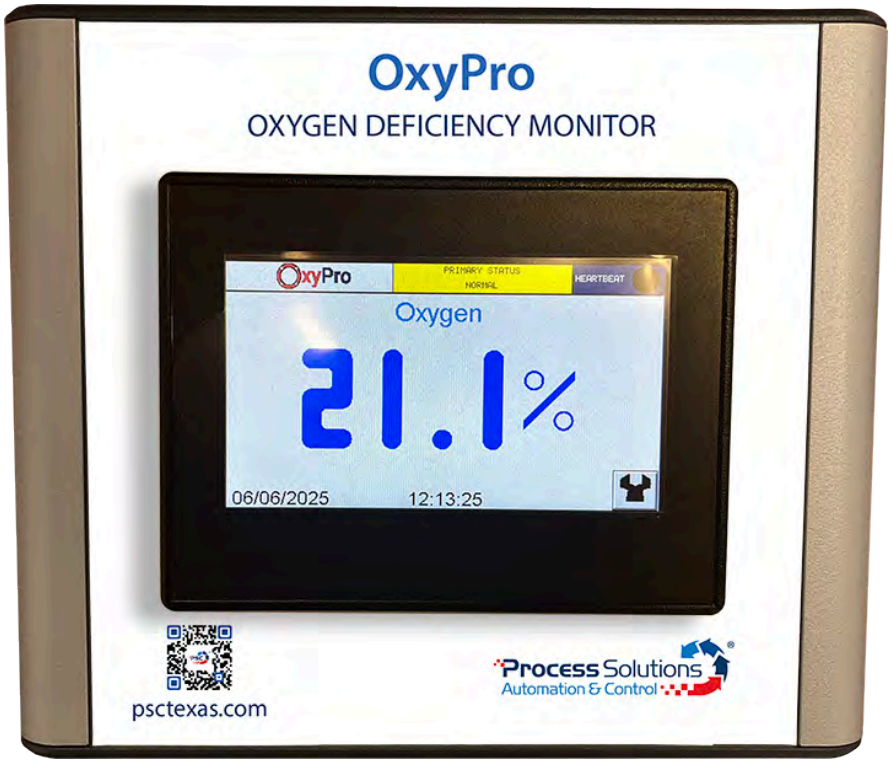
Process Solutions
Automation & Control



Learn more on our website: www.psctexas.com/oxypro

USER MANUAL

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Important Information

Safe and reliable operation of this equipment depends on proper installation, operation, and maintenance performed according to and within the limitations of relevant manuals and documentation by qualified personnel with appropriate training and experience.

Failure to follow the instructions in this User Manual and supplemental documentation may void the warranty, damage equipment, and could make the user responsible for any resulting consequences.

Process Solutions Corp. does not accept liability for unauthorized use or modifications to Process Solutions Corp. supplied equipment.

Process Solutions Corp. has prioritized Health and Safety throughout this manual. Wherever specific precautions are required due to the nature of the equipment or product, a safety icon and warning message are provided. Be sure to review Section 1.2 carefully, as it summarizes all safety-related notices.

As part of our ongoing commitment to research, development, and continuous improvement, we reserve the right to modify models and specifications without prior or subsequent notice.

This User Manual reflects information accurate at the time of distribution but should be considered outdated if the product's specifications or appearance are later modified.

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Note

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1. Descriptions and Definitions

1. **Scope of this Manual**
   a. This User Manual provides installation, operation, and routine maintenance instructions for the OxyPro, Oxygen Deficiency Monitor from Process Solutions Corp. The OxyPro may be abbreviated to "unit" or "equipment" or "instrument" or "device" in the remainder of this User Manual.

2. **Safety Information**
   a. Before installing, operating, or maintaining the unit, read this manual thoroughly to ensure full understanding. Critical safety information is clearly marked throughout as WARNINGs and CAUTIONs, defined as follows:

WARNINGS, CAUTIONS, AND NOTES

This publication includes WARNINGS, Cautions, and Notes which provide, where appropriate, information relating to the following:

WARNING: A WARNING ALERTS THE USER TO SPECIFIC HAZARDS WHICH, IF NOT TAKEN INTO ACCOUNT, MAY RESULT IN PERSONAL INJURY OR DEATH.

Caution: A Caution alerts the user to hazards which, if not taken into account, may result in equipment or property damage.

Note: Notes alerts the user to pertinent facts and conditions, which may be useful to be aware of such as operating conditions or related information.

3. **Model/Version Deviations**
   a. Throughout this User Manual, items may deviate depending on the model/version of OxyPro that operators are using. This will be indicated as follows:
      i. Model (Number of Sensors) - Instructions for the OxyPro may deviate based on the number of sensors they feature with:
         - "A. **Single Sensor model**" for models with only one paramagnetic oxygen sensor and,
         - "B. **Multi-Sensor model**" for models with more than one oxygen sensor.
      ii. Version (Function of the Alarms) - Instructions for the OxyPro may also deviate based on the function of the alarms with:
         - *"Life Safety version – Model: OxyPro-LS-XX-XX-XX-XX"* for life-critical versions, which feature a Low Latched (Low Low) Alarm and a Low Alarm and,
         - *"Percent Oxygen version – Model: OxyPro-PO-XX-XX-XX-XX"* for Percent Oxygen versions, which feature a Low Latched (Low Low) Alarm and a High Alarm.

1. Descriptions and Definitions

4. **Description**
   a. The OxyPro is a fixed or table-top oxygen gas detector with a built-in oxygen sensor that provides a linear 4-20 mA output corresponding to ambient oxygen levels. The unit also includes three changeover relays to indicate specific detector status conditions:
      i. Alarm 1 - Fault Alarm for instrument faults
      ii. Alarm 2 - Low Latched (Low Low) Alarm for oxygen measurement ≤19.5% O_2

Life Safety version – Model: OxyPro-LS-XX-XX-XX-XX
      iii. Alarm 3 - Low Alarm for oxygen measurement ≤20.0% O_2

Percent Oxygen version – Model: OxyPro-PO-XX-XX-XX-XX
      iii. Alarm 3 - High Alarm for oxygen measurement ≥23.5% O_2

   b. These outputs can be integrated into a gas detection system or DCS however, the instrument also gives direct visible and audible warnings and alarms of an irregular oxygen environment.
      i. Gas sample readings are displayed on the instrument and can be transmitted as a 4-20 mA signal, RJ45, or via switch and/or relay status indicators for gas alarm levels.

      NOTE: See Section 13 for more information about warnings and alarms.
   c. The OxyPro measures ambient oxygen in the surrounding air based on the principles of paramagnetism, which is an inherently linear measurement technique that relies upon a non-depleting paramagnetic sensor.
   d. The instrument is intended for installation in indoor work environments, including workshops, laboratories, manufacturing facilities, analyzer shelters, etc.
   e. Due to its paramagnetic sensor, the OxyPro requires minimal routine maintenance as the sensor is non-consumable and does not require replacement or to be refilled.
      i. With a drift rate of less than ±0.2% O_2 per month, frequent calibrations are not required, however, operators are encouraged to self-determine and schedule routine calibrations to ensure accurate gas measurements, no longer than every 6-months.

5. **Ordering Options**
   a. For assistance ordering the OxyPro, please contact Process Solutions Corp. directly or visit https://psctexas.com/oxypro for more information.
      Phone: +1 (281) 491-3833
      Email: sales@psctexas.com
      Website: www.psctexas.com

1. Descriptions and Definitions

WARNING

THE OXYPRO IS NOT A MEDICAL DEVICE AS DEFINED IN THE MEDICAL DEVICES DIRECTIVE 93/42/EEC AND IS NOT INTENDED TO BE USED ON HUMAN BEINGS FOR THE DIAGNOSIS, PREVENTION, MONITORING, TREATMENT, OR ALLEVIATION OF DISEASE.

WARNING

THE OXYPRO IS NOT INTENDED FOR USE IN PROCESS CONTROL OR PROCESS MONITORING.

WARNING

DO NOT MODIFY THE DEVICE MECHANICALLY OR ELECTRICALLY AS THIS COULD CAUSE MALFUNCTION AND UNSAFE OPERATION.

WARNING

OPERATORS MUST ENSURE THAT THE OPERATING ENVIRONMENT IS WITHIN THE LIMITS SPECIFIED IN THE PRODUCT SPECIFICATIONS (SEE SECTION 3).

WARNING

DO NOT OPEN THE ENCLOSURE IF THE DEVICE IS ENERGIZED.

WARNING

ONLY USE A SOFT, CLEAN CLOTH MOISTENED WITH WATER TO WIPE CLEAN THE OUTSIDE OF THE ENCLOSURE.

END OF SECTION

2. Introduction

The OxyPro is a next-generation oxygen (O_2) monitor designed to continuously measure atmospheric oxygen levels for life-critical applications in safe areas. Unlike traditional electrochemical sensors, the OxyPro uses the advanced, non-depleting Paracube® Modus paramagnetic sensor (from Servomex-Hummingbird), which offers exceptional linearity, accuracy, and long-term reliability without sensor degradation. Widely trusted in the medical OEM market, this reliable, low-maintenance sensor ensures consistent performance over time. The OxyPro delivers superior safety, performance, and stability, while also reducing long-term ownership costs compared to conventional oxygen detection solutions.

Features of the OxyPro include industry-leading accuracy, fault alarm and two O_2 alarms, remote monitoring via Ethernet or Modbus TCP, and flexible installation options (wall-mounted, rack-mounted, or table-top). The OxyPro is ideal for confined spaces and life-critical environments like laboratories, analyzer shelters, manufacturing facilities, and hospitals.

