

PendoTECH® Turbidity System

Background

Turbidity can be defined as an optical property of a liquid that causes light passing through it to be scattered rather than transmitted. Simply stated, it is the relative clarity of the liquid and is the result of solids suspended in the liquid. Turbidity measurements are affected by the number of particles in the liquid and the size and shape of the particles. Turbidity measurement detects the presence of particles by determining the difference between the amount of light that is emitted from the light source and that received by the detector. The difference is a measure of solids in the light path that have scattered the incoming light. Most turbidity measurements utilize light in the spectrum's near-infrared (IR) region, especially at a wavelength of 880 nm. The standard unit of measure of turbidity is the Nephelometric Turbidity Unit (NTU).

In bioprocess operations, the turbidity of the liquid, post-filtration, is often measured as an indication of filter performance. The measurement may indicate that undesired components are "breaking through" the filter, meaning it is losing its retention capacity. It can also measure unclarified material directly from a bioreactor or fermentation vessel. The turbidity measurement at 880nm can be used with pressure measurements in constant flow filtration processes to assess filter performance. To make a turbidity measurement, a sample may be drawn and measured off-line or by an online measurements unit such as the PendoTECH Turbidity System consisting of the photometer light source/detector, flow cells, fiber optic cables, flow cell stand, and cables to connect to monitor or control system. The PendoTECH Single Use Flow Cell can be used with the system to eliminate the need for cleaning.



Benefits

- **Quality control:** Turbidity measurements effectively monitor the quality of liquids in various industries, including bioprocess operations. By measuring the turbidity, it is possible to detect the presence of unwanted particles and contaminants, which can help ensure that the liquid meets the required quality standards.
- **Filter performance monitoring:** Turbidity measurements can be used to monitor filters' performance and determine if they are functioning correctly. By measuring the turbidity of the liquid post-filtration, it is possible to determine if any undesired components are breaking through the filter, indicating that it is losing its retention capacity.
- **Process optimization:** Turbidity measurements can be used to optimize various processes, including bioreactors and fermentation vessels. By measuring the turbidity of unclarified material directly from these vessels, it is possible to adjust the process parameters to optimize the yield and quality of the final product.
- **Real-time monitoring:** Turbidity measurements can be performed in real-time, continuously monitoring the liquid quality and filter performance. This can help identify issues early on and allow for quick corrective action.
- **Single-use options:** Single-use flow cells, such as the PendoTECH Single Use Flow Cell, can eliminate the need for cleaning and reduce the risk of contamination, making turbidity measurements more effortless and more convenient to perform.
- **Easy Integration:** Dual functionality for lab and benchtop uses or panel mount installations. Digital communication protocols for connecting to other devices and networks

Dual Wavelength Photometer PM2

PendoTECH® offers a Dual Wavelength version of the PM2 Photometer, which is equipped with two LED light sources. This system is available to output 260 nm, 280 nm, 300 nm or 880 nm, and measures two wavelengths simultaneously. Measuring the absorbance of two wavelengths in the same sample has many advantages in biopharmaceutical development and manufacturing. For instance, the user could detect protein, and measure turbidity simultaneously in the same sample by using a system at 280 and 880 nm. Likewise, a photometer with two wavelengths in the UV range can detect binary mixtures if the products have different absorption spectra. For example, measuring the absorbance of a sample at 280 nm to detect proteins, as well as at 260 nm to detect nucleic acids, and then taking the ratio, to provide an estimate of the purity of the solution.

Technical Details and Integration

The PM2 Photometer is a versatile instrument for lab and industrial applications. It can be used in both benchtop and panel mount versions, making it suitable for integrating into different systems. It can be configured with seven different wavelength combinations: 260nm, 280nm, 300nm, 880nm, 260-280nm, 280-300nm, and 280-880nm.

The photometer is designed to be integrated into a monitor with data acquisition capability. PendoTECH offers PM2 photometer solutions, such as PressureMAT PLUS models, which can be used with a PC for data logging, and PendoTECH Process Control Systems.

The transmitter's output is two 4-20mA signals spanning 0 to 3AUs. This means that the instrument provides two output signals that can be used to monitor the readings from the photometer. The transmitter also has a local display to view the readings directly from the instrument.

Other data acquisition devices with analog inputs may be used to collect the data from the photometer. These devices can be connected to the output signals of the transmitter to collect and store the data. Higher-level control systems like PLCs and HMIs can also be used to integrate the photometer into a more extensive control system.

