User Manual

For models

OxyFlo™ Pro
OxyFlo™ Pro XL

Continuous laser Doppler blood flow monitoring

Product Documentation and User Manual

Revision 1.1

For the purposes of this User Manual and unless otherwise stated, OxyFlo Pro shall also mean OxyFlo Pro XL

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1. SAFETY INFORMATION

This section contains important safety information related to the general use of the OxyFlo Pro monitor. Other important safety information appears throughout this manual in the form of warnings and cautions.

1.1 Intended Use

The OxyFlo Pro is a laser Doppler blood flowmetry (LDF) monitor intended for monitoring microvascular blood flow in tissue.

Most applications are concerned with monitoring the competence of regional (microvascular) blood supply in specialties such as peripheral vascular disorders, cerebral perfusion monitoring in models of stroke and brain injury, tumour perfusion monitoring / angiogenesis, blood flow in free flaps and pedicle flaps, wound healing, surgery, transplantation and more.

A range of fibre-optic based probes is available in support of these application areas, including small and lightweight probes for (non-invasive) skin and tissue surface measurements and needle type probes for direct (invasive) measurements within tissue, such as muscle and vitals organs.

In common with all LDF devices, quantitative measurements of tissue blood flow in absolute units (e.g. ml/min/g of tissue) are **not** possible with the OxyFlo Pro.

The OxyFlo Pro has been specifically developed for use with the OxyLite Pro, a fibre optic tissue pO_2 and temperature monitor. The combination of these two fibre optic measurement systems provides simultaneous tissue blood flow and oxygenation data. Combined sensors are available that support simultaneous pO_2 and blood flow monitoring.

1.2 Contra-Indications

The OxyFlo Pro is purely for laboratory, industrial and research use and is NOT a medical device. The OxyFlo Pro does NOT possess regulatory approvals for use with human subjects or patients.

1.3 FCC Compliance

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this

equipment in a residential area is likely to cause interference, in which case the user will be required to correct the interference at his/her own expense.

1.4 EMC Compliance – EC Declaration of Conformity

This equipment meets the intent of Directive 2004/108/EC for Electromagnetic Compatibility.

Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities.

- **EN 61326-1:2006**
- **EN 61326-2-1:2006**

1.5 Laser Safety

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Never apply an OxyFlo Pro probe directly to the eye. The laser exposure may cause permanent damage to the retina.

OxyFlo Pro is classified as a Class 1 Laser Product in accordance with the European Standard EN 60825-1:1994 and 21 CFR 1040.10 and 1040.11. In accordance with the standard, the back panel of the monitor carries the declaration:

Class 1 Laser Product

OxyFlo Pro incorporates semiconductor laser diode devices operating in continuous mode and emitting invisible laser radiation at a nominal operating wavelength of 830nm. The maximum output power at the probe tip is less than 0.5mW. Laser light emitted from the optical fibre is highly divergent.

Although the characteristics of the laser radiation place the OxyFlo device within the Class 1 classification, users should avoid directing the laser radiation onto the eye.

Applying the probe to any tissue other than the eye is harmless, even over prolonged time periods.

1.6 OxyFlo Pro Symbols

SN	Serial number	**REF**	Catalogue number (product code)

	Date of manufacture		Equipment should not be disposed of in the normal waste stream
	Attention. See instructions for use.		Read instructions for use
	Alternating current		Direct current
	Digital output		Analogue outputs

Table 1: OxyFlo Pro symbols

1.7 Definitions

	A warning indicates the possibility of injury to the operator.
	A caution indicates a condition that may lead to equipment damage and/or malfunction.

1.8 Summary of Warnings for the OxyFlo Pro Monitor

 WARNING	Do not attempt to open the OxyFlo Pro. There are no user-serviceable parts inside. There is a risk of electrical shock or other injury or permanent damage to the monitor.
 WARNING	The OxyFlo Pro should only be repaired or serviced by Oxford Optronix Ltd. trained service staff.
 WARNING	Use ONLY the NX-PSU universal AC adapter provided by Oxford Optronix. Failure to do so may result in irreparable damage to the OxyFlo Pro monitor and may cause harm to the user.
 WARNING	To avoid the risk of electric shock or shorts, do not spray, pour or spill any liquid in or on the OxyFlo Pro.
 WARNING	Never apply an OxyFlo Pro probe directly to the eye. The laser exposure may cause permanent damage to the retina.

1.9 Summary of Cautions for the OxyFlo Pro Monitor

 CAUTION	To avoid damage, do not use sharp objects to operate the touch screen display.
 CAUTION	To avoid damage, do not spray, pour or spill any liquid on the touch screen display.
 CAUTION	DO NOT attempt to operate the OxyFlo Pro in the vicinity of imaging or therapeutic equipment that emits ionising radiation or produces a strong magnetic field as the performance of the monitor may be affected. Extended probe lengths are available that allow the OxyFlo Pro monitor to be operated at a safe distance from such equipment.
 CAUTION	DO NOT attempt to autoclave, pressure sterilise, or expose to radiation, any part of the monitor.
 CAUTION	Connecting the NX-PSU universal AC adapter to the DC POWER IN inlet at the rear of the OxyFlo Pro, having already powered it via its On/Off switch MAY trigger the surge protection circuit within the OxyFlo Pro. If the OxyFlo Pro does not start up, turn off the AC adapter, wait 2 - 3 minutes, then turn the AC adapter on once more.
 CAUTION	Attempting to disconnect the probe by pulling the cable sleeving instead of the probe connector may cause irreparable damage to the probe.
 CAUTION	Use only probes, cables and accessories supplied by Oxford Optronix Ltd., otherwise serious damage may result.

1.10 Summary of Cautions for OxyFlo Pro Probes

 CAUTION	OxyFlo Pro probes must be HANDLED WITH CARE. Failure to do so may result in breakage of the internal optical fibres, scratching the polished probe ends or separation of the cable from the probe ends or connectors.
 CAUTION	OxyFlo Pro probes are NOT approved for use on patients.
 CAUTION	DO NOT drop, apply tension or ‘kink’ any part of an OxyFlo Pro probe. Permanent damage may result.
 CAUTION	OxyFlo Pro probes should be stored, with the probe cable carefully coiled to avoid ‘kinks’, in the dedicated protective case in which they are supplied.
 CAUTION	Do not use a probe if it appears worn or damaged.
 CAUTION	Avoid immersing the probe *connector* in any cleaning solution.
 CAUTION	If the probe connector has been immersed in 70% alcohol ensure that it is completely free of pockets of non-evaporated alcohol prior to use.
 CAUTION	The effectiveness of ETO gas, radiation or plasma methods for probe sterilization has not been validated.
 CAUTION	It is the responsibility of the user to validate the sterility of OxyFlo probes after sterilisation.

1.11 Summary of Cautions for Probe Calibration

 CAUTION	It is essential that the calibration procedure is performed on a stable and vibration-free surface. Any movement or vibration during the calibration procedure - however slight - is likely to result in a failed calibration.
 CAUTION	The motility standard has a limited life. The expiry date is indicated on the label. The solution must not be used beyond this date, as it may produce misleading values due to the gradual aggregation of the latex spheres.
 CAUTION	Do not use the motility standard in ambient temperatures below 15ºC or above 25ºC.
 CAUTION	Store the motility standard within the temperature range 3 – 25ºC. DO NOT FREEZE the solution.
 CAUTION	Do not dilute the motility standard.
 CAUTION	It is important that all probes to be used with any one OxyFlo Pro monitor have *different probe identification numbers* in order to prevent possible probe calibration errors. Please contact technical support for advice.

2. INTRODUCTION

2.1 General description

The OxyFlo Pro is a microvascular blood flow monitor that is capable of monitoring red blood cell (erythrocyte) perfusion in the microcirculation of a tissue.

The monitor uses a technique referred to as Laser Doppler Flowmetry (LDF), an established and reliable method for the measurement of blood perfusion in microvascular research.

OxyFlo Pro probes plug into the OxyFlo Pro monitor, which contains the laser source and sensitive photo-detection and signal processing circuitry.

Probes are standardised using a reference motility standard consisting of latex microspheres undergoing Brownian motion.

Microvascular blood flow is indicated on the touch screen display in relative units called Blood Perfusion Units (BPU).