Unrivaled Performance

- Industry leading linearity, accuracy, and stability with fast response times
- Leader in paramagnetic sensor technology
- Advanced Magneto-Dynamic design delivers unprecedented performance and reliability

Easy to Use

- No cell replacement required
- User-friendly digital interface
- Fault alarm via mA jam to 0 mA
- Flexible mounting options
- Fast single point calibration that does not require reference gas

Customizable, Modular Design

- Multi-Sensor model
- Remote sensor options with no tubes or pumps required
- Remote interface, live monitoring, integration to DCS or PLC via 4-20mA, RJ45, and/or switch

Note

This OxyPro User Manual details the operation and installation of the OxyPro Oxygen Deficiency Monitor from Process Solutions Corp. A listing of OxyPro variants can be found in Section 5. Information is subject to change without notice.

END OF SECTION

3. Product Specifications

Performance	
Sensor Technology	Paramagnetic
Measurement Range	0 to 100% O_2
Over Range Capability	-15 to 200% O_2
Accuracy	±0.2% O_2
Repeatability	< ±0.2% O_2
Update Time	< 1/2 second
Zero Drift	< ±0.2% O_2 per month
Zero Temp Coefficient	< ±0.5% O_2 per 10˚C
Signal Noise	< 0.2% O_2
Ambient Pressure Effects	< 0.04% reading per 1% change

Input/Output	
Analog Outputs	Isolated 4-20 mA
Relay Outputs	6 relay outputs
Ethernet Outputs	RJ45, Modbus TCP
Serial Ports	RS232, RS485
I/O Options	Yes

Environmental Data	
Operating Altitude	-1,540 to 15,400 ft
Operating Pressure	Ambient
Operating Temperature	41 to 122˚F (5 to 50˚C)
Storage Temperature	-22 to 158˚F (-30 to 70˚C)
Storage Pressure	10-200 kPa (1.5-30 PSI)
Relative Humidity	10-90%, non-condensing
Environmental Limits	For indoor use only

User Interface	
Display	4.3" 65k color touchscreen
Resolution	480 x 272 pixels
Backlight	White LED
Data Logging	Yes
Internal Memory	15 Mb
External Memory	32 Gb

Additional Features

- Internal orientation compensation
- Fault alarm output to 3.5 mA
- Real-time monitoring, remote interface

Approvals

- UL Safe Area (general purpose)
- IP66 Rating (enclosure) for indoor use
- RoHS, REACH compliance (sensor only)

WARNING

THE PROTECTION, ACCURACY, OPERATION, AND CONDITION OF THIS DEVICE MAY BE IMPAIRED IF THE INSTRUMENT IS NOT INSTALLED IN ACCORDANCE WITH THE REQUIREMENTS OF THIS AND SUBSEQUENT SECTIONS OF THE USER MANUAL.

END OF SECTION

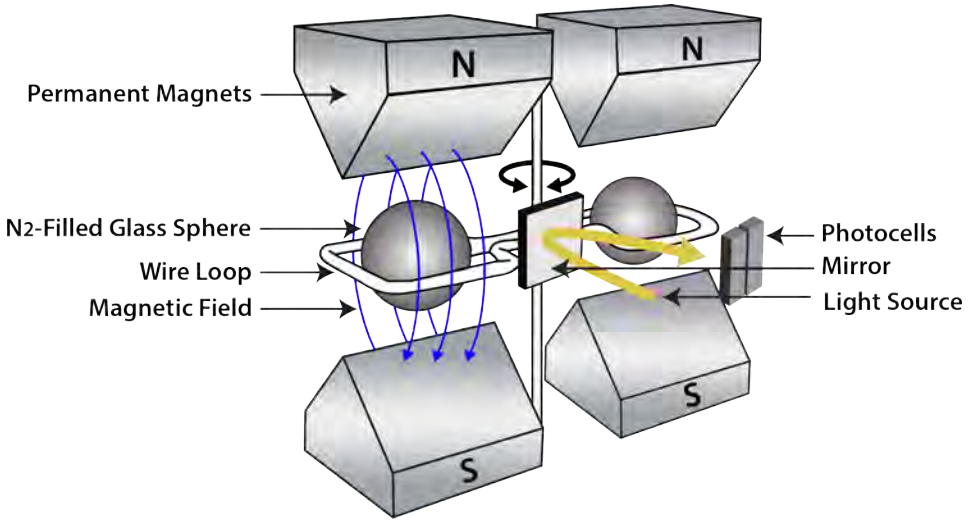
4. Paramagnetic Measurement Principle

Hummingbird's non-depleting paramagnetic technology delivers long-term, consistent performance while reducing overall cost of ownership. Its high selectivity for oxygen ensures accurate measurements without interference from other respiratory gases. The sensor offers a stable and inherently linear oxygen reading.

The Paracube sensor operates by leveraging the paramagnetic susceptibility of oxygen, a property that sets it apart from most common gases. At its core is a suspension assembly consisting of two nitrogen-filled glass spheres mounted on a taut, noble-metal band. This assembly is positioned within a non-uniform magnetic field. When oxygen is present in the surrounding gas, it is attracted to the magnetic field, causing the spheres to be pushed away from the strongest magnetic region. The resulting torque on the assembly is proportional to the oxygen concentration.

A differential photo-sensor detects any displacement of the suspension, using light reflected from a mirror attached to it. This signal is processed and used to generate a feedback current in a coil surrounding the assembly. The system is "null-balanced," meaning the feedback current restores the assembly to its original position.

This feedback serves two purposes: it balances the torque induced by oxygen, and the required current is directly proportional to the oxygen partial pressure, providing a precise voltage output. Additionally, the feedback current dampens oscillations, enhancing the sensor's resistance to shock and vibration, and improving stability and reliability in demanding environments.



END OF SECTION

5. Configurations

The OxyPro is available in a range of customizable configurations to meet the unique demands of the oxygen monitoring industry. Below is a configuration guide for most standard and optional features:

OxyPro	Software Version	Power	Sensor Type	Enclosure Type	Adders
OxyPro	-XX	-XX	-XX	-XX	-XX
	-LS (Life Safety)	-AC	-LO (local)	-AB (ABS plastic)	-00 (No Adders)
	-PO (Percent Oxygen)	-DC	-RE (remote)	-ME (metal)	-BB (Battery Backup)
	-XX (Special Purpose)				-HK (Hard Keys)
					-HT (Heater)
					-SL (Stack Light)
					-SR (Special Range)
					-XX (Special Option)

1. **Standard Configurations**
   The OxyPro is available in four standard options as follows:
   (1) **ABS Enclosure with Local Sensor**
   OxyPro-LS-XX-LO-AB-HK
   Life Safety version, optional Power Type, Local Sensor, ABS Enclosure, adders: Hard Keys

   (2) **ABS Enclosure with Remote Sensor(s)**
   OxyPro-LS-XX-RE-AB-HK
   Life Safety version, optional Power Type, Remote Sensor(s), ABS Enclosure, adders: Hard Keys

   (3) **Metal Enclosure with Local Sensor**
   OxyPro-LS-XX-LO-ME-00
   Life Safety version, optional Power Type, Local Sensor, Metal Enclosure, adders: none

   (4) **Metal Enclosure with Remote Sensor(s)**
   OxyPro-LS-XX-RE-ME-00
   Life Safety version, optional Power Type, Remote Sensor(s), Metal Enclosure, adders: none

NOTE: ABS Enclosure versions (-AB) include Hard Keys (-HK) as a standard. Fully customized OxyPro models are also available. Contact Factory for additional information.

Exclusions:
- Battery Backup (-BB) is not available on DC Power models.
- Only Remote Sensor versions (-RE) support Multi-Sensor functionality. Local Sensor versions (-LO) do not support Multi-Sensor functionality.

5. Configurations

2. **Custom Configuration Examples**
   OxyPro-LS-AC-LO-ME-SL
   Life Safety version, AC power, Local Sensor, Metal Enclosure, adders: Stack Light

   OxyPro-PO-AC-RE-AB-BB-HK-SL
   Percent Oxygen version, AC power, Remote Sensor(s), ABS Enclosure, adders: Battery Backup, Hard Keys (standard for -AB Enclosures), Stack Light

   OxyPro-LS-DC-LO-AB-HK-HT
   Life Safety version, DC power, Local Sensor, ABS Enclosure, adders: Hard Keys (standard for -AB Enclosures), Heating Blanket

3. **General Use Throughout User Manual**

- Life Safety version = *OxyPro-LS-XX-XX-XX-XX*
- Percent Oxygen version = *OxyPro-PO-XX-XX-XX-XX*
- Single Sensor model
- Multi-Sensor model

4. **Standard Enclosure Sizes**
   The OxyPro is available with two standard enclosure options to support a Local Sensor (-LO) or one or more Remote Sensors (-RE). Our standard options include:

- ABS Enclosure (-AB) [Control Unit] - 10.25 x 9.25 x 5.75 inch (approximate)
- Metal Enclosure (-ME) [Control Unit] - 8 x 6.75 x 3.75 inch (approximate)
- Other enclosure options may be available. Contact Factory for additional information.