The PM2 Photometer can also be integrated with control systems with its built-in digital communication protocols. The photometer supports Modbus communication over RS485, as well as Modbus-TCP over Ethernet. These protocols can be used to monitor and control the device, as well as communicate with other systems or a network.

Overall, the PM2 Photometer is a versatile instrument that can be integrated into different types of systems. Its output signals and compatibility with different data acquisition devices and control systems make it a flexible solution for monitoring bioprocesses



6.5 cm flow cell installed in stand



1 cm flow cell installed in stand



1 cm flow cell with tubing installed

Single-Use Flow Cells

The PendoTECH Single Use Flow Cells enable the measurement to be made non-invasively. These flow cells contain a unique silica glass lens installed within the optical path. The difference between the intensity of the light source and the detector is measured without any physical product contact. The stream to be measured flows between the lenses by way of tubing attached to the ports of the flow cell. It comes in multiple sizes, including a 3/4inch sanitary flange with a 6.5cm path length, 1/2inch hose barb with a 1cm path length, a 1/4inch hose barb with a 0.5cm path length, and a 1/8inch hose barb with a 2mm path length. For best performance, the largest path length flow cells are recommended for turbidity applications. Testing with Formazin Turbidity standards demonstrated the 6.5cm flow cell is best for turbidity measurements below 400 NTU, and the 1cm flow cell is best for applications above 400 NTU, however this may vary depending on fluid. The low cost of the flow cell makes it ideal for single-use applications; however, the cell may be cleaned and reused repeatedly. All polymeric materials in the fluid path meet USP Class VI standards, and flow cells are assembled in an ISO 9001 facility. The flow cell may be gamma and x-ray irradiated up to 50KGy and autoclaved up to 121°C.



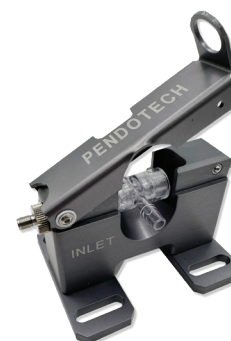
6.5 cm Single Use
Turbidity Flow Cell

Flow Cell Stand Details



SMA905 connectors for
connection of fiber optics

Flow cell stand for 6.5 cm flow cell
PART#: 30849504



Flow cell stand for 1 cm flow cell
PART#: 30849505

Measuring Turbidity

The PendoTECH Turbidity System operates on the principle of light scattering of particles at a wavelength of 880nm, which is the traditional wavelength for turbidity measurements. The raw reading of the instrument is AUs. This can be directly correlated to NTUs that are the typical units of measurement for turbidity. The correlation of AUs to turbidity is based on the path length. Some measurement units can detect the scattering of light that passes either straight through the sample (forward light scattering), scattering at 90 degrees, scattering back toward the light source, or some combination of all scattering modes. The PendoTECH Turbidity System exclusively uses forward light scattering. Because of its in line nature, and its ability to only measure forward light scattering, the precision/repeatability is noted below, and may not be comparable to a benchtop unit.

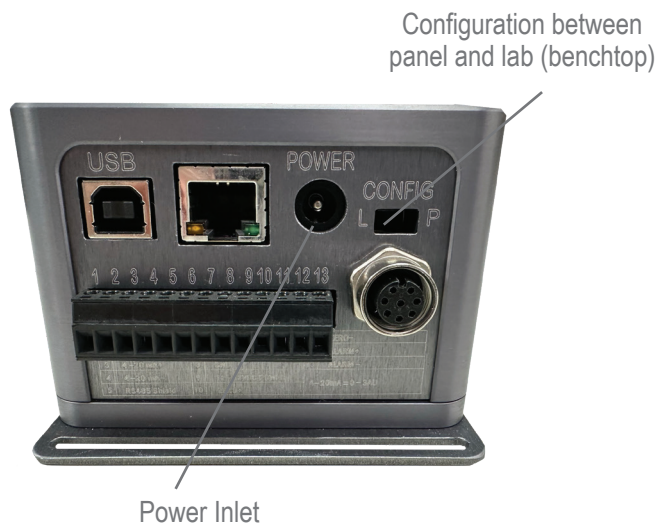
NTU Standard Measurement, Dynamic Range and Repeatability		
Flow Cell Optical Path Length (OPL)	Approximate Maximum Dynamic Range (NTUs)	Precision/Repeatability (approx)
2.5 in (6.5 cm)	425	±2NTUs
0.4 in (1 cm)	2750	±14NTUs
0.2 in (0.5 cm)	6000	±30NTUs

However, the correlation may vary between samples from different processes. For best results a product specific correlation from AUs to NTUs may be determined with multiple offline measurements to develop an AU to NTU correlation equation.