The OxyFlo Pro laser Doppler blood flow monitor is available in two configurations;

OxyFlo Pro
A dual-channel device, capable of monitoring up to two independent tissue sites simultaneously.

OxyFlo Pro XL
A four-channel device, capable of monitoring up to four independent tissue sites simultaneously.

2.2 List of Key Features

- Continuous tissue blood flow assessment
  Uncompromised reliability in continuous tissue blood flow assessment; ideally suited to measurements of changing tissue blood flow in acute experimental models.
- Versatility
  A range of probe types and probe formats provide support for a host of specialist disciplines and applications requiring either invasive or non-invasive tissue blood flow assessment.
- ART
  A proprietary artefact rejection technology that effectively filters out the presence of motion artefacts in the blood flow signal. Substantially reduces and in most cases, completely eliminates motion artefacts or

'spikes' in the blood flow data arising from probe cable movement and/or regular tissue movement (e.g. due to breathing).

- Plug and play
  Probes require no calibration procedures or configuration following one-time probe calibration. Probes supplied at the time of monitor shipment are supplied factor pre-calibrated.
- Touch-screen display and interface
  A touch-sensitive, high-contrast, 140º viewing-angle screen displays real-time data in both digital and graphical (trace) formats, and provides access to instrument/user settings.
- Multi-channel productivity
  Available in dual or 4-channel models to suit all needs including the simultaneous monitoring of blood flow from multiple tissue sites (e.g. comparison of pathological versus control tissue sites).
- Upgradeable
  The OxyFlo Pro dual-channel model can be factory upgraded to the 4-channel OxyFlo Pro XL device.
- Multi-parameter monitoring
  Our OxyFlo Pro blood flow monitors are designed specifically to be used in tandem with our OxyLite Pro range of oxygen monitors, providing support for simultaneous measurements of tissue oxygenation, blood flow and temperature from each combined sensor.
- USB digital output
  A dedicated USB output supports direct streaming of recordings to a PC running the popular LabChart® Pro charting software. Features automatic identification of the monitor and pre-loading of configuration and channel settings for 'plug and play' convenience.
- Analogue data outputs
  Continuous data recording to PC or Mac platforms is also supported via standard analogue data outputs offering compatibility with third party data recording solutions.
- USB digital output
  A dedicated USB output supports direct streaming of recordings to a PC running the popular LabChart® Pro charting software. Features automatic identification of the monitor and pre-loading of configuration and channel settings for 'plug and play' convenience
- 2-year product warranty
  Our comprehensive manufacturer's warranty covers defects in material, function or in workmanship for a period of 2 years following delivery.

2.3 Laser Doppler flowmetry and the OxyFlo Pro

Laser Doppler Flowmetry ('LDF') is an established and reliable method for the measurement of blood perfusion in microvascular research that in no way harms or disturbs the normal physiological state of the microcirculation.

The OxyFlo Pro blood flow monitor implements this method by illuminating tissue with low power laser light using a probe containing optical fibre light guides. Laser light from one fibre is scattered within the tissue and some is scattered back to the probe. A second optical fibre collects the backscattered light from the tissue and returns it to the monitor. Most of the light is scattered by tissue that is not moving but a small percentage of the returned light is scattered by moving red blood cells. The light returned to the monitor undergoes signal processing to extract the signal related to the moving red blood cells.

Laser Doppler signals from the tissue are recorded in BPU (Blood Perfusion Units) which is a relative units scale defined relative to a carefully controlled motility standard comprising a suspension of latex spheres undergoing Brownian motion.

Perfusion is also referred to as tissue blood flow, microvascular blood flow or red blood cell flux.

In common with all LDF devices the OxyFlo Pro generates arbitrary, non-absolute units of tissue blood flow since the tissue sampling volume cannot be reliably established. Thus, LDF is best suited to observations of continuous, acute changes in blood flow relative to a baseline (control) obtained within the same experiment.

In other words, measurements obtained by LDF are intrinsically of a relative nature; although such measurements are proportional to perfusion, the factor of proportionality will be different for different tissues.

2.4 Measurement parameters generated by the OxyFlo Pro

The blood flow (BPU) parameter

The primary function of the OxyFlo Pro is to produce a tissue blood flow output signal that is proportional to the red blood cell perfusion (or flux) in the area of tissue being investigated. This represents the transport of blood cells through the microvasculature and is defined as,

Tissue blood flow	=	Number of blood cells moving in the tissue sampling volume	x	Mean velocity of these cells

Tissue blood flow therefore, is the product of mean blood cell velocity and mean blood cell number (concentration) present in the measuring volume of tissue under illumination from the probe.

For the OxyFlo Pro, tissue blood flow is indicated in relative units called Blood Perfusion Units (BPU). All OxyFlo Pro monitors have been calibrated with a constant, known motility standard so that, for a given blood flow situation, all OxyFlo Pro probes will read the same value of blood flow expressed in BPU.

The standard BPU output has been optimally filtered with a time constant of 200ms to give a clean and smooth looking signal whilst able to respond to dynamic changes and pulsatile blood flow changes.

The 'ART' parameter

ART is a processed version of the standard blood flow output, also measured in arbitrary 'BPU' units, in which a proprietary artefact rejection algorithm effectively filters out the presence of motion artefacts in the blood flow signal. This substantially reduces motion artefacts or 'spikes' in the blood flow data arising from regular probe cable movement and/or regular tissue movement (e.g. due to breathing), as well as unwanted spikes e.g., from accidental cable movement. The ART parameter can be output on the secondary data channel for each probe, via the touch screen (see table 4).

The 'RAW' parameter

The optional 'RAW' output is a version of the standard blood flow output that is subject to reduced filtering. This provides faster response times to rapid blood flow changes, at the expense of a degree more noise. The RAW parameter can be output on the secondary data channel for each probe, via the touch screen (see table 4).

The 'Backscatter' parameter

The OxyFlo Pro also generates a signal which is proportional to the total light remitted or backscattered from the tissue. This is called the Backscatter Signal (BS).

Backscatter is expressed as a percentage (%) fraction of the laser light remitted from the tissue relative to the total amount of laser light incident on the tissue.

For example, in highly perfused tissues the BS will be low due to increased photon absorption. Situations where the BS signal is close to zero may indicate that the probe has come into contact with whole blood, this could cause the BPU reading to saturate since the system is no longer monitoring microvascular blood flow.

The backscatter parameter too can be output on the secondary data channel for each probe, via the touch screen (see table 4).

2.5 The OxyFlo Pro Monitor

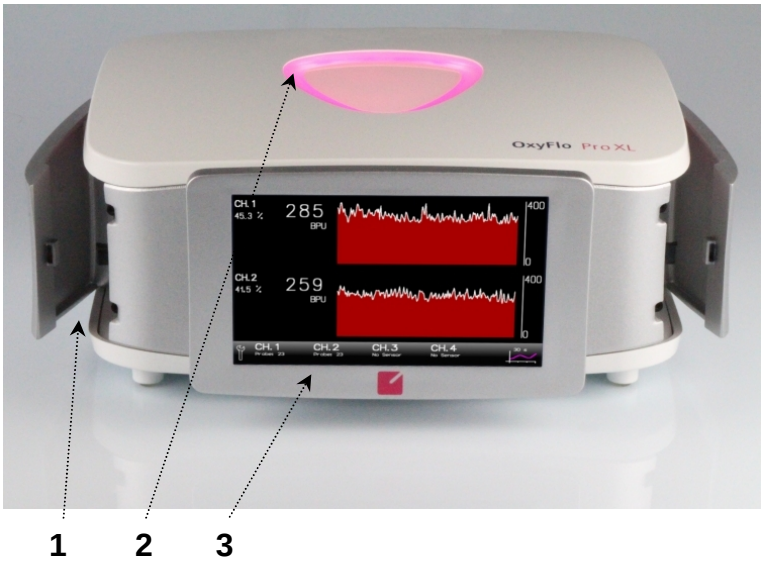


Figure 1: Front view of the OxyFlo Pro

1. Power-on indicator light.
2. Sensor connector bay (one on each side for OxyFlo Pro XL).
3. Touch-screen display (with adjustable viewing angle).