5. **Remote Sensors**
   Remote Sensor versions (-RE) offer Single Sensor or Multi-Sensor functionality. Remote Sensor versions include a Control Unit in addition to one or more Remote Sensor Units:

- ABS Enclosure (-AB) [Remote Sensor Unit] - Part Number: *OxyPro-Rem-AB*
  - 6.25 x 3.5 x 3.25 inch (approximate)
- Metal Enclosure (-ME) [Remote Sensor Unit] - Part Number: *OxyPro-Rem-ME*
  - 6.25 x 5.25 x 3.25 inch (approximate)
- Other enclosure options may be available. Contact Factory for additional information.

   No Tubes or Pumps Required
   Remote Sensors for the OxyPro measure oxygen concentration in-place. Each Remote Sensor unit is equipped with an independent paramagnetic oxygen sensor, which then communicates with the Control Unit via M12 cable. Unlike other remote oxygen monitoring devices, the OxyPro does not require pumps or tubes to deliver air to the control unit to read the oxygen concentration.
   NOTE: See Section 13.3 for more information about Remote Sensors.

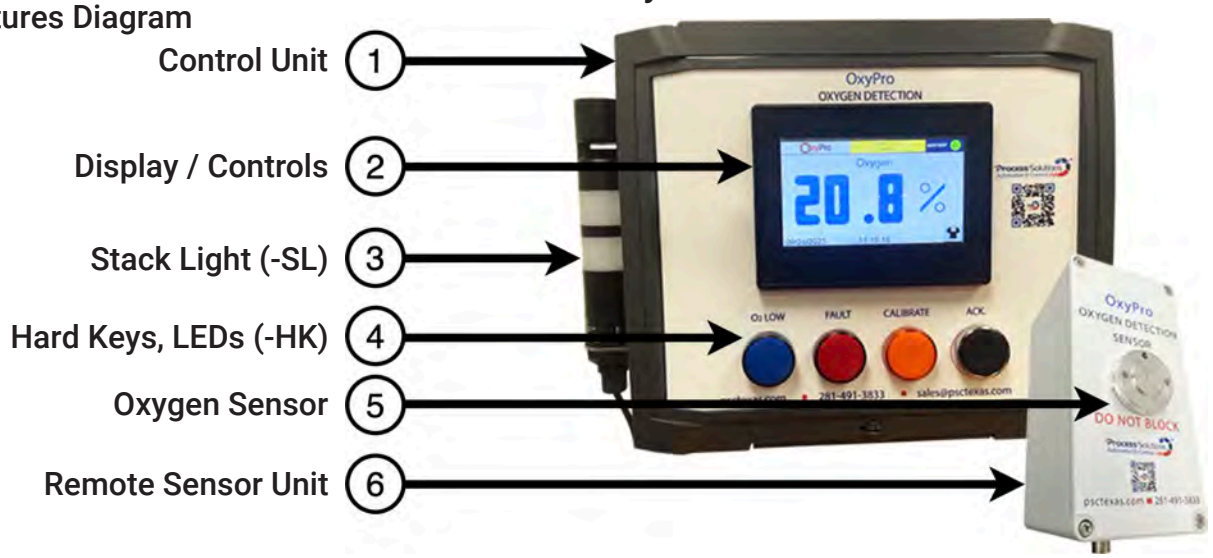
5. Configurations

6. **Optional Features**
   a. Battery Backup (-BB)
      i. Battery backup ensures the device continues to operate even after the event of power-loss.
      ii. The battery backup option is currently only available for OxyPro models that use AC power.
      iii. The length of battery life can be customized to fit exact application requirements.
   b. Hard Acknowledge Button and LEDs (-HK)
      i. A hard key Acknowledge button and/or physical LEDs.
      ii. A hard key Acknowledge button acts as a redundant option in parallel with the on-screen Acknowledge button; the physical LEDs act as a redundant option in parallel with the on-screen alarms/indicators or optional Stack Light.
      iii. Other hard keys or LEDs can also be integrated upon request.
   c. Heating Blanket
      i. For environments that are often exposed to cold temperatures, a heating blanket may be included to allow reliable operation.
   d. Stack Light
      i. Integral and/or remote Stack Lights work in tandem with native Alarm functions.
      ii. Other external beacons, lights, and audible alarms can also be integrated upon request.
   e. Special Measurement Range
      i. For non-standard applications, special oxygen measurement ranges can be programmed.
   f. Alarms
      i. Alarm setpoints, actions, and notifications can be modified upon request.
   g. Integration
      i. Integration with a DCS, gas detection system, etc. is available upon request.

NOTE: Additional physical or program features may be available upon request. Contact Factory for additional information.

7. **Features Diagram**

OxyPro-XX-XX-RE-AB-HK-SL



5. Configurations

8. Standard Configurations Diagram

OxyPro-LS-XX-LO-AB-HK
(Standard ABS with Local Sensor)

OxyPro-LS-XX-RE-AB-HK
(Standard ABS with Remote Sensor)

OxyPro-Rem-AB

OxyPro-LS-XX-LO-ME-00
(Standard Metal with Local Sensor)

OxyPro-LS-XX-RE-ME-00
(Standard Metal with Remote Sensor)

OxyPro-Rem-ME

END OF SECTION

6. Unpacking the Device

1. **Remove the Device**
   a. Remove the OxyPro and any other components from its packaging.

2. **Inspect the Unit and Components**
   a. Inspect the unit and any other supplied items to ensure there is no damage.
      NOTE: In the event that damage has occurred, contact Factory immediately.
   b. Check to ensure that you have received all items that you ordered.
      NOTE: In the event that any components are missing, contact Factory immediately.

3. **Install or Store Properly**
   a. If you plan to immediately install your device, continue to Section 7 for more information about Installation Guidelines.
   b. If you do not intend to use the unit immediately after opening:
      i. Replace any protective sleeves or covers.
      ii. Place the unit and other included components back into the box it arrived in.
      iii. Store the unit in a dry, indoor, temperature-controlled area that meets storage specifications.
      NOTE: See Section 3 for more information about storage temperatures, etc.

WARNING

THE INSTRUMENT IS DELICATE AND CARE MUST BE TAKEN WHEN HANDLING.

Note

It is advised to retain packaging and documentation for future use in the event that the unit requires return to the Factory.

END OF SECTION

7. Installation Guidelines

1. **Location**
   a. The paramagnetic sensor in the OxyPro is sensitive to movement and vibration.
      i. The OxyPro should be mounted to a rigid assembly and away from vibrating components.
      ii. Avoid mounting the OxyPro onto a chassis or plate that may act like a level or spring.
      NOTE: If mounting near vibrating components or where the unit will be subjected to excessive mechanical shocks is unavoidable, it may be necessary to mount the OxyPro on shock absorbers to dampen the impact on the output of the sensor.
   b. The OxyPro should be protected from sudden temperature swings, such as from cooling fans or boilers, as this can affect both the zero and span calibrations.
      i. Fitting the OxyPro into a temperature controlled environment will eliminate varying environmental conditions and optimize its performance.

2. **Exposure to Contaminants**
   a. Avoid installing the OxyPro near "dirty" operations such as cutting, drilling, filing, deburring, packaging, or finishing areas.

NOTE: See Section A2.4. for more information about Sample Gas Cross Sensitivity.

3. **Orientation of the OxyPro**
   a. To achieve optimum performance, the OxyPro should operate in the orientation of calibration.
   b. Any small offsets resulting from a change in orientation may be removed by performing a single point calibration. See Section 9 for more information about the Single Point Calibration Procedure.

4. **Conditioning of the Sample**
   a. Due to the inherent protection offered by the filter at the gas exchange interface, sample conditioning can be kept to a minimum.
      i. The sensor's hydrophobic filter will prevent particulates larger than 1 micron and water from entering the measurement cavity.
      ii. It is however good practice to reduce particulate contamination of the sample gas to less than 3 microns to prevent blockage.
   b. *Ideal Conditions*: Dry, non-corrosive, non-flammable gas, free of entrained oil, less than 3 micron particulates, non-condensing, dew point 10˚C below sensor operating temperature.
   c. *Sample Temperature*: Condensation within the sensor may be avoided by ensuring that the sensor temperature is at least 10˚C above the sample gas dew point.

5. **Pressure Effects**
   a. The sensor is a partial pressure device and variations in sample gas pressure will cause fluctuations in the observed oxygen output, proportional to the pressure change.
   b. Do <u>not</u> block the sensor and ensure proper ventilation to prevent back pressure and inaccurate oxygen concentration readings.

7. Installation Guidelines

WARNING

AS THE FINAL CONDITIONS OF USE ARE OUTSIDE PROCESS SOLUTIONS CORP. CONTROL, IT IS THE RESPONSIBILITY OF THE END-USER TO ENSURE THAT THE DEVICE IS INSTALLED IN ACCORDANCE WITH ANY REGIONAL STANDARDS OR REGULATIONS GOVERNING THE FINAL APPLICATION.
THE DEVICE SHOULD NOT BE RELIED UPON AS A SINGLE SOURCE OF SAFETY MONITORING UNLESS EXPRESSLY PERMITTED WITHIN THE REGIONAL STANDARDS OR REGULATIONS GOVERNING THE FINAL APPLICATION.

WARNING

THE DEVICE MUST BE INSTALLED BY A QUALIFIED AND COMPETENT INDIVIDUAL. TO ENSURE SAFETY AND AVOID POTENTIAL HAZARDS, THE FOLLOWING PROCEDURE MUST BE STRICTLY FOLLOWED.

WARNING

ENSURE THE OXYPRO HAS THE APPROPRIATE APPROVALS FOR THE ENVIRONMENT WHERE IT WILL BE INSTALLED AND OPERATED.