Photometer / Transmitter Details



Back panel view



DIN Rail Adapter Mounting Plate

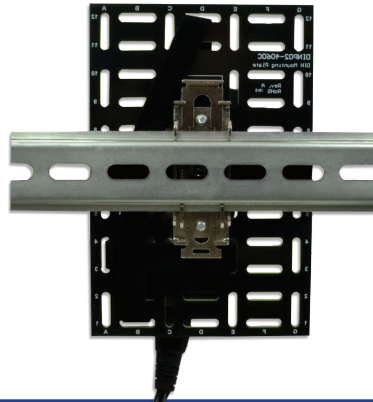
PART #: PHOTO-DR

The PendoTECH Photometer is available as a standalone bench top unit or in a panel mount model. When integrating the PendoTECH Photometer into an electrical cabinet there are several mounting options available (See Technical Note: PendoTECH Dual Wavelength Photometer Monitor/Transmitter Mounting Instructions). For mounting on a DIN rail installed in a cabinet there is a customized accessory available to streamline this process. It comes with the required hardware to mount the photometer:

- 4x #6 - 32 x 3/8inch Philips pan head machine screws
- 4x #6 - 32 Hex nuts

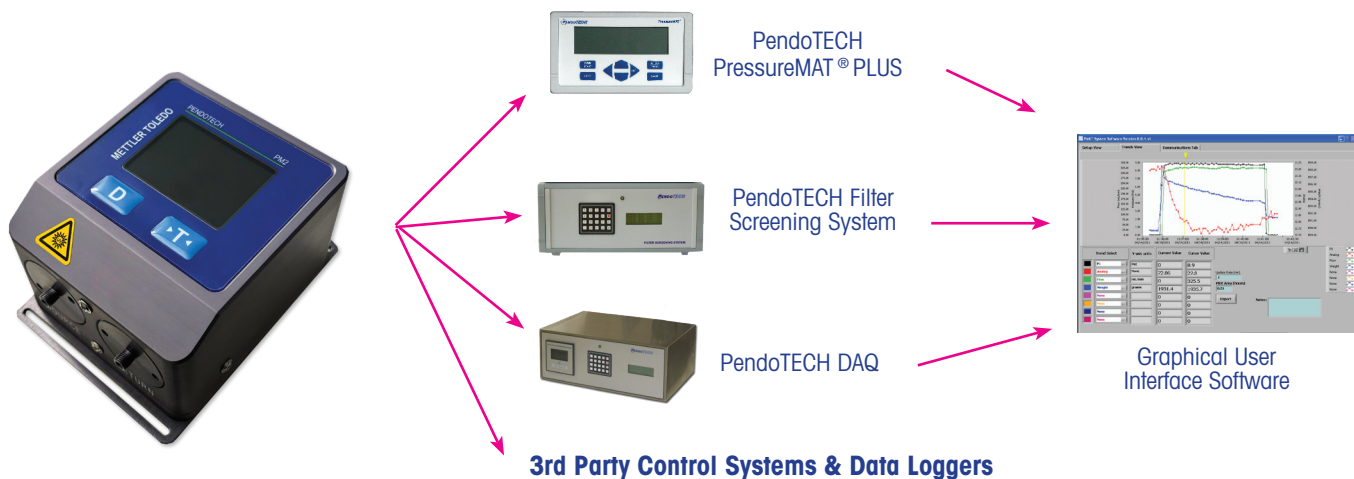


Spring loaded latch
for easy removal



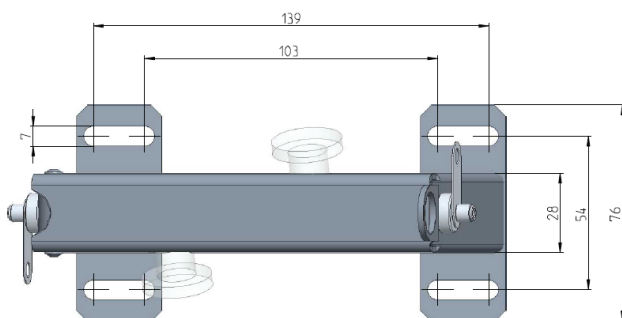
Photometer/transmitter output enables simple integration to other systems

The unit is designed to be integrated to a monitor with data acquisition capability. PendoTECH offers solutions for using the photometer/transmitter with data acquisition devices such as PressureMAT® PLUS models (which can in turn be used with a PC for datalogging) and PendoTECH Process Control Systems. Other data acquisition devices with analog inputs may be used, as well as higher level control systems like PLCs and HMI's.