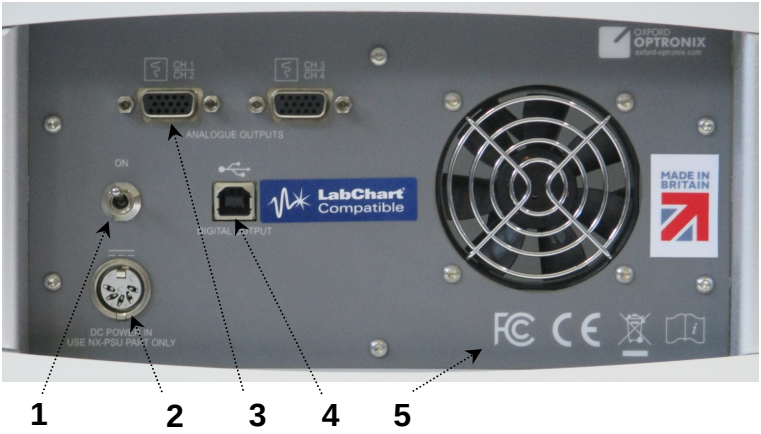


Figure 2: Rear view of the OxyFlo Pro

1. On/Off switch
2. Low voltage power inlet (**use 'NX-PSU' universal AC Adapter only**)
3. Analogue output connectors:
   Ch 1 / Ch 2 (common to all OxyFlo Pro models)
   Ch 3 / Ch 4 (OxyFlo Pro XL model only)
4. USB serial output for optional *direct* data streaming to LabChart® Pro
5. Symbols applicable to OxyFlo Pro

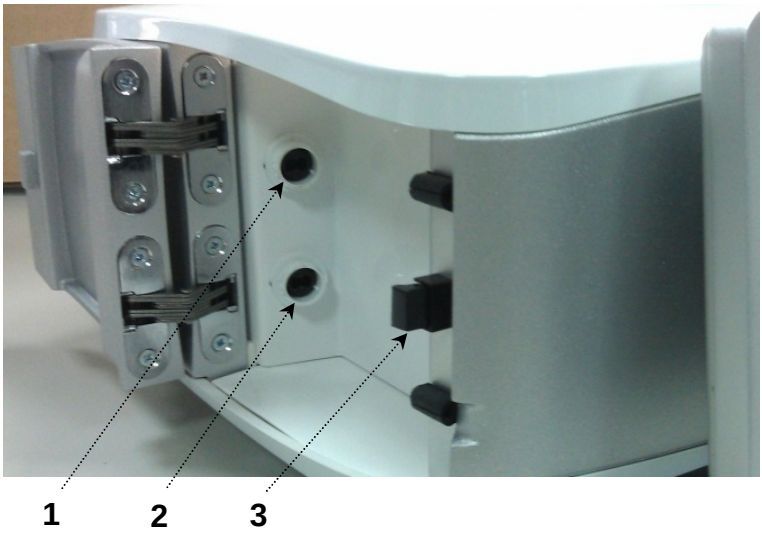


Figure 3: Side-view of OxyFlo Pro, showing open probe connector bay

1. Channel 1 probe connector
2. Channel 2 probe connector
3. Push-release latch opens side panel to reveal probe connector bay

Channel 3 and Channel 4 probe connectors (OxyFlo Pro XL model only) are located inside the connector bay on the right-hand side of the monitor.

Figure 4: The OxyFlo Pro universal AC adapter

NOTE: Use ONLY the universal AC adapter provided by Oxford Optronix. Failure to do so may result in irreparable damage to the OxyFlo Pro monitor.

2.6 OxyFlo Pro Probes

Introduction

A comprehensive range of Laser Doppler probes is available for use with the OxyFlo Pro monitor, a description of which can be found on our website (www.oxford-optronix.com).

All probes are comprised of a pair of 125 µm optical fibres, which are used to direct low power laser light to and from the tissue. The fibres terminate at one end of the probe in the probe head (of variable design, depending on probe type) and at the other end in a connector plug that attaches to the OxyFlo Pro. The connector plug is colour-coded with a **red** band.

OxyFlo Pro probes are either referred to as 'dedicated blood flow probes', for the exclusive measurement of tissue blood flow, or as 'combined sensors' for the simultaneous measurement of tissue blood flow and tissue pO_2/temperature, where the OxyFlo Pro is used in conjunction with its optional counterpart, the OxyLite Pro.

The number of plugs on a sensor is dependent on the number of parameters being measured. Dedicated blood flow probes feature a single plug, while combined sensors featuring support for tissue pO_2/temperature measurements (and requiring the counterpart OxyLite Pro monitor), feature *two* connector plugs.

In the case of combined sensors, the connector plug carrying the oxygen/temperature signal is colour coded with a **blue** band.

Probe Presentation

OxyFlo Pro probes consist of a pair of optical fibres used to direct weak laser light to and from the probe head.

The fibres terminate at one end in the probe head (MSP300NX surface probe type depicted here) and, at the other end, in a connector plug that attaches to the OxyFlo Pro (colour-coded with a red band).

A durable white silicone sleeving serves to protect the optical fibres along the 3 m length of the probe.

Figure 5: An OxyFlo Pro probe ('MSP300NX' type depicted)

PROBE-RELATED CAUTIONS:

 CAUTION	OxyFlo Pro probes must be HANDLED WITH CARE. Failure to do so may result in breakage of the internal optical fibres, scratching the polished probe ends or separation of the cable from the probe ends or connectors.
 CAUTION	The optical fibres used in OxyFlo Pro probes consist of glass with a diameter of 125 µm. The fibres are flexible and can be bent, however it is recommended that they are not subjected to bends with a radius of less than 30mm.
 CAUTION	DO NOT drop, apply tension or ‘kink’ any part of an OxyFlo Pro probe. Permanent damage may result.
 CAUTION	OxyFlo Pro probes are NOT approved for use on patients.
 CAUTION	Do not use a worn or damaged probe.
 CAUTION	OxyFlo Pro probes should be stored, with the probe cable carefully coiled to avoid ‘kinks’, in the dedicated protective case in which they are supplied.
 CAUTION	Avoid using OxyFlo Pro probes under strong (e.g. surgical) lights.

2.7 Accessories

The following accessories are available from Oxford Optronix Ltd. for use with the OxyFlo Pro;

Product Code	Product Description
CAL KIT	Calibration kit for LDF probes and MSFD NX adapter
MSP140AR	Double-sided adhesive rings for surface LDF probes. Pack of 200
NX-BNC	High-density 15-pin D-connector to 4 BNC data adapter cable for OxyFlo Pro or OxyFlo Pro (1 m)
IA100NX	LDF interlock adapter for OxyFlo Pro (applicable only to monitors manufactured prior to May 2015)
MH-10	Miniature holders (10mm diam) for MNP100NX-3/10 probe. Pack of 5
MH-05	Miniature holders (5mm diam) for MNP100NX-3/10 probe. Pack of 5
LABCHART_PRO	LabChart® Pro software (PC/Windows® only), incl. 1 user license and 5 years free updates
VALUE ADC	12 channel analogue output data recorder and PC software, by Dataq Inc.
POWERLAB	A range of analogue output data recorders and associated PC or Mac software, by ADInstruments
NX-PSU	Universal voltage input AC adapter (including integral power On/Off switch)

Table 2: Optional accessories for OxyFlo Pro

Use only probes, cables and accessories supplied by Oxford Optronix Ltd., otherwise serious damage may result.

3. MONITOR SETUP AND USE

3.1 Unpacking and Inspection

Immediately notify Oxford Optronix Ltd. or your local distributor if the outer packaging or carton is wet or damaged in any way. Unpack the OxyFlo Pro and its components, ensuring that all items listed on the enclosed packing list / dispatch note are present. If anything is missing or damaged please contact Oxford Optronix Ltd. or your local distributor.

NOTE: We recommend that the original shipping carton and shock-absorbing inserts be stored in a safe place rather than discarded, since these will be required for any warranty returns and/or for shipping the OxyFlo Pro safely at servicing intervals.

3.2 List of Standard Components

- OxyFlo Pro Unit/Monitor
- Universal voltage input AC adapter (including integral power On/Off switch)
- Country-specific IEC power cable
- User Manual (this document)

3.3 Connecting and Powering Up the Monitor

1. Position the unit on a flat and stable surface close to the point of measurement. Note that the standard probe cable length is 3 metres (approx. 10 feet).
2. Ensure that the integral power On/Off switch on the universal voltage AC adapter is set to the OFF (0) position.

