems, this procedure is valid once electrical connectivity is established.

DO NOT power the unit until directed to do so in this procedure.

1. Ensure that the fiber optic connections to the photometer and the corresponding optical flow cell couplers are hand tight. See Section 5.5 for instructions
   a. Insert single-use flow cell into the flow cell stand/holder (if applicable). Replace the stand's cover and close the cover firmly to securely hold the flow cell.
2. Ensure that both the power and the analog output connections are wired correctly. See Section 5.7 for instructions.
3. Provide power to the unit.
4. Zero (tare) the unit.

   NOTE: For best results, the unit should be tared with the process background fluid in the flow cell if possible. A tare with air in the flow cell may be used instead if not possible.

10 System Specification

This section provides detailed specifications for the PM2 UV Photometer system purchased. In addition, this section may contain application-specific notes on operability and functionality.

10.1 Optical Configuration

The optical configuration listed is for a complete analyzer system. The detectors and light-emitting diode (LED) are internal to the photometer housing.

Optical Method	Absorbance
Light Source	LED
Reference Selection	Internal Source Reference

10.2 PM2 Specifications

Configuration	Internal Source Reference
Optical Connectivity	SMA-905
Mechanical	4" (10.2cm) W x 4" (10.2cm) L x 2.5" (6.4cm) H Weight: ~1.9lbs.
Power Requirement	12 - 48VDC nominal, 10W max power
Max. supply voltage fluctuations	±10% of DC supply voltage
Overvoltage Category	Category I
Output	4-20mA (Active/sourcing) spanned 0-3AU
Analog Loop Resistance	500 ohms
Alarm Relay	Max. 48 VDC, Max. 1 A
Operating Temperature	41 to 122°F (5 to 50C)
Storage Temperature	-4 to 122°F (-20 to 50C)
Operating altitude	Max. 5000 m above sea level
Humidity	20-80% relative humidity, non-condensing
Measurement Range	0.00-3.00AU
Response Time	1 second
Accuracy*	0-2AU: ±1%FS (±0.03AU) ; 2-3AU: ±2%FS (±0.06AU)
Precision/Repeatability	±0.5% full scale (±0.015AU)
LED Lifetime	> 5 years
Available Wavelengths	240-1000 nm
Regulatory	RoHS3, REACH, CE, UKCA

When converting the 4-20mA output to Absorbance Units (AU):

Let x = 4-20mA output

$$\left(\frac{x-4}{16}\right) \times 3.000 = AU$$

10.3 Service Information

Any product which is under warranty must be returned to PendoTECH for repair. If out of warranty, the user should call PendoTECH for over-the-phone assistance and our service staff will help determine if the unit should be returned for repair.

For factory service, please contact PendoTECH at request@pendotech.com or call +1-609-799-2299 for a return authorization number.

Then pack the unit carefully, preferably in the original shipping container, insure it, and ship it to PendoTECH.