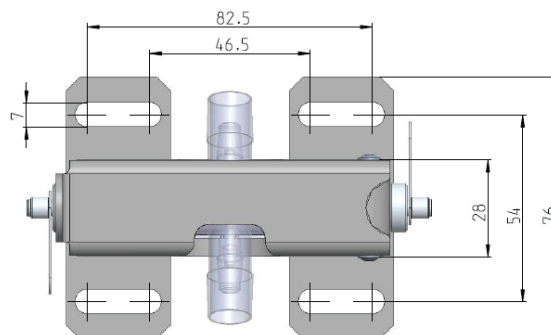


Flow Cell Stand Mounting Information

30849504 Panel Mounting (all dimensions in mm)



30849505 Panel Mounting (all dimensions in mm)



Photometer Specifications:

Optical Configuration	LED light source
Optical Connectivity	SMA-905
Mechanical	4 in (10.2 cm) W x 4 in (10.2 cm) L x 2.5 in (6.4cm) H Weight: ~1.5 lbs.
Power Requirement	24VDC nominal, 2.7W max power
Output	4-20mA (Active/sourcing) spanned 0-3AU
Analog Loop Resistance	500ohms at 24VDC
Operating Temperature	41 to 122°F (5 to 50°C)
Storage Temperature	-4 to 122°F (-20 to 50°C)
Measurement Range	0.000-3.00AU
Response Time	1 second

Maximum Zero Shift	±0.1% full scale (±0.002AU)
Accuracy*	0-2AU ±1%FS (±0.03AU) ; 2-3AU ±2%FS (±0.06AU)
Long Term Output Drift	±0.1% full scale (±0.002AU)
Repeatability	±0.5% full scale (±0.015AU)
LED Lifetime	> 5 years
Available Wavelengths	260, 280, 300 and 880 nm

* Accuracy is dependent on system arrangement and proper tare

The Photometer's LED provides a specific wavelength (or wavelengths for dual channel models) range for measurement, selected to coincide with analyte-specific molecular absorbance. Shown below are three example LED spectrum profile graphs, for typical LED light source wavelengths 260/280/880nm (Figures 1-3).

- **CWL (Center Wavelength):**

The wavelength of an optical source that is considered its' middle. The wavelength of the peak of the spectral density curve.

- **Important:**

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.

- **Important:**

If the light source FWHM width is wider than the molecule's absorption peak, that will produce false, low absorption values.