Use ONLY the NX-PSU universal AC adapter provided by Oxford Optronix. Failure to do so may result in irreparable damage to the OxyFlo Pro monitor and may cause harm to the user.

3. Plug the male connector end of the NX-PSU universal AC adapter into the mains power inlet labelled *DC POWER IN* at the rear of the monitor.
4. Plug the IEC power cable into the NX-PSU AC adapter and then into a wall mains supply.

5. Power up the monitor via the On/Off switch on the NX-PSU AC adapter. The AC adapter will automatically detect the local mains voltage (110/120V or 220/240V supported). The red, ring-shaped power-on indicator light on top of the monitor will illuminate and the monitor will generate an audible ‘beep’. While the monitor runs its internal boot sequence and start-up checks (approx. 15 seconds) the display will initially remain blank. There will be two further audible ‘beeps’ approx. 5 seconds apart, at which point the Oxford Optronix logo will be briefly displayed before the screen launches into its ‘default’ view (below).
6. The monitor is now ready for probe connection and use (see section 3.4).

CAUTION

Connecting the NX-PSU universal AC adapter to the *DC POWER IN* inlet at the rear of the OxyFlo Pro, having *already* powered it via its On/Off switch MAY trigger the surge protection circuit within the OxyFlo Pro. If the OxyFlo Pro does not start up, turn off the AC adapter, wait 2 - 3 minutes, then turn the AC adapter on once more.

3.4 Connecting / Disconnecting Probes

The OxyFlo Pro automatically recognises previously calibrated probes and applies the necessary probe calibration coefficients on connection. This essentially alleviates the requirement for repeated re-calibration.

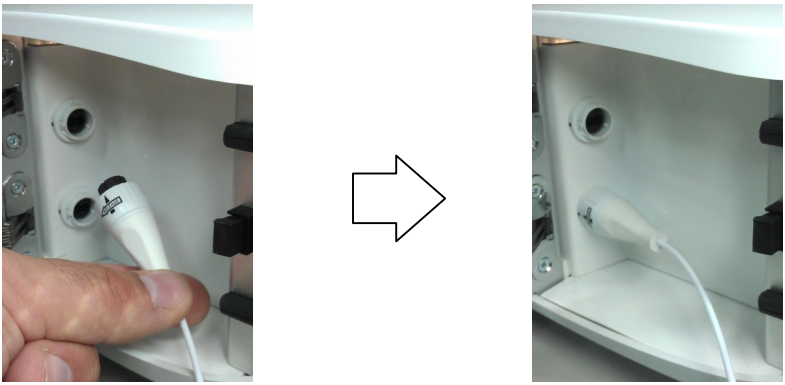


Figure 6: Connecting and disconnecting a probe

Align the probe connector such that the arrow is aligned with the black dot on the instrument connector surround and simply push. The connector will lock into position, the probe ID will be read and calibration coefficients loaded automatically by the monitor (provided the probe has been either factory-calibrated or calibrated by the user – see instructions below).

Disconnect by twisting the front portion of the probe connector anti-clockwise, in the direction of the 'Release' arrow printed on the connector.

NOTE: OxyFlo Pro monitors shipped **prior to May 2015** will only function if **pairs** of connectors are occupied. An optional 'interlock adapter' may be used to occupy the unused channel where the user wishes to use an odd number of probes (one or three).

CAUTION

Attempting to disconnect the probe by pulling the cable sleeving instead of the probe connector may cause irreparable damage to the probe.

3.5 The Touch-Screen Display

The following pages provide an introduction to the touch-screen display.

Figure 7: The touch screen display with no probes connected

Following monitor start up, the display will initially show the default screen (OxyFlo Pro XL model in this example).

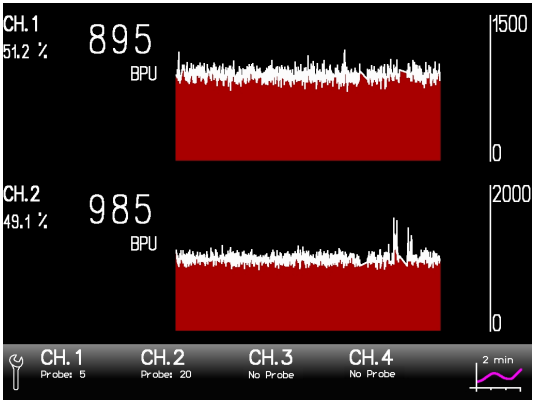


Figure 8: Touch screen display with 2 probes connected

The screen will concurrently display a trace and a numerical value of blood flow for each probe connected, as in the example above.

Description of icons:

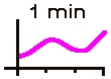
	The toolbar confirms the recognised numerical 'ID' for connected probes, per channel. Touch to display the probe status dialogue (figure 10).
	Touch to display the settings toolbar (see figure 9).
	Touch to toggle x-axis compression. Press and hold to display the x-axis compression selection screen.

Table 3: Touch screen default toolbar icons

Useful touch screen functionality:

- Press and hold on any of the numerical digits to hide trace(s) and display digits in large.
- Press and hold the y-axis (for any channel) to display the y-axis scale selection screen for that channel.

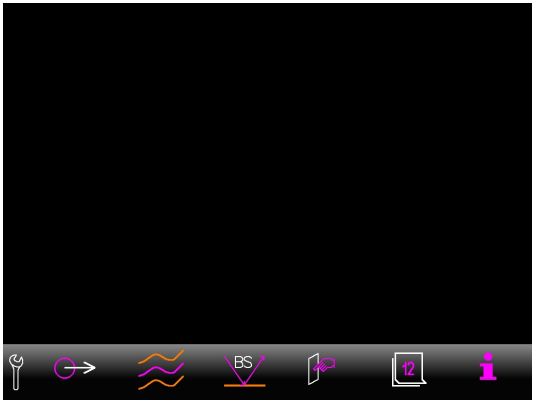


Figure 9: The touch screen settings toolbar

Touching the 'spanner' icon displays the settings toolbar on which display parameters and instrument settings can be defined (see below). Return to the default screen by touching the 'spanner' icon once more. The settings toolbar will automatically revert to the default screen after 20s of inactivity.

Description of settings toolbar icons:

	Touch once to display the analogue output scaling screen. This allows the user to specify the analogue data output range for the flow parameter (default is 5V = 5000 BPU). Touch this icon again to display the secondary parameter selection screen. The OxyFlo Pro will output the Flow parameter on the first of two outputs; the second output is selectable (Backscatter, Raw and ART - refer to section 2.4). Changes to this function are saved and will apply the next time the OxyFlo Pro is powered up.
	Touch once to display the trace-selection screen; touch a second time to display the trace-fill options screen. Changes to this function are saved and will apply the next time the OxyFlo Pro is powered up.
	Displays the backscatter (BS) cut-off selection screen. Generally there is no need to adjust this parameter away from the factory default. Low = 1% BS threshold Medium = 2% BS threshold High = 5% BS threshold Changes to this function are saved and will apply the next time the OxyFlo Pro is powered up.
	Displays the screen ‘swipe’ sensitivity controls, used to set the sensitivity of the touch screen to swipe motions for controlling x-axis and y-axis scaling. Changes to this function are saved and will apply the next time the OxyFlo Pro is powered up.
	Displays the system date for optional adjustment. Changes to this function are saved and will apply the next time the OxyFlo Pro is powered up.
	Displays software/firmware version information.

Table 4: Touch screen settings toolbar icons

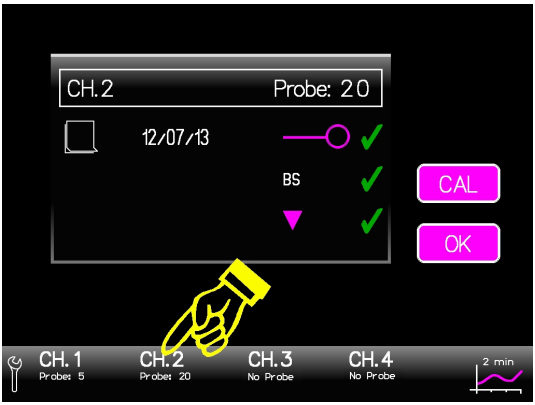


Figure 10: The touch screen probe status dialogue

Probe status and calibration information is displayed by selecting the appropriate channel/probe from the toolbar.

Refer to the table below and Troubleshooting for probe warnings and errors.