WARNING

DIFFERENT GASES HAVE VARYING DENSITIES AND MAY RISE OR SETTLE IN THE AIR. THE INSTRUMENT SHOULD BE INSTALLED IN A LOCATION APPROPRIATE TO THE SPECIFIC GAS HAZARD, FOLLOWING A PROPER HAZARD ASSESSMENT.

WARNING

THE SAFE AREA MODEL OF THE OXYPRO IS NOT TO BE USED IN CERTIFIED OR HAZARDOUS AREA LOCATIONS OR POTENTIALLY EXPLOSIVE ENVIRONMENTS.

7. Installation Guidelines

WARNING

THE OXYPRO IS NOT SUITABLE FOR CORROSIVE ATMOSPHERES WHERE GASES AND VAPORS ARE PRESENT IN HIGH ENOUGH CONCENTRATIONS TO CAUSE CORROSION TO NORMAL INDUSTRIAL INSTRUMENTS OR WHERE SPECIALIZED COATINGS, FINISHES, OR MATERIALS WOULD NORMALLY BE REQUIRED TO AVOID CORROSION.

WARNING

FOLLOW THE SAFETY INSTRUCTIONS WHEN INSTALLING THE INSTRUMENT. FAILURE TO DO SO MAY VOID THE WARRANTY, IMPAIR PROPER OPERATION, OR RESULT IN DAMAGE TO THE INSTRUMENT.

WARNING

MAKE SURE THE INSTRUMENT'S ELECTRICAL INSTALLATION COMPLIES WITH ALL RELEVANT LOCAL AND NATIONAL ELECTRICAL SAFETY REGULATIONS.

WARNING

ROUTE ALL CABLES CONNECTED TO THE INSTRUMENT IN A WAY THAT PREVENTS THEM FROM CREATING A TRIP HAZARD.

WARNING

THE OXYPRO DOES NOT HAVE A BUILT-IN ON/OFF SWITCH. AN EXTERNAL MEANS OF ISOLATING ITS POWER SUPPLY MUST BE PROVIDED. USE A CLEARLY LABELED SWITCH OR CIRCUIT BREAKER LOCATED NEAR THE MONITOR TO SERVE AS THE DISCONNECTING DEVICE. THIS MUST INCLUDE APPROPRIATE FUSING OR OVER-CURRENT PROTECTION. TO MEET SAFETY STANDARDS, THE DISCONNECTION DEVICE MUST BE CERTIFIED IN ACCORDANCE WITH: UL 489 FOR EQUIPMENT USED IN THE USA; CSA C22.2 NO. 5.1 FOR EQUIPMENT USED IN CANADA; IEC 60497 FOR EQUIPMENT USED IN THE EU AND THE REST OF THE WORLD.

7. Installation Guidelines

WARNING

THE OPTIONAL MODBUS TCP/IP COMMUNICATION OUTPUT MUST NOT BE USED AS THE PRIMARY SAFETY INDICATOR FOR MEASURED OXYGEN LEVELS IN THE GAS ALARM MANAGEMENT SYSTEM. IT IS INTENDED SOLELY FOR DIAGNOSTICS AND SECONDARY STATUS INDICATION OF THE DETECTOR.
THE PRIMARY SAFETY INDICATION FOR MEASURED OXYGEN LEVELS IS PROVIDED BY THE MA OUTPUT AND STATUS RELAYS.

WARNING

ENSURE THAT THE ELECTRICAL SUPPLY VOLTAGE MATCHES THE AVAILABLE POWER SUPPLY. IF THE VOLTAGE IS INCORRECT, DO NOT INSTALL THE EQUIPMENT. INSTEAD, CONTACT THE FACTORY IMMEDIATELY FOR ASSISTANCE.

WARNING

BEFORE CONNECTING THE CONDUCTORS IN THE ELECTRICAL SUPPLY CABLE, MAKE SURE THE EXTERNAL POWER SUPPLY OUTLET IS PROPERLY ISOLATED AND LOCKED OUT.

WARNING

ALL EQUIPMENT TERMINALS CONNECTED TO THE OXYPRO BY THE USER MUST BE ISOLATED FROM MAINS VOLTAGES WITH A MINIMUM OF REINFORCED INSULATION.

WARNING

VERIFY THAT THE INSTRUMENT IS COMPATIBLE WITH YOUR ELECTRICAL SUPPLY. USING AN INCOMPATIBLE SUPPLY MAY RESULT IN IMPROPER OPERATION OR POTENTIAL DAMAGE TO THE INSTRUMENT.

7. Installation Guidelines

WARNING

IF USING DC POWER, ENSURE THAT THE DC POWER SUPPLIED TO THE OXYPRO IS NOT SOURCED DIRECTLY FROM AN AC SUPPLY RATED ABOVE 253 VAC.

WARNING

IF USING DC POWER, ENSURE THAT IT IS SUITABLY APPROVED FOR THE ENVIRONMENT IN WHICH IT IS TO BE INSTALLED AND USED.

WARNING

IF USING DC POWER, THE 24VDC POWER SUPPLY UNIT SHOULD BE INSTALLED AS CLOSE AS POSSIBLE TO THE OXYPRO WHILE FOLLOWING PROPER ELECTRICAL INSTALLATION PRACTICE TO PREVENT GROUND LOOPS.

WARNING

TO MEET IEC61010 STANDARDS, THE CABLE GLANDS USED TO CONNECT THE OXYPRO MUST:

- **BE RATED FOR TEMPERATURES 41 TO 113˚F (5 TO 45˚C).**
- **BE ABLE TO PROVIDE CABLE STRAIN RELIEF THAT CAN WITHSTAND PULLING AND TWISTING AS SPECIFIED BY RELEVANT SAFETY STANDARDS APPLICABLE TO THE INSTALLATION.**
- **BE METAL OR HAVE A FLAMMABILITY RATING OF V-1 OR BETTER**
- **MAINTAIN A MINIMUM OF IP40 RATED ENVIRONMENTAL PROTECTION CLASSIFICATION FOR SAFE AREA INSTALLATIONS.**

Caution

To meet EMC requirements, analog outputs must connect with twisted pair screened cables.

7. Installation Guidelines

Caution

Avoid installing the instrument in areas exposed to excessive vibration or significant temperature fluctuations, as these conditions may lead to false alarms.

Caution

Do not install the instrument in locations with strong magnetic fields or significant changes in magnetic field intensity, as these can lead to inaccurate oxygen readings.

Caution

Ensure the door of the device is closed and screws are tightened before powering on.

Note

If connecting to a DCS, gas detection system, etc. the connecting cable should not leave the building in which it is installed without suitable isolation.

Note

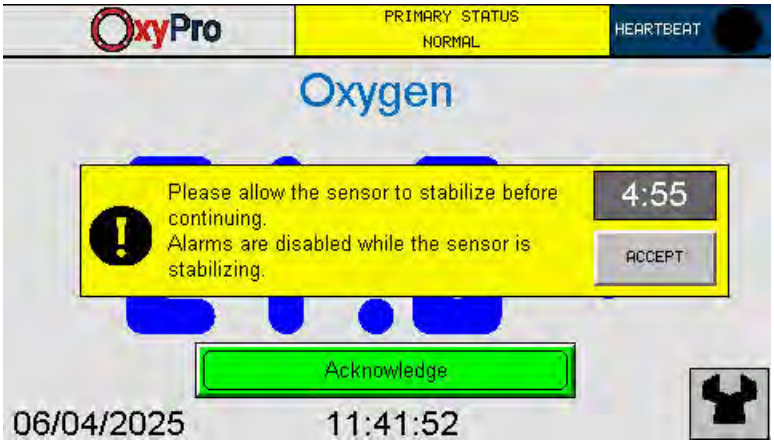
If connecting to a DCS, gas detection system, etc. the connecting cable must be shielded CAT5E with standard RJ45 connectors.

END OF SECTION

8. Start-Up

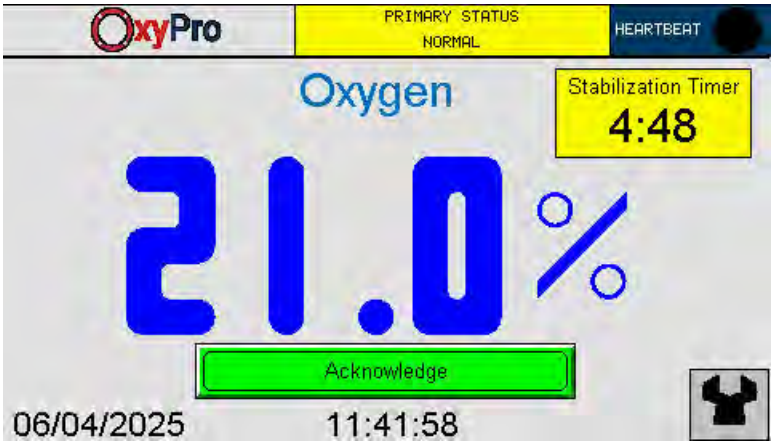
1. **Installation and Power-On**
   a. Check to ensure the system is installed in an appropriate environment according to the Installation Guidelines in Section 7 of this User Manual.
   b. Check to ensure all connections are secure and properly in place.
   c. Check to ensure the Control Unit (and optional Remote Sensor[s], if included) is securely and properly mounted.
   d. Connect the unit to power.
   NOTE: There is no power button (on/off switch) on the unit and the unit should power on automatically after connecting to power.