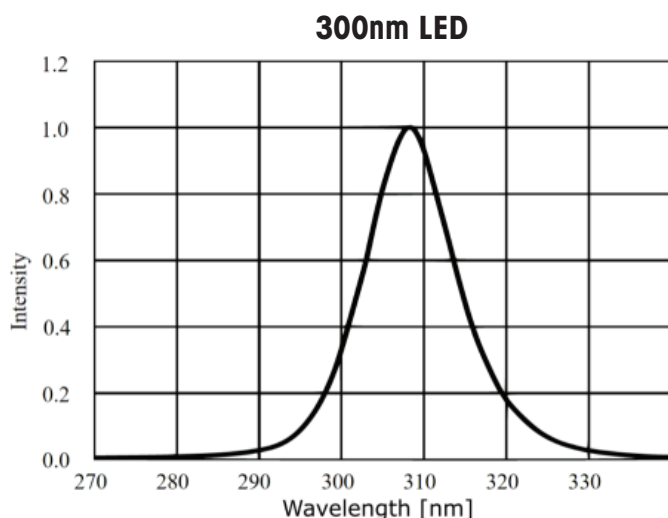


Fig. 1: LED wavelength spectrum example for 300 nm UV PM2 Photometer

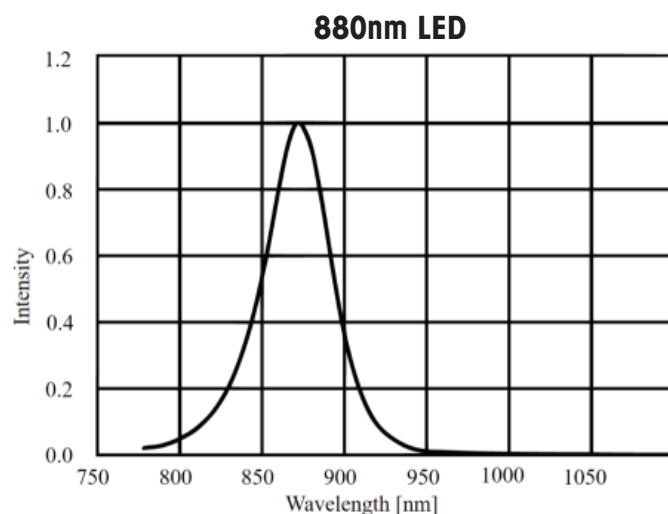


Fig. 2: LED wavelength spectrum example for 880 nm UV PM2 Photometer

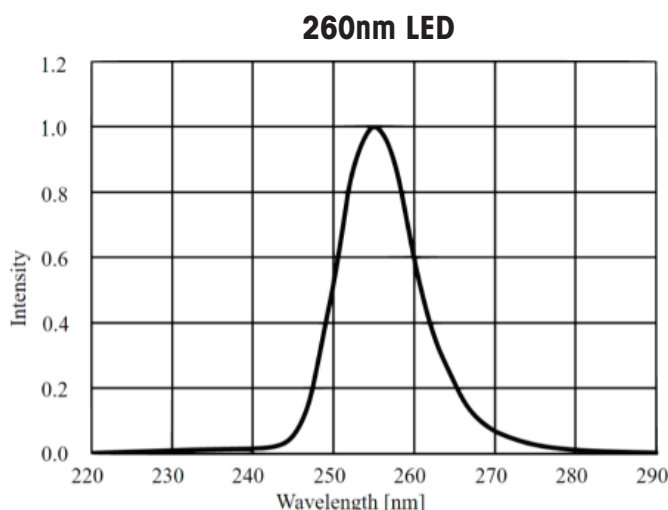


Fig. 3: LED wavelength spectrum example for 260 nm UV PM2 Photometer

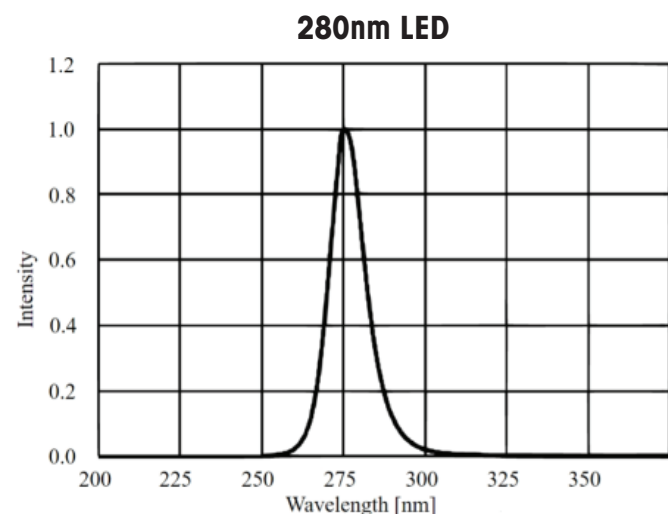


Fig. 4: LED wavelength spectrum example for 280 nm UV PM2 Photometer

Single Use Flow Cell Specifications

Manufacturing Testing	<ul style="list-style-type: none"> - Each product is leak-tested to confirm integral assembly - Each product is visually inspected to confirm optical clarity of lenses 				
Material	Polysulfone and fused silica with silicone O-ring				
Pressure range	Rated for pressure up to 75psi (5bar)				
Biocompatibility	All materials in contact with product fluid path meet USP Class VI requirements				
Regulatory and Compliance Testing	<ul style="list-style-type: none"> • USP Class VI • RoHS Compliant 	<ul style="list-style-type: none"> • ISO 10993-5 • Bacteriostatis and Fungistatis (B&F) 	<ul style="list-style-type: none"> • ADCF 	<ul style="list-style-type: none"> • Bioburden 	<ul style="list-style-type: none"> • REACH Compliant
Manufacturing Environment	ISO 7 clean room				
Gamma Irradiation	Up to 50 kiloGrays				
X-ray Irradiation	Up to 50 kiloGrays				
Operating temperature	2°C to 50°C (other ranges with process qualification)				
Storage temperature	-25°C to 65°C				
Shelf Life	>5 years				
Packaging	Individually packaged in polybag				