Description of probe status dialogue icons:

	Indicates probe calibration date.
	Indicator for probe status. '✓' indicates that the probe is reading blood flow normally. '**X**' indicates a probe error. '↓' indicates a very poor blood flow signal. '↑' indicates a saturating blood flow signal.

BS	Indicator for 'backscatter' threshold. '✓' indicates that the backscatter return from the probe is sufficient to allow reliable measurements. '⇩' symbol indicates that the backscatter return from the probe is below the cut-off threshold and may be insufficient to allow reliable measurements. '⇧' symbol indicates excessive backscatter. Note: a persistent low backscatter ('⇩') state may be alleviated by adjusting the cut-off threshold via the dedicated settings toolbar function (see table 4 above).
▼	Calibration data indicator. '✓' indicates that the probe has been calibrated. '**X**' indicates that the probe requires calibration prior to use (see section 3.6).

Table 5: Probe status dialogue icons

3.6 Probe Calibration

The OxyFlo Pro monitor is designed to automatically recognise and apply the correct calibration coefficients when probes are connected.

Probes purchased with a monitor will be calibrated at the factory. Since the calibration data is stored within the monitor, if a probe has previously been calibrated for the channel it is being used in, then calibration coefficients will be loaded automatically and the probe will be ready to use almost immediately.

Where additional probes are purchased from Oxford Optronix Ltd. subsequent to monitor delivery, a one-time user calibration is required in the channel that the probe is to be used in.

IMPORTANT:
For users wishing to use combined blood flow and oxygen/temperature sensors (requiring the counter part OxyLite Pro oxygen/temperature monitor), there is NO REQUIREMENT to carry out individual flow calibration. These sensors will be recognized automatically by the OxyFlo Pro with a 'generic' probe ID of 25.

When the calibration procedure ends, the calibration data for that particular probe/channel configuration is automatically stored within the monitor. The calibration data is then automatically retrieved every time that particular probe is connected to that particular channel.

To use the same probe in multiple channels, the calibration procedure must be repeated in each individual channel.

Every probe features a probe ID number (between 1 and 26) that the monitor 'reads' each time the probe is connected. This is confirmed on the display toolbar and on the probe status dialogue.

Probe identification numbers are assigned such that no two probes (issued to the same user) feature the same ID.

The exception to this rule are combined blood flow and oxygen/temperature sensors (requiring the counterpart OxyLite Pro monitor), which feature a fixed ID number (25).

There is no recommended re-calibration interval for probes; generally speaking probe calibration coefficients should remain valid for a number of months or even years. However, where an experiment requires the simultaneous use of multiple probes it may be sensible to ensure all are freshly calibrated prior to use.

Calibration Procedure

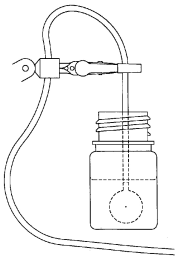
To perform a new probe calibration, you will require a Calibration Kit (product code CAL KIT) which consists of a motility standard and a positioning clamp. The motility standard is a solution of latex spheres at a precisely defined concentration. The positioning clamp is used to maintain the probe in the solution.

IMPORTANT: In order for the calibration to succeed, it is crucial that the probe and calibration solution are not subjected to vibration or movement of any kind during the calibration procedure.

IMPORTANT: Do not use the motility standard in ambient temperatures below 15ºC or above 25ºC.

Proceed as follows to calibrate a probe:

1. Gently swirl the bottle to disperse the contents before use.
2. Open the bottle and allow the contents to settle for one minute before proceeding.
3. Carefully position the probe into the solution. This is best achieved by grasping the probe cable within the jaws of the clamp and carefully lowering the active area of the probe into the centre of the solution as shown:

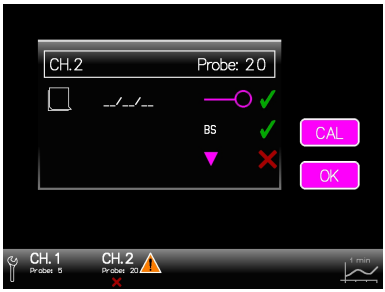


Keep the active probe surface or probe tip away from the edges or the bottom of the bottle. The probe should be supported in such a way that it does not swing or move whilst in the solution.

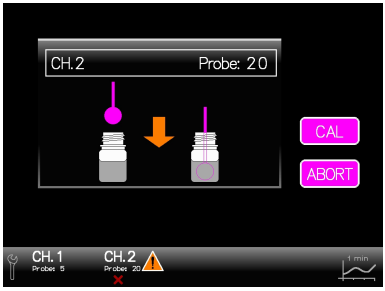
4. Connect the probe that you wish to calibrate into the requisite channel of the monitor (ensuring that the paired channel is occupied either by another probe or by an LDF Interlock Adapter).

   NOTE: If the probe has not previously been calibrated in this channel the toolbar will display a warning triangle *and* a red cross.

5. Select the probe from the toolbar to call up the probe status dialogue. If the probe has not previously been calibrated in this channel the status dialogue will display no date and a red cross against the calibration data indicator, as follows:



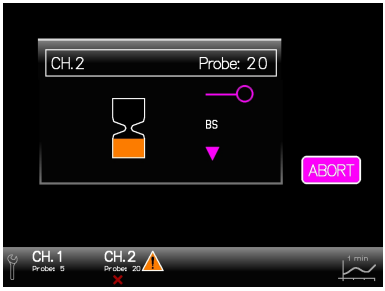
6. Touch the ‘CAL’ button to initiate the calibration routine.



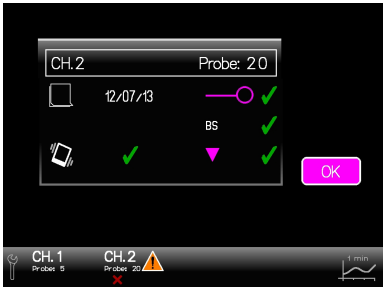
A visual reminder is displayed that the probe needs to be in the calibration solution, which will be accompanied by an audible double ‘beep’ every 2 seconds.

7. Touch the CAL button a second time to trigger the calibration. A 5s continuous ‘beep’ is emitted, followed by the following (animated) graphic which confirms that the calibration is progressing.

   IMPORTANT: This 20 - 30 second period is where any vibration or movement will cause the calibration procedure to fail.



If the calibration is successful the monitor will emit an audible double ‘beep’ and briefly display the following on-screen confirmation:



The display will then automatically revert to the default view (the warning triangle now absent) and will display a reading from the calibration solution, which should be in the region of 1,000 BPU (+/- 50 BPU).

Re-calibration of Probes

Probes can be re-calibrated at any time as above, via the ‘CAL’ function available on the probe status dialogue view.

Failed Calibration

A failed calibration will be indicated by a long continuous ‘beep’ followed by a series of ‘beeps’ corresponding to the error number identified. The probe

status dialogue will display a cross against the calibration data icon and against the calibration success icon.

Touching the dialogue will display a further error screen confirming the calibration error number.

There are 6 error codes, as follows:

Error	Probable cause	Remedial action
1, 3, 4	Incorrect probe position or malfunctioning probe	Reposition probe in motility standard solution and repeat calibration. Repeat calibration as necessary.
2	Signal level low	May indicate probe or internal fibre damage. Check for fibre integrity (see section 5.2).
5, 6	Vibration or probe/cable movement	Ensure motility standard solution is on a vibration-free surface and that probe and cable movement is eliminated. Repeat calibration as necessary.

Table 6: Calibration error codes

Please refer to our support site for further details describing the calibration procedure and failure modes.

 **CAUTION**	It is essential that the calibration procedure is performed on a stable and vibration-free surface. Any movement or vibration during the calibration procedure - however slight - is likely to result in a failed calibration.
 **CAUTION**	The motility standard has a limited life. The expiry date is indicated on the label. The solution must not be used beyond this date, as it may produce misleading values due to the gradual aggregation of the latex spheres.
 **CAUTION**	Do not use the motility standard in ambient temperatures below 15ºC or above 25ºC.
 **CAUTION**	Store the motility standard within the temperature range 3 – 25ºC. DO NOT FREEZE the solution.

CAUTION	Do not dilute the motility standard.
CAUTION	It is important that all probes to be used with any one OxyFlo Pro monitor have *different probe identification numbers* in order to prevent possible probe calibration errors. Please contact technical support for advice.