2. **Stabilization Mode**
   a. Once connected to power, the unit will automatically power-on and enter a Stabilization Mode.
   b. A 5-minute countdown will appear on the Home screen while in Stabilization Mode. All access to settings and alarms is disabled for the duration of the countdown.
   c. Operators can select the "Accept" button on the countdown notice, if desired. The countdown notice will automatically dismiss once Stabilization Mode completes.



   NOTE: Stabilization mode is required for the oxygen sensor to function properly and accurately.

3. **Calibration**
   a. Once Stabilization Mode has completed, select the "Acknowledge" button.
   b. Select the Maintenance button in the bottom right corner of the Home screen to access the Main Menu.
   c. From the Main Menu, select the "Single Point Calibration" menu option.
   d. Enable Calibration Mode for the sensor then select the "Start" button.
   NOTE: See Section 9 for more information about Calibration Procedures.



8. Start-Up

4. **Additional Information**
   a. Although Stabilization Mode runs for 5-minutes, it's recommended to allow the oxygen sensor to stabilize for 20-minutes upon start-up to allow for more accurate oxygen measurement.
   b. Trending of Oxygen Concentration Value(s) is disabled by default upon start-up. See Section 12.2.b. for instructions to enable Trending.
   c. By default, alarm values are as follows:
      i. Low Latched (Low Low) Alarm = 19.5% O_2
      ii. Low Alarm = 20.0% O_2 (*Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX*)
      iii. High Alarm = 23.5% O_2 (*Percent Oxygen Version – Model: OxyPro-PO-XX-XX-XX-XX*)
      NOTE: For custom Alarm Values, contact Factory for additional information.

Caution

After initial installation, it is recommended to allow the sensor to stabilize for one hour before it is calibrated. Even though Stabilization Mode only runs for five minutes, the most accurate performance will require an hour to stabilize before calibration.

END OF SECTION

9. Calibration

The OxyPro is calibrated prior to shipment however it is advised that the OxyPro is calibrated immediately prior to use to remove any offsets that may have occurred during shipment.

Calibration at Installation
It is necessary to perform a Single Point Calibration after installing the OxyPro, and before initial use, to ensure any fluctuations due to offset and orientation are removed.

Initial Conditions
- Connect to power via the provided external power supply.
- Ensure a constant gas flow passing across the diffusion interface.

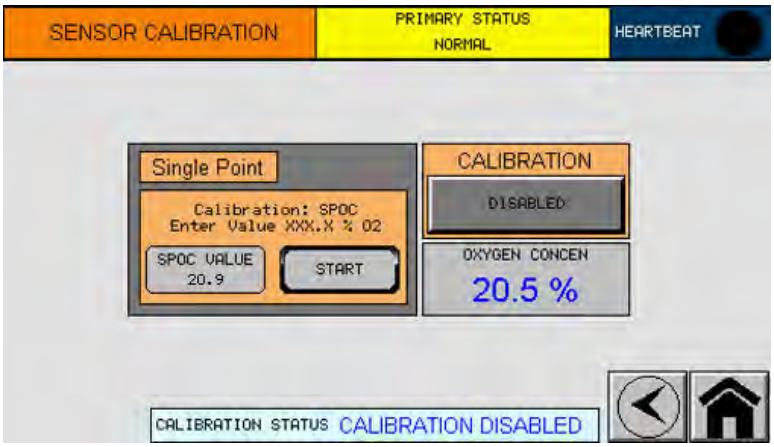
Single Point Calibration
The calibration procedure will need to be performed upon initial start-up, after any reboot and/or loss of power, or after a location change. This procedure ensures a consistent operational range between 0-99% O_2 monitorization and ensures linear measurements within ±0.2% tolerances.

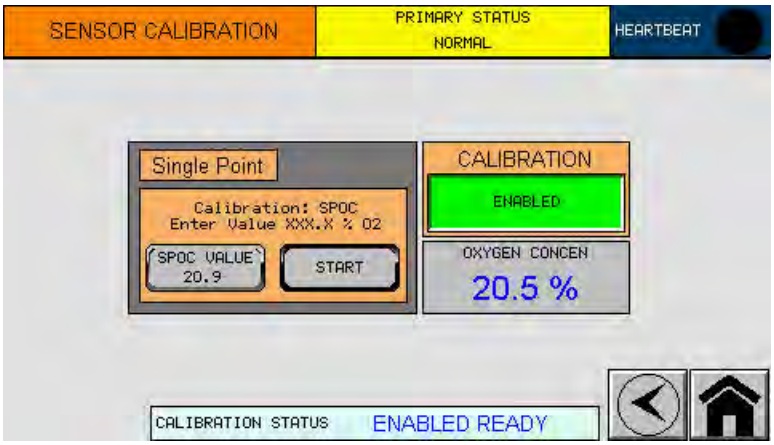
A. **Single Point Calibration Procedure for Single Sensor Model**

1. **Verify Installation**
   a. Verify that the device is properly installed.

2. **Enter Calibration Mode**
   a. To enter Calibration Mode, select the "Maintenance" button on the Home screen to access the Main Menu. 
   b. From the Main Menu, select the “Single Point Calibration” button in the bottom left corner to access the Sensor Calibration screen.

3. **Enable Calibration**
   a. To enable Calibration, toggle the “Disabled” button in the “Calibration” section in the upper right side of the Sensor Calibration screen so that it now displays as “Enabled” and the button turns green. 

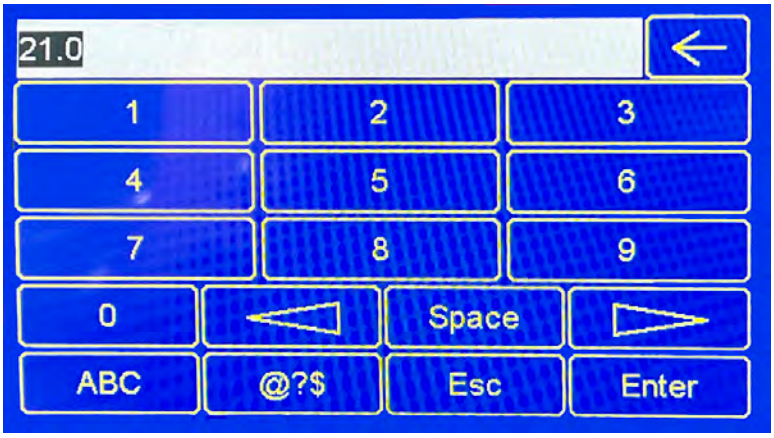




9. Calibration

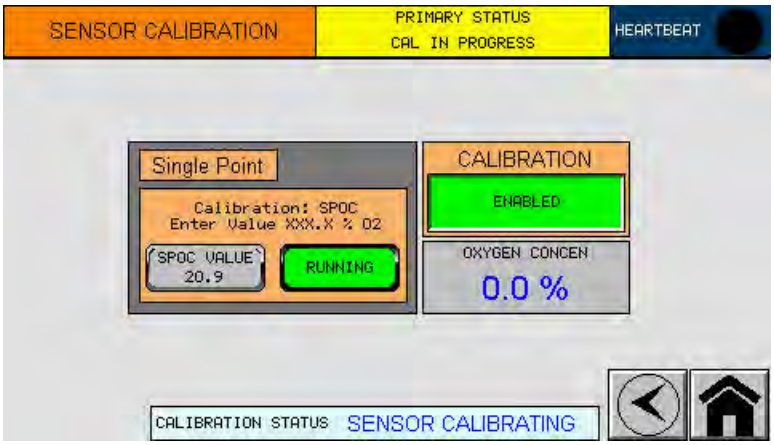
3. **Enable Calibration** (*continued*)
   i. Once enabled, the unit will engage an audible alarm. The audible alarm will remain engaged until the successful completion of the calibration.
   ii. The “Calibration Status” in the bottom center of the screen will indicate as “Enabled Ready.”
   iii. If Hard Keys (-HK) are included, the "Calibrate" indicator light will begin to flash in yellow.

4. **Set the Single Point Offset Correction (SPOC) Value**
   a. Once Calibration Mode is enabled, operators can modify the SPOC value (if necessary) by selecting the "SPOC Value" field and using the keypad to input the value, then selecting the "Enter" key.



   i. To exit the SPOC Value screen without making changes, select the “Esc” key to return to the Sensor Calibration screen.

5. **Run Calibration**
   a. Once the SPOC Value is input, select the “Start” button to begin the calibration process.
   b. The calibration process lasts approximately 10-seconds.
   c. During the calibration process:
      i. The “Start” button will display as “Running” and will turn green.
      ii. The Primary Status in the top center of the screen will indicate as “Cal in Progress.”



   iii. The “Calibration Status” in the bottom center of the screen will indicate as “Sensor Calibrating” then “Calibration Complete.”
   iv. If Hard Keys (-HK) are included, the "Calibration" indicator light will indicate in solid yellow.

6. **Calibration Complete**
   After approximately ten seconds, upon successful calibration, the device will automatically disable Calibration Mode:
   a. The audible alarm will disengage.