UV/VIS Photometer PM2 Test Rig

The PendoTECH Photometer Test Rig and Standards is designed for quick and easy accuracy verification of PendoTECH's PM2 Photometers. The test kit includes one blank, and 5 NIST Traceable filters, a test rig for holding the filters and for connecting the photometer, and a convenient holder. See the datasheet for further details.



PART #: 30849507

Ordering Information

****Please note that all photometers come with power supply, however country specific power cord is sold separately, please specify on purchase order.**

Photometers	
30849447	Photometer PM2 260 nm
30849498	Photometer PM2 280 nm
30849499	Photometer PM2 300 nm
30849500	Photometer PM2 880 nm
30849501	Photometer PM2 260-280 nm
30849502	Photometer PM2 280-300 nm
30849503	Photometer PM2 280-880 nm
Single Use Flow Cells	
SPECPS-N-012	Single use UV flow cell, 0.08 in (2 mm) path length, non-sterile, polysulfone, 1/8 in (0.318 cm) hose barb
SPECPS-N-025	Single Use UV Flow Cell, 0.2 in (0.5 cm) path length, non-sterile, polysulfone, 1/4 in (0.64 cm) hose barb
SPECPS-N-050	Single Use UV Flow Cell, 0.4 in (1 cm) path length, non-sterile, polysulfone, 1/2 in (1.28 cm) hose barb
SPECPS-880-6CM	Single Use Flow Cell, 2.5 in (6.5 cm) path length, non-sterile, polysulfone, 3/4 in (6.5 cm) Sanitary Flange Inlet/Outlet
Couplers, Cables & Power Cords	
30849506	Optical Coupler Single Use Flow Cell
30830317	Optical Fiber Photometer 1.64 ft (0.5 m)
30919657	Optical Fiber Photometer 2.29 ft (0.7 m)
30830318	Optical Fiber Photometer 3.28 ft (1 m)
30830319	Optical Fiber Photometer 6.56 ft (2 m)
30830320	Optical Fiber Photometer 9.84 ft (3 m)
SPEC-OC-PANEL	Panel mount SMA-905 connector (for pass through)
30305179	Power Cord CN 3 Prong
30305178	Power Cord EU 3 Prong
30305174	Power Cord UK 3 Prong
30305173	Power Cord US 3 Prong
87920	Mains Cable CH, 3P - For PM2 Photometer (Swiss Power Cord)
Accessories	
30849507	Calibration Kit with Standards 3AU
30849508	Replacement Standards for Calibration Kit
30849504	SU Flow Cell Stand 2.5 in (6.5 cm) path length
30849505	SU Flow Cells Stand 0.4 in (1 cm) path length
PMAT-DAQ	Analog display with 4 inputs with alarm inputs and serial port for data collection
PMAT-DAQ-A	Analog display with 4 inputs, 4 analog outputs, alarms, and serial port for data collection
PHOTO-DR	PendoTECH Photometer DIN Rail mounting kit, includes mounting plate and mounting hardware
Interface Cables	
PDKT-PM2-1-PMAT	Cable from single channel PM2 photometer to PendoTECH PressureMAT analog input, 6ft
PDKT-PM2-2-PMAT	Cable from dual channel PM2 photometer to PendoTECH PressureMAT analog input, 6ft
PDKT-PM2-1-PCS	Cable from single channel PM2 photometer to PendoTECH PCS Control System (DAQ/TFF), mA, 6ft
PDKT-PM2-2-PCS	Cable from dual channel PM2 photometer to PendoTECH Gen 2 TFF Control System, mA, 6ft
PDKT-PM2-1-NFFSSB	Cable from single channel PM2 photometer to PDKT-BOX-NFFSS breakout box, M8 male, mA signal, 6ft
PDKT-PM2-2-NFFSSB	Cable from dual channel PM2 photometer to PDKT-BOX-NFFSS breakout box, 6ft
PDKT-PM2-FL	Cable from dual channel/turbidity photometer to flying leads, 6ft