3.7 Placement of Probes

Please note that detailed guidelines for the use of probes in a variety of tissue monitoring applications are maintained on our dedicated OxyFlo support site:

http://www.oxford-optronix.com/support/supp_oxyflo.htm

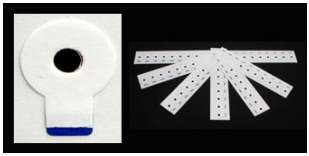
IMPORTANT: In all cases direct 'occlusive' pressure on the tissue under investigation and tissue or probe movement must be avoided as far as possible.

In summary:

Recommendations for probe placement depend primarily on the probe type being used.

Surface probes

Surface type probes (e.g. MSP310NX or MSP300NX) may be attached to skin or dry tissue surfaces using our double-sided adhesive rings (product code MSP140AR),



Alternatively, our suturable surface probe (MSP300NX) is designed to be sutured directly onto a tissue surface.

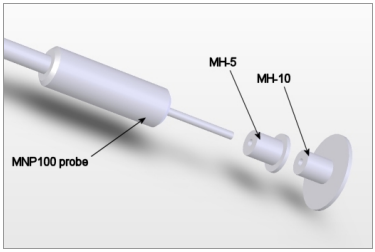
Needle probes

Needle style probes have a blunt end and, where used for invasive measurements, should generally be inserted into tissue via a suitable introducer (e.g. Angiocath™) or via an appropriate incision.

For non-invasive use, needle probes can be placed above the tissue such that the tip is in gentle contact with, or very close proximity to, the tissue. Ensuring that the probe is maintained in a perpendicular position will help maximize signal quality and minimize the effects of ambient light.

Optionally, needle probes may be mounted in a micromanipulator assembly or stand.

Our needle type probe for MCAO applications (MNP100NX-3/10) can be secured to bone (skull) via dedicated miniature holders (product code MH-05/MH-10),



3.8 Digital (USB) Data Output

Our monitors now offer compatibility with the highly acclaimed LabChart® Pro data recording and analysis software by ADInstruments.

LabChart supports direct streaming of real-time recordings to a PC, via the dedicated USB output at the rear of the monitor.

Compatibility requires a dedicated and free software Add-on for LabChart (the 'Device Enabler'*), which supports automatic recognition of the Oxford Optronix monitor, the use of multiple Oxford Optronix monitors simultaneously and provides a choice of pre-loaded configuration settings specifically tailored to our monitors.

The Add-on also supports the simultaneous recording of data from an existing AD Instruments PowerLab® module.

A single LabChart Pro user license, inclusive of 5 years of free updates is available to order.

The Oxford Optronix Device Enabler can be downloaded via the 'Feature Manager' utility integral to LabChart.

Alternatively the Oxford Optronix Device Enabler is available for download from the 'Downloads' section of the ADInstruments website.

Dedicated instructions for setting up LabChart Pro for recording from OxyFlo Pro monitors can be found on our support site (www.oxford-optronix.com/support/supp_oxyflo.htm).

*Notes: PC/Windows platforms supported only at this time; LabChart 8.0.4 or later required.

3.9 Analogue Data Outputs

Blood flow measurements can be recorded continuously to a PC or Macintosh computer via analogue outputs located at the rear of the OxyFlo Pro (see figure 2).

Analogue output ports consist of a 15-pin female D-type connector (one per pair of channels).

Data recording requires a third-party data acquisition module and accompanying software (optionally available from Oxford Optronix), which will accept analogue input in the range -5V to +5V.

A dedicated data adapter cable (product code 'NX-BNC'), terminating in standard BNC connectors, provides compatibility with the vast majority of third party data acquisition systems.

The dual-channel OxyFlo Pro requires one such cable (carrying data for channels 1 and 2), while the 4-channel OxyFlo Pro XL model requires two such cables (carrying data for channels 1 and 2, and 3 and 4, respectively).

The data adapter cable terminates in 4 colour-coded BNC connectors, which carry data parameters in the following order:

Output labelled 'Ch1 / Ch2'

Cable colour	Parameter
Red cable	Channel 1 Blood Flow
Green cable	Channel 1 *Configurable* (Backscatter, ART* or RAW*)
Blue cable	Channel 2 Blood Flow
White cable	Channel 2 *Configurable* (Backscatter, ART* or RAW*)

Output labelled 'Ch3 / Ch4' (OxyFlo Pro XL only)

Cable colour	Parameter
Red cable	Channel 3 Blood Flow
Green cable	Channel 3 *Configurable* (Backscatter, ART* or RAW*)
Blue cable	Channel 4 Blood Flow
White cable	Channel 4 *Configurable* (Backscatter, ART* or RAW*)

* The secondary output per channel/probe is user-selectable via the settings toolbar (see figure 9).

Table 7: Parameter identification on analogue output data cable

The following table summarizes the unit conversion parameters required for data acquisition via the analogue outputs at the rear of the OxyFlo Pro monitor when using third-party data recorders (factory defaults shown):

Parameter	Backscatter	Blood Flow / ART / RAW
Output voltage range	0 – 5V	0 – 5V
Zero output (0V)	0%	0 BPU
Full scale output (5V)	100%	5000 BPU
Output resolution	20%/V	1000 BPU/V

Table 8: OxyFlo Pro analogue output unit conversion

The following table summarizes normal analogue output voltages during instrument boot-up and/or error states:

Scenario	Backscatter output	Blood Flow / ART / RAW output
Initial boot	0V (typically)	0V (typically)
Instrument start-up	2.5V	2.5V
No Probe	0V	-2.5V

Table 9: Analogue output voltages during monitor boot and error states

4. CARE OF OXYFLO PRO

4.1 Use of OxyFlo Pro

OxyFlo Pro should only be operated on a secure, flat, horizontal surface and in ambient temperatures of 15°C - 30°C.

4.2 Cleaning and Storage of OxyFlo Pro

The monitor enclosure may be surface-cleaned by wiping lightly using a soft cloth dampened with a commercial, nonabrasive cleaner.

The monitor enclosure may be disinfected by wiping the surface with a soft cloth dampened with a solution of 70% alcohol in water.

 WARNING	To avoid the risk of electric shock or shorts, do not spray, pour or spill any liquid in or on the OxyFlo Pro.

The OxyFlo Pro should be stored between 10°C to 40°C. When returning from extremes of temperature, the unit should be allowed to acclimatise at room temperature for 30 minutes before use.

4.3 Handling and Cleaning of the Touch Screen

 CAUTION	To avoid damage, do not use sharp objects to operate the touch screen display.
 CAUTION	To avoid damage, do not spray, pour or spill any liquid on the touch screen display.

The touch screen display should be operated using a finger, fingernail, or optionally a dedicated touch screen pen.

The touch screen may be gently surface-cleaned using dedicated ‘screen clean’ wipes.

4.4 Handling and Storage of Probes

The optical fibres used within the OxyFlo Pro probes consist of glass, with a diameter of 125µm. The fibres are flexible and can be bent. However, it is recommended that they are not subjected to bends with a radius less than 30mm.

 CAUTION	OxyFlo Pro probes must be HANDLED WITH CARE. Failure to do so may result in breakage of the internal optical fibres, scratching the polished probe ends or separation of the cable from the probe ends or connectors.
 CAUTION	OxyFlo Pro probes should be stored, with the probe cable carefully coiled to avoid 'kinks', in the dedicated protective case in which they are supplied.

Probe connectors must be kept clean and free from dust. Connectors should be inspected before use. Dust can be removed from the connectors using a good quality 'air-duster'.

OxyFlo Pro probes should be stored, with the probe cable carefully coiled to avoid 'kinks', in the dedicated protective case in which they are supplied.

The integrity of OxyFlo Pro probes may be checked by holding the probe end to a source of bright light and inspecting the connector end for two spots equally intense light from the pins within the connector (refer to section 5.2).

4.5 Cleaning, Disinfection and Sterilization of Probes

Cleaning

OxyFlo Pro probes are cleaned prior to packaging and dispatch. It is recommended that the probe end on all new probes be wiped with a soft cloth, preferably one that does not shed fibres, impregnated with 70% alcohol in water.