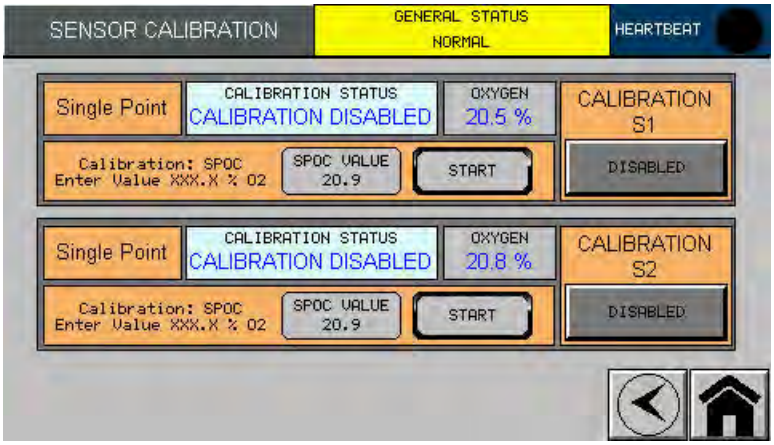
9. Calibration

6. **Calibration Complete** (*continued*)
   b. The “Calibration” button for the selected sensor will return to “Disabled” and turn gray.
   c. The “Calibration Status” at the bottom center of the screen will indicate as “Calibration Disabled.”
   d. The Primary Status at the top center of the screen will return to “Normal.”
   e. If Hard Keys (-HK) are included, the "Calibration" indicator light will disengage.

7. If calibration is not successful, Calibration Mode will continue to be enabled, and the audible alarm will continue to be engaged. If this occurs, repeat Step 5 until the calibration process completes successfully.

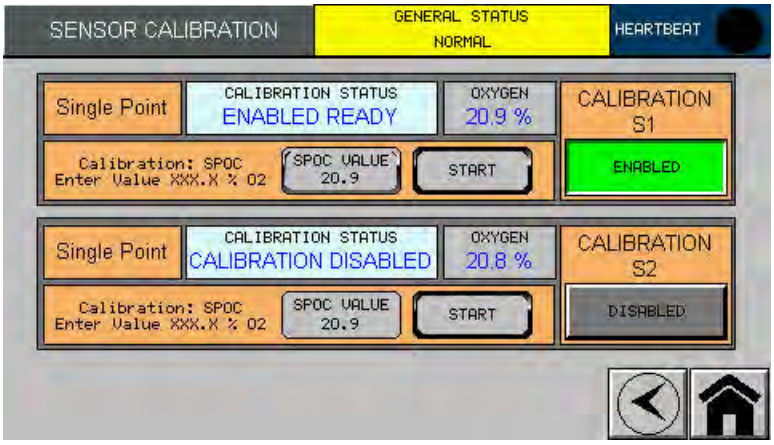
8. After completing a calibration, operators can select the Home button to return to the Home screen, then select the “Acknowledge button” to acknowledge a successful calibration.

B. **Single Point Calibration Procedure for Multi-Sensor Model**
NOTE: It is <u>not</u> recommended to calibrate multiple sensors at the same time. If all sensors require calibration, calibrate each one consecutively.



1. **Verify Installation**
   a. Verify that the device is properly installed.

2. **Enter Calibration Mode**
   a. To enter Calibration Mode, select the Maintenance button on the Home screen to access the Main Menu.
   b. From the Main Menu, select the “Single Point Calibration” button in the bottom left corner to access the Sensor Calibration screen.

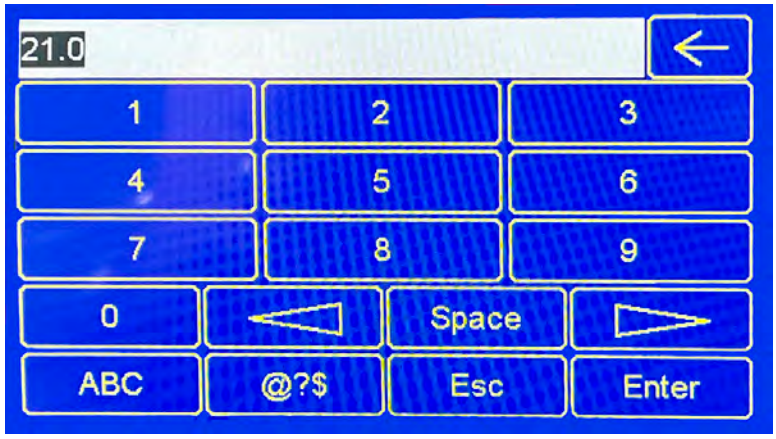


3. **Enable Calibration**
   a. To calibrate the first sensor, toggle the “Disabled” button in the “Calibration S1” section in the upper right side of the Sensor Calibration screen so that it now displays as “Enabled” and the button turns green.

9. Calibration

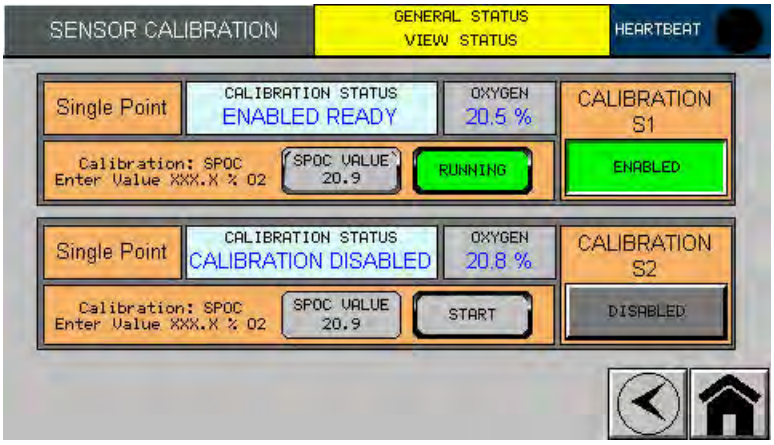
3. **Enable Calibration** (*continued*)
   i. Once enabled, the unit will engage an audible alarm. The audible alarm will remain engaged until the successful completion of the calibration.
   ii. If Hard Keys (-HK) are included, the "Calibrate" indicator light will begin to flash in yellow.

4. **Set the Single Point Offset Correction (SPOC) Value for Sensor 1**
   a. Once Calibration Mode is enabled, operators can modify the SPOC Value (if necessary) by selecting the "SPOC Value" field in the section for the desired sensor to be calibrated, and using the keypad to input the value, then selecting the "Enter" key.



   i. To exit the SPOC Value screen without making changes, select the "Esc" key to return to the Single Point Calibration screen.

5. **Run Calibration for Sensor 1**
   a. Once the SPOC Value is input, select the "Start" button, in the section for the desired sensor to be calibrated, to begin the calibration process.
   b. The calibration process lasts approximately 10-seconds.
   c. During the calibration process:
      i. The "Start" button will display as "Running" and will turn green.
      ii. The General Status in the top center of the screen will indicate as "View Status."
      iii. If Hard Keys (-HK) are included, the "Calibration" indicator light will indicate in solid yellow.

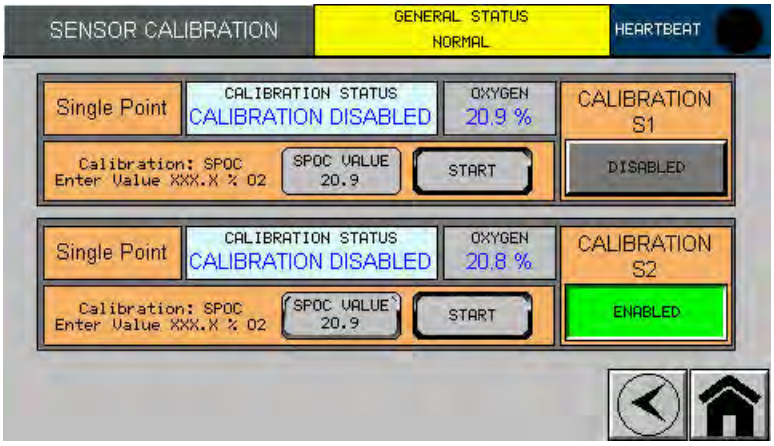


9. Calibration

6. **Calibration Complete for Sensor 1**
   After approximately ten seconds, upon successful calibration, the device will automatically disable Calibration Mode:
   a. The audible alarm will disengage.
   b. The “Calibration” button for the selected sensor will return to “Disabled” and turn gray.
   c. The General Status at the top center of the screen will return to “Normal.”
   d. If Hard Keys (-HK) are included, the "Calibration" indicator light will disengage.

7. If calibration is not successful, Calibration Mode will continue to be enabled, and the audible alarm will continue to be engaged. If this occurs, repeat Step “5. Run Calibration” until the calibration process completes successfully.

8. **Enable Calibration**
   a. To calibrate the next sensor, toggle the “Disabled” button in the “Calibration S2” section in the lower right side of the Sensor Calibration screen so that it now displays as “Enabled” and the button turns green.



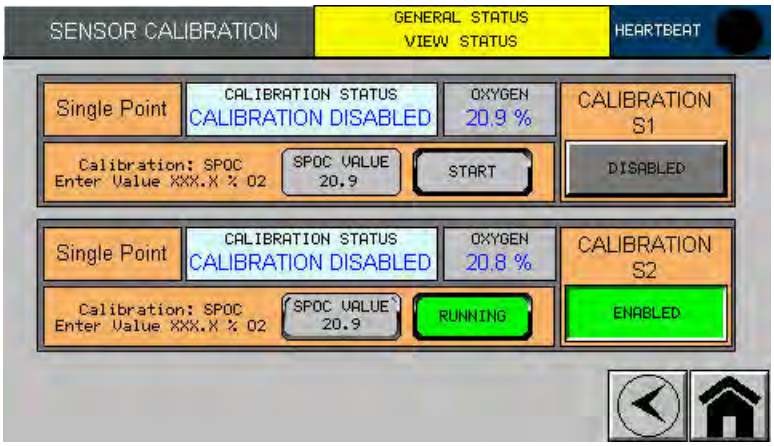
   i. Once enabled, the unit will engage an audible alarm. The audible alarm will remain engaged until the successful completion of the calibration.
   ii. If Hard Keys (-HK) are included, the "Calibrate" indicator light will begin to flash in yellow.