It is recommended that after use probes are cleaned immediately as it is easier to remove soiling and particulate matter before it dries onto surfaces, as follows:

- Visually inspect the probe end, cable and connector. If there is no visible soiling, wipe the probe end and cable with a soft cloth impregnated with 70% alcohol in water. Allow the alcohol to dry completely before reusing the probe.
- If there is visible soiling, clean the probe with warm water containing a mild detergent.
- Careful rubbing with a soft cloth or brush should be employed to ensure that all soiling and particulate matter is removed. These actions should be carried out beneath the surface of the cleaning solution.
- Rinse the probe end and cable in clean water.
- Wipe the probe end and cable (without stretching it) with an absorbent cloth and leave the probe to dry.

 CAUTION	Avoid immersing the probe *connector* in any cleaning solution.

Disinfection

OxyFlo Pro probes can be disinfected by immersion of the probe end and cable in either 2% gluteraldehyde or in 70% alcohol (industrial methylated spirit, IMS or isopropyl alcohol IPA) in water.

The disinfectant manufacturer's recommended immersion times should be used.

 CAUTION	If the probe connector has been immersed in 70% alcohol ensure that it is completely free of pockets of non-evaporated alcohol prior to use.

Sterilization

OxyFlo Pro probes are not supplied sterile.

OxyFlo Pro probes are NOT capable of withstanding sterilisation by dry or moist heat (autoclaving).

The materials and components used in OxyFlo Pro probes may be compatible with ETO (ethylene oxide) gas, radiation and plasma sterilization methods.

 CAUTION	The effectiveness of ETO gas, radiation or plasma methods for probe sterilization has not been validated.
 CAUTION	It is the responsibility of the user to validate the sterility of OxyFlo probes after sterilisation.
 CAUTION	DO NOT attempt to autoclave, pressure sterilise, or expose to radiation, any part of the monitor.

4.6 Disposal of Probes

After use, failure and/or expiry, please dispose of probes carefully and in accordance with local and national biohazard regulations and guidelines.

5. TROUBLESHOOTING AND MAINTENANCE

5.1 Troubleshooting

If you experience a problem using the OxyFlo Pro that you are unable to correct by reconnecting the probe(s) and/or turning off and turning back on the monitor, please contact Oxford Optronix technical support (see p2 of this document).

Do not attempt to open the OxyFlo Pro. There are no user-serviceable parts inside. There is a risk of electrical shock or other injury or permanent damage to the monitor.

The following is a list of possible monitor errors / failure modes and suggestions for correcting them.

The display does not confirm the connection of a probe even though a probe is connected

Was your monitor manufactured prior to May 2015? If so it may only function if **pairs** of probes are plugged into the monitor (i.e. into channels 1 & 2 for the OxyFlo Pro and into channels 1 & 2 and/or channels 3 & 4 for the OxyFlo Pro XL).

If it is intended to operate the monitor with only a single probe, then an LDF interlock adapter must occupy the corresponding unused channel. The LDF interlock adapter is available as an optional accessory (product code IA100NX).

If the monitor does not register the presence of a probe even though the corresponding second channel is occupied by another probe or an interlock adapter, then this is indicative of a probe fault. Try a spare probe if available and/or carry out the simple probe integrity check (section 5.2). If the problem persists please contact technical support.

The monitor does not seem to power up

Check that the NX-PSU universal AC adapter itself is receiving power from the wall socket (i.e. that the wall socket is live) by confirming that the integral LED is lit.

Check that the male connector of the NX-PSU universal AC adapter is securely seated in the *DC POWER IN* inlet at the rear of the monitor.

Check that the monitor isn't in a 'surge prevented mode' by turning off the AC adapter, waiting 2-3 minutes, then turning the AC adapter back on.

Connecting the NX PSU AC adapter to the *DC POWER IN* inlet at the rear of the OxyFlo Pro, having *already* powered it up via its On/Off switch MAY trigger the surge protection circuit within the OxyFlo Pro. If the OxyFlo Pro does not start up, turn off the AC adapter, wait 2 - 3 minutes, then turn the AC adapter on once more.

If the problem persists please contact technical support.

The monitor is receiving power (the magenta power-on indicator light on top of the monitor is on) but is not booting to the usual 'default' screen

Turn off the universal AC adapter, wait 2-3 minutes and try again. If the problem persists there is likely to be a fault, in which case please contact technical support.

The monitor boots into the usual 'default' screen but does not respond to the connection of a probe

Try power-cycling the monitor by turning off the AC adapter, waiting 2-3 minutes and turning the AC adapter (i.e. the monitor) back on. Try another probe and/or try switching channels. If the problem persists there is likely to be a fault, in which case please contact technical support.

The monitor boots into the usual 'default' screen but the display does not respond to any touch inputs

Try power-cycling the monitor by turning off the AC adapter, waiting 2-3 minutes and turning the AC adapter (i.e. the monitor) back on. Try connecting a probe in one or more channels. If the problem persists there is likely to be a fault, in which case please contact technical support.

There is a continuous sound upon power-on

The monitor has failed the power-on self-test. If the problem repeats itself after multiple power-on attempts contact technical support.

There is an audible 'beep' every 5 seconds and a warning triangle has appeared in the bottom right of the display which displays a 'Temperature Out of Range' message when selected

If the internal temperature of the OxyFlo Pro monitor rises above the maximum permitted internal operating temperature threshold then the message 'Temp out of Range' will appear on the display. If this occurs check that the fan at the rear of the OxyFlo Pro is not obstructed and/or move the instrument to a cooler location. Analogue outputs will continue but the trend values will not appear on the display. Data generated during this

condition may no longer be within the calibrated tolerance of the system and should be interpreted with caution.

If the ambient temperature is 'normal' (typically 18-25ºC) and this message occurs repeatedly soon after power-on, then a fault may have occurred and you should contact technical support for further advice.

The monitor re-starts repeatedly mid-recording

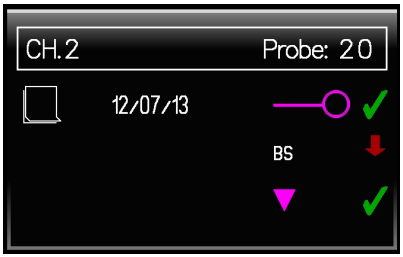
Confirm that, a), you are operating within the recommended operating temperature and humidity limits for the monitor (see Specifications towards the back of this document), b), that the mains supply is stable and c), that the connection of the universal AC adapter at the rear of the monitor is securely seated. Try turning off the monitor for a period of 30 minutes and then turning it back on. If the problem persists there is likely to be a fault, in which case please contact technical support.

The analogue output signal is zero

There may be a cable problem. Check that the cable(s) attached to the analogue output connector(s) is/are securely seated and correctly configured at the data acquisition module end. Check that the correct data channels are being viewed on the software package provided by the data acquisition module supplier. Check that the analogue output settings are correctly configured by selecting the appropriate icon from the display settings toolbar.

A probe displays a warning triangle

Call up the probe status dialogue by touching the warning triangle to determine the problem (refer to Section 3.5 above). Contact technical support as necessary.



Example probe warning

Probe-related warnings are indicated on the toolbar by a warning triangle against the relevant channel/probe.

The probe status dialogue allows identification of the parameter that is in a fault condition (backscatter below cut-off threshold in the example shown).

Note: the toolbar warning triangle turns grey once the fault state has been previewed via the probe status dialogue.

Calibration of a probe generates an error message and audible 'beeps'

Please refer to section 3.6 (Probe Calibration).

Erratic Flow (BPU) values / signal artefacts

Certain environmental conditions and probe application and positioning errors can affect the reliability of laser Doppler blood flow readings.

Irrespective of the probe used, it is important to reduce the possibility of signal artefact, noise and signal dropout in the blood flow reading.

The presence of motion artefact noise in the blood perfusion signal is often due to relative movements of the tissue (e.g. induced by breathing) with respect to the probe and/or probe cable movements. These artefacts can be minimised by allowing the probe to come into contact with the tissue such that the probe and tissue 'move in unison' and by ensuring the cables do not move. It may be helpful to secure the probe cable to the table at intervals with adhesive tape.

If the signal artefact is regular in nature (e.g. induced by breathing) try selecting the 'ART' filtered analogue output (refer to section 3.8).

It is also essential to ensure that undue probe pressure is not applied to the tissue; otherwise local occlusion of the microvasculature may result in a corresponding reduced blood flow reading.