9. **Set the Single Point Offset Correction (SPOC) Value for Sensor 2**
   a. Once Calibration Mode is enabled, operators can modify the SPOC Value (if necessary) by selecting the “SPOC Value” field in the section for the desired sensor to be calibrated, and using the keypad to input the value, then selecting the “Enter" key.

   i. To exit the SPOC Value screen without making changes, select the “Esc” key to return to the Single Point Calibration screen.

9. Calibration

10. **Run Calibration for Sensor 2**
    a. Once the SPOC Value is input, select the “Start” button, in the section for the desired sensor to be calibrated, to begin the calibration process.
    b. The calibration process lasts approx imately 10-seconds.
    c. During the calibration process:
        i. The “Start” button will display as “Running” and will turn green.
        ii. The General Status in the top center of the screen will indicate as “View Status.”
        iii. If Hard Keys (-HK) are included, the "Calibration" indicator light will indicate in solid yellow.



11. **Calibration Complete for Sensor 2**
    After approximately ten seconds, upon successful calibration, the device will automatically disable Calibration Mode:
    a. The audible alarm will disengage.
    b. The “Calibration” button for the selected sensor will return to “Disabled” and turn gray.
    c. The General Status at the top center of the screen will return to “Normal.”
    d. If Hard Keys (-HK) are included, the "Calibration" indicator light will disengage

12. If calibration is not successful, Calibration Mode will continue to be enabled, and the audible alarm will continue to be engaged. If this occurs, repeat Step “10. Run Calibration” until the calibration process completes successfully.

13. After completing a calibration, operators can select the Home button to return to the Home screen, then select the “Acknowledge button” to acknowledge a successful calibration.

Caution

After initial installation, it is recommended to allow the sensor to stabilize for one hour before it is calibrated. Another calibration is recommended after one week of operation, then routine calibration is recommended every three months. Depending on operational requirements, this final routine interval can be extended to a maximum of six months.

9. Calibration

Caution

The device should be calibrated after losing power to ensure accurate oxygen measurement.

Caution

During the first week of operation, the oxygen measurement may drift slightly more than in the following weeks.

Caution

The device should be calibrated if subjected to a shock such as an impact or accidental knock to ensure accurate oxygen measurement.

Caution

The device should be calibrated if exposed to temperature swings of more than 18˚F (10˚C) to ensure accurate oxygen measurement.

Caution

The device should be calibrated if ambient temperature falls below 32˚F (0˚C) to ensure accurate oxygen measurement.

END OF SECTION

10. Routine Maintenance

1. **Cleaning the Device**
   a. When needed, the device can be cleaned by wiping the outer surfaces of the instrument with a damp (not wet) cloth to avoid allowing dust or other particles to enter the instrument's interior.

2. **Preventative Maintenance**
   a. To reduce the risk of unscheduled instrument downtime, ensure optimal performance, and maintain compliance with relevant regulatory requirements, we recommend regularly inspecting the device and testing its function.
   b. At minimum, a yearly inspection of alarms and faults should be conducted, to ensure the instrument continues to meet its original factory specifications.
   c. If any issues or concerns are detected, contact Factory for assistance.

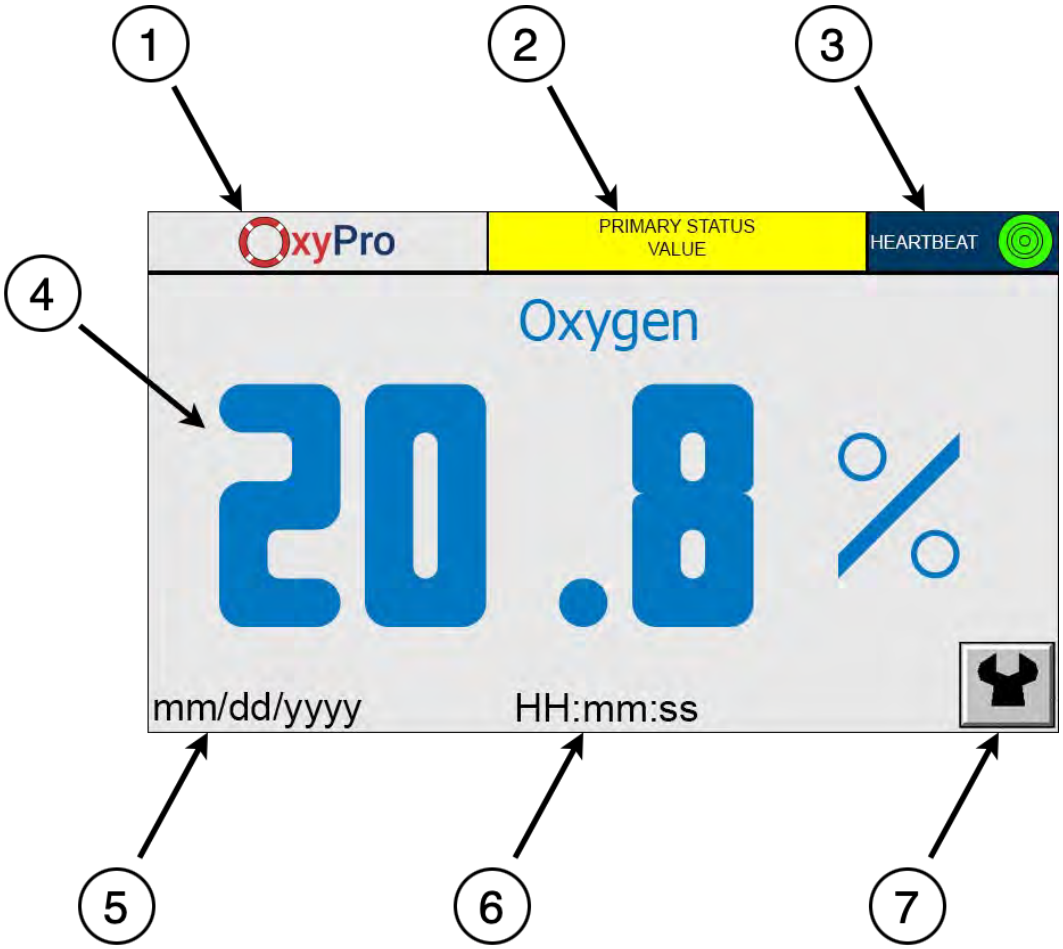
3. **Calibration**
   a. It is required to calibrate the device after initial start-up.
      i. It is recommended to wait 1-hour before calibrating the device initially so that sensor can fully stabilize.
   b. It is recommended to calibrate the device again after remaining in use for one week as drift can be higher during the first week of operation.
   c. It is recommended to begin a routine calibration procedure at regular intervals as determined appropriate by the operator.
      i. Routine calibration at 3-month intervals is appropriate.
      ii. Routine calibration should be performed, at minimum, once every 6-months.

   NOTE: See Section 9 for more information about Calibration Procedures.

END OF SECTION

11. Home Screen

Diagram



Key	Description
1	OxyPro Logo
2	Status
3	Heartbeat
4	Current Oxygen Concentration Value
5	Date
6	Time
7	Maintenance button / Main Menu

11. Home Screen

Home Screen Functions

The Home screen is the default screen for the OxyPro and displays current Current Oxygen Concentration Levels, Alarm Notifications, Date, Time, System Statuses, and provides access to Maintenance settings via Main Menu.

1. **OxyPro Logo**
   The **OxyPro Logo** is a non-functioning screen object.

2. **Status**

A. *Single Sensor Model*

The **Primary Status** is displayed in the top middle of the screen and indicates normal, alarm, and error statuses.

a. **Normal** is indicated when the unit is in proper working condition.
b. **Critical Malfunction** is indicated when a malfunction has occurred within the sensor and the unit needs to be returned to Factory for repair.
c. **Cal in Progress** is indicated when the unit is currently undergoing the calibration process.
d. **Comm Failure** is indicated when the oxygen sensor is having a communication error with the oxygen sensor and a Fault Alarm is engaged.
e. **Factory Reset** is indicated when the unit has recently undergone a reset back to all default settings.
f. **Calibration Required** is indicated when the oxygen sensor requires calibration.
g. **Low Latched Level O_2** is indicated when oxygen levels are critically low, below the Low Latched (Low Low) Alarm value and the Low Latched Alarm status is active.

Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX

h. Low O_2 Detected is indicated when oxygen levels are lower than the preset Low Alarm value and the Low Alarm status is active.

Percent Oxygen Version – Model: OxyPro-PO-XX-XX-XX-XX

h. High O_2 Detected is indicated when oxygen levels exceed the preset High Alarm value and the High O_2 Alarm status is active.

B. *Multi-Sensor Model*

The **General Status** is displayed in the top middle of the screen and indicates normal or alarm statuses.

a. **Normal** is indicated when the unit is in proper working condition.
b. **View Status** is indicated when there is in an active alarm status and the System Diagnostics screen needs to be opened to view all alarm statuses.

NOTE: *See Section 13 for more information about Alarm Statuses*.

11. Home Screen

3. **Heartbeat**
   The **Heartbeat** feature is displayed in the top right of the screen. It includes a color-indicating icon that identifies if the interface is properly communicating with the oxygen sensor.
   a. A blinking green icon indicates that the interface is properly communicating with the oxygen sensor.
   b. A solid red icon indicates a Fault Alarm - that the unit is not properly communicating with the oxygen sensor and troubleshooting is required.