Excessive ambient lighting at the probe measurement site can also disturb the blood flow reading. Avoid direct illumination of the measurement site from external lighting sources and direct sunlight. If erroneous readings due to excessive ambient lighting levels are suspected, cover the measurement area with a light piece of opaque material.

In summary, avoid the following situations:

- Strong ambient lighting sources such as surgical lights
- Fluctuating ambient lighting
- Probe movement relative to the tissue
- Movement of the probe cable
- Excessive physical pressure of the probe against the tissue under investigation

Baseline blood flow values vary widely between measurements

The laser Doppler flowmetry technique provides only arbitrary, non-absolute units of tissue blood flow since the sampling volume/depth cannot be reliably determined and thus a probe may generate widely varying baseline values from the same/similar tissue site/region at every placement.

The OxyFlo Pro may not therefore be suited to the non-continuous or repeated assessment of changes in tissue blood flow over chronic time

periods. The strengths of the laser-Doppler technique lie in observing continuous, *acute* changes in blood flow relative to a baseline (control).

What is the Meaning of Zero and Negative BPU?

The calibrated zero reading has been obtained by calibrating the system against a special static scattering material where no movements occur. In such cases the back-scattered light processed by the OxyFlo Pro contains no Doppler shifted frequency components and a true zero is obtained. In a true physical sense, 'noise' around zero can be both positive and negative, thus it is possible that a small negative reading (of up to –10 BPU) can be observed in conditions of zero perfusion.

A zero reading indicates zero motion both in the measuring volume under examination and artefactual motion arising from relative movements between the probe and the measuring volume. During *in vivo* measurements, rarely is an absolute zero obtained. Even during total occlusion of tissue blood flow, there is often some small, residual motion of blood cells trapped in the vessels, as well as some small muscle and tissue movement in the measuring volume. Even after surgical removal of tissue, localised red blood cell movement and Brownian motion may still occur.

5.2 Simple Probe Integrity Check

The integrity of the optical fibres within OxyFlo probes can be checked by holding the probe end to a source of bright diffuse light (e.g. a ceiling light) whilst visually inspecting the connector end. Two bright spots of light of equal intensity should be visible from the two pins within the connector. The light spots may be more obvious if the probe end is slowly waved across the light source repeatedly.

If light is visible from just a single pin or if light from one of the pins is obviously dimmer than the other then this indicates either a fibre-break or fibre damage. Generally (but not in all cases) such damage can be repaired; please contact technical support accordingly.

5.3 Obtaining Technical Assistance

Contact information for obtaining technical assistance is provided at the beginning of this manual and on the Oxford Optronix web site.

When contacting technical support or your local distributor please provide the serial number of your monitor (found at the rear of the unit), details of probe type(s) used, the nature of the application, and details of the problem or error message(s) encountered.

5.4 Maintenance and Servicing

The OxyFlo Pro should only be repaired or serviced by Oxford Optronix Ltd. trained service staff.

Do not attempt to open the OxyFlo Pro. There are no user-serviceable parts inside. There is a risk of electrical shock or other injury or permanent damage to the monitor.

The monitor should be inspected regularly for signs of wear and tear.

The OxyFlo Pro monitor is supplied with a 2 year warranty. Please refer to the Terms and Conditions of the Warranty at the end of this document for further details.

Like all specialist laboratory equipment the OxyFlo Pro will benefit from regular servicing. The recommended service interval for OxyFlo Pro is every 2 years.

Whilst optional, servicing is strongly recommended to ensure continued optimal performance and operational reliability. Our maintenance servicing provides not only a complete technical/mechanical overhaul, update and recalibration but also ensures that your monitor receives the latest applicable software/firmware upgrades introduced as a result of our continuing R&D and product enhancement programmes.

Please contact technical support for detailed service schedules and pricing.

5.5 Returning the OxyFlo Pro Monitor

Contact Oxford Optronix or your local distributor for shipping instructions.

A **Returned Materials Authorisation** (RMA) number and completed **Decontamination Declaration form** MUST be obtained prior to shipping the equipment.

Pack the OxyFlo Pro in its original shipping carton where available. If the original carton is not available, wrap the unit extensively using bubble wrap, **paying particular attention to protecting the touch screen** and pack it in a suitably sized, STRONG box surrounded by at least 10 cm (4”) of tightly packed polystyrene chips, bubble wrap and/or suitable foam inserts.

For a small fee, Oxford Optronix can provide new original shipping cartons and foam inserts that will ensure safe transportation.

Failure to pack the OxyFlo Pro monitor appropriately for repair or service is likely to result in potentially costly damage to the monitor during transit.

Probes for return should be shipped in their original, dedicated sturdy plastic cases, inside either a large padded envelope or packed in a suitably-sized box. Where accompanying a monitor for return, probes may be included within the larger carton of the monitor, provided there is suitable protective material between them.

Use a recognized international courier company for the return of product to Oxford Optronix (e.g. UPS, FedEx, DHL etc).

Oxford Optronix will not accept responsibility for any loss or damage to goods shipped to us, howsoever caused.

6. TECHNICAL SPECIFICATIONS

Physical	
Dimensions	150 mm (H) x 310 mm (W) x 280 mm (D)
Weight	4Kg / 9lbs
Operating temperature	10 - 30°C
Operating humidity	0 – 70% (non-condensing)
Power requirements	40W max.
Number of probes supported/ Number of channels	OxyFlo Pro 2 OxyFlo Pro XL 4
Display	High contrast 800 x 480 full colour LCD touch-screen
User configuration	Via touch-screen display
Analogue voltage outputs	2 x 15-pin D type, 4 outputs (Pro) or 8 outputs (Pro XL)
Laser type	Temperature-stabilized semi-conductor laser diode(s)
Laser wavelength	830 ± 10nm
Laser classification	Class 1 (EN 60825-1 and 21 CFR 1040.10)
Laser power	<0.5mW from probe tip/underside

Performance	
Mode of operation	Laser Doppler Flowmetry
Measurement units (displayed)	0 – 9999 BPU (blood perfusion units)
Stability of reading	± 5%
Sampling rate	200Hz
Measurement time constant (filtering)	200ms (Flow); 200ms (Backscatter); 5ms (Raw); 5s (ART)
Display update time (numerical)	2s (5s rolling averaged)
Probe identification	Automatic; monitor stores one-time calibration
Probe calibration	Factory or user-calibrated using Oxford Optronix motility standard
Zeroing	Automatic, controlled
Default analogue data output range	0 - 5V (= 0 - 5000 BPU or 0 - 100% Backscatter)
Analogue data output rate	65 Hz

Table 10: OxyFlo Pro technical specifications

7. WARRANTY

Oxford Optronix Ltd. warrants its Products against defects in material or in workmanship, when used under appropriate conditions and in accordance with the appropriate Operating or User Instructions for a period of **24 months** from the date of purchase.

Oxford Optronix Ltd's sole obligation shall be to repair or to replace at Oxford Optronix' option, FOB its factory, without charge, any part(s) that prove defective within the warranty period. Software programs are supplied on the strict understanding that we do not warrant their functions to be free from defects, errors or bugs.

Any claim under the warranty must be made in writing. The Products to which the claim refers must be returned to us within 2 months from the date the claim was made, suitably packaged, using our Returned Materials Authorisation (RMA) procedure and our courier (e.g. FedEx) account reference. No returned Products will be accepted without prior written authorisation and an RMA number.

Oxford Optronix Ltd. is not liable under this warranty:
- for any defect arising from fair wear and tear, wilful damage, negligence, misuse, repair of the Products without our written approval; or
- any use of or dealing with the Products in conjunction with any other item where such item causes or gives rise to the alleged defect; or
- any use of the Products which is not in accordance with the Operating or User Instructions or from any failure to service or maintain the Products in accordance with such instructions.

Oxford Optronix Ltd. specifically disclaims any other express or implied warranty, including warranties of merchantability and of fitness for use. To the full extent permitted by law, we shall not be liable in any way whatsoever whether in contract, in tort, in misrepresentation or under statute or common law or otherwise (whether caused by our negligence or otherwise) in respect of defects in the Products or failure to correspond to specification or for any injury, damage or loss resulting from such defects or failure. In no event shall any breach of contract on our part or tort (including negligence) or failure of any kind on our part give rise to any liability for loss of revenue or loss of profits or any other consequential or indirect loss or damage arising from any cause whatsoever.