NOTE: *See Section 13.1.A.b. (for Single Sensor model) or 13.1.B.c. (for Multi-Sensor model) for more information about Fault Alarms*.

4. **Current Oxygen Concentration Value**

A. **Single Sensor Model**
   If your OxyPro includes the Single Sensor option, the **Current Oxygen Concentration Value** is displayed in the center of the Home Screen in large numeric values under the label “Oxygen.”
   a. Oxygen values in solid blue indicates that no alarm status is active.
   b. When Oxygen values are blinking (rather than remaining a solid blue), an alarm status is active, and action is required.

NOTE: *See Sections 13.1.A.c. and 13.1.A.d. for more information about Alarm Statuses for Oxygen Concentration Values for Single Sensor models.*

B. **Multi-Sensor Model**
   If your OxyPro includes the optional Multi-Sensor functionality, the **Current Oxygen Concentration Values** for Sensor will be displayed in a large numeric value in the center of the Home Screen under the label “Oxygen Main.” The oxygen concentration values for Sensor will be displayed in a smaller numeric value in the bottom right side of the Home Screen, under the label “Oxygen Remote Unit.”
   a. Oxygen values in solid blue indicates that no alarm status is active.
   b. When Oxygen values are blinking (rather than remaining a solid blue), an alarm status is active, and action is required.

NOTE: *See Sections 13.1.B.d. and 13.1.B.e. for more information about Alarm Statuses for Oxygen Concentration Values for Multi-Sensor models.*

5. **Date**
   The **Date** is displayed in the lower left corner of the screen and can be programmed from the “Main Menu.”

NOTE: *See Section 12.4.c. for more information about programming the Date*.

11. Home Screen

6. **Time**
   The **Time** is displayed in the lower middle of the screen and can be programmed from the "Main Menu."

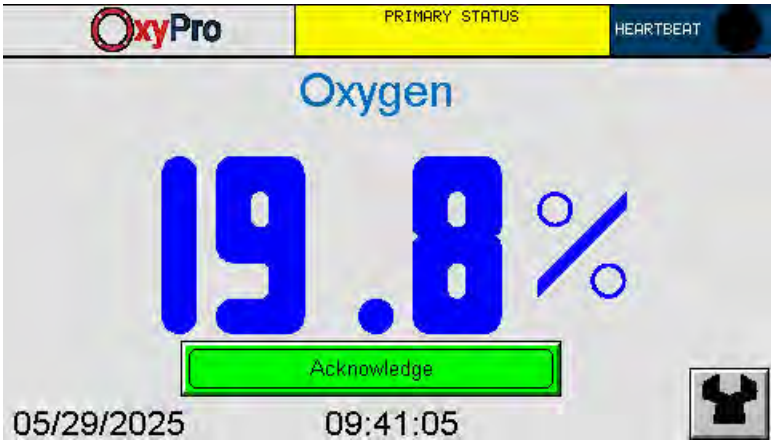
NOTE: *See Section 12.4.b. for more information about programming the Time*.

7. **Maintenance Button / Main Menu**
   The **Maintenance button** is displayed in the lower right corner of the screen and is used to access the "Main Menu."

NOTE: *See Section 12 for more information about the Main Menu*.

8. **Acknowledge Button**
   The **Acknowledge button** will pop-up when an alarm is active is used to disable the alarm function once any alarm status has been activated.

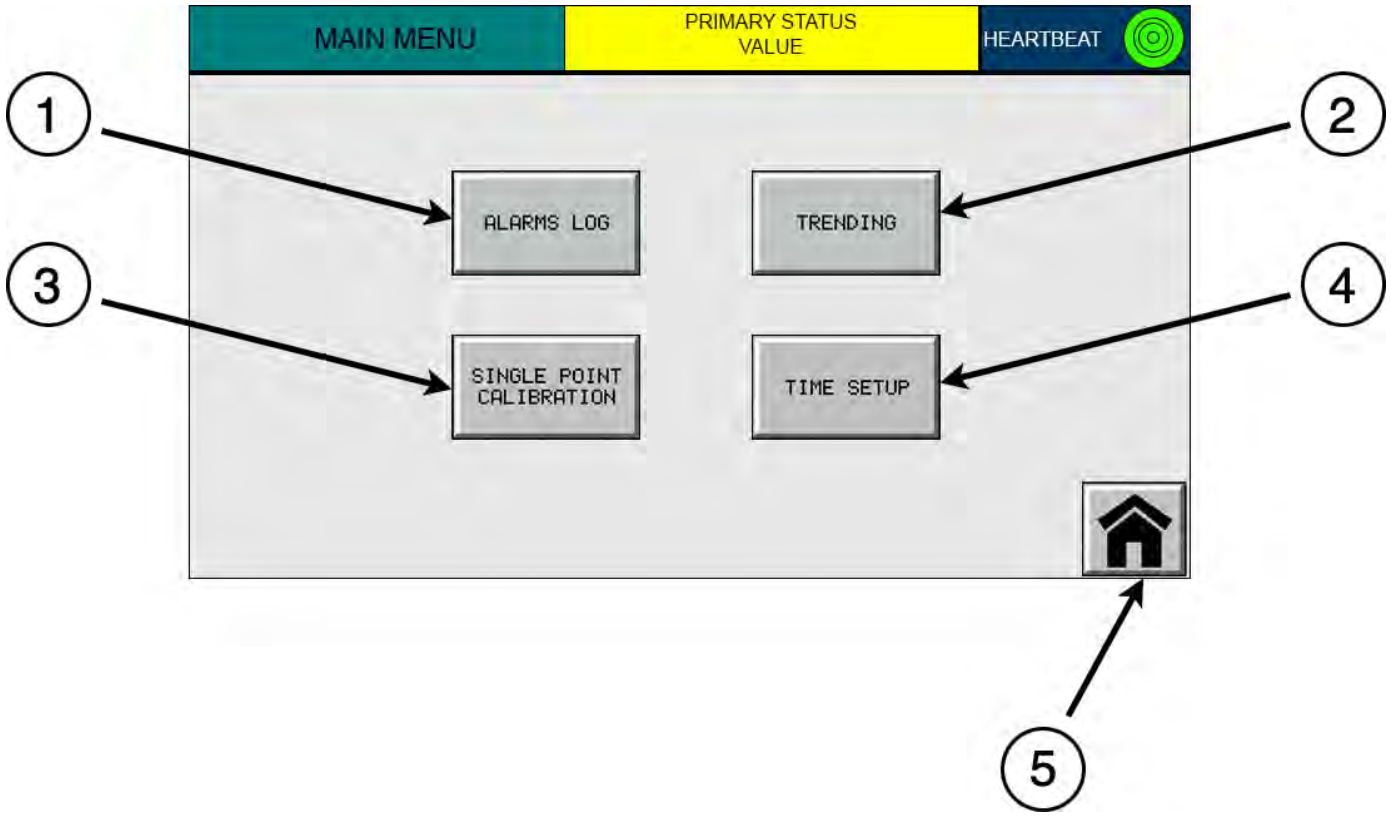
NOTE: *See Section 13.2 for more information about the Acknowledge button*.



END OF SECTION

12. Main Menu

Diagram



Key	Description
1	Alarms Log
2	Trending Oxygen Concentration Values
3	Single Point Calibration
4	Time and Date Setup
5	Home button / Home screen

12. Main Menu

Accessing the Main Menu Screen

To access the Main Menu screen, select the “Maintenance” button in the bottom right corner of the home screen.

a. From the Main Menu, operators can navigate to the Alarms Log screen, Trending values screen, Single Point Calibration screen, and the Time and Date Setup feature.
b. Upon entering a Menu screen, operators can return to the Main Menu by selecting the “left facing arrow” button  or, operators can select Home button to return to the Home screen.
c. Both buttons are located at the bottom right corner of the display.

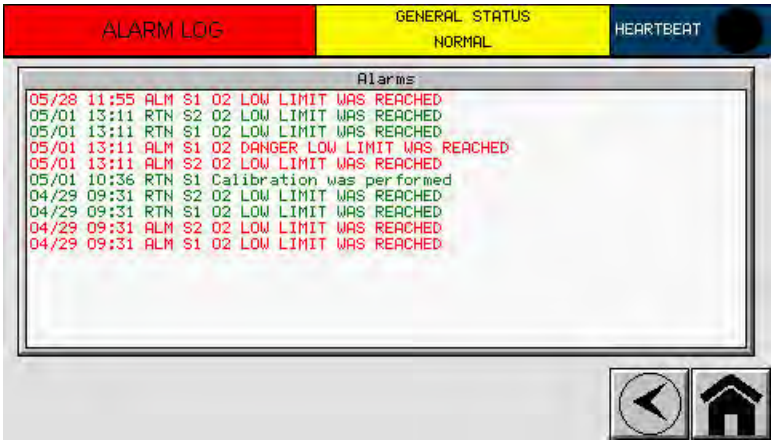
Main Menu Functions

The Main Menu screen allows operators to view the Alarms Log and Oxygen Concentration Trends, perform Single Point Calibrations, and modify the Date and Time.

1. **Alarms Log**

The **Alarms Log** can be accessed by selecting the “Alarms Log” menu option in the top left of the Main Menu screen.

a. The Alarms Log will display a history of the alarms that have been triggered, including the date and time of the alarm, whether the alarm status was activated “ALM” (red text) or deactivated “RTN” (green text), the sensor that had an alarm status, and the alarm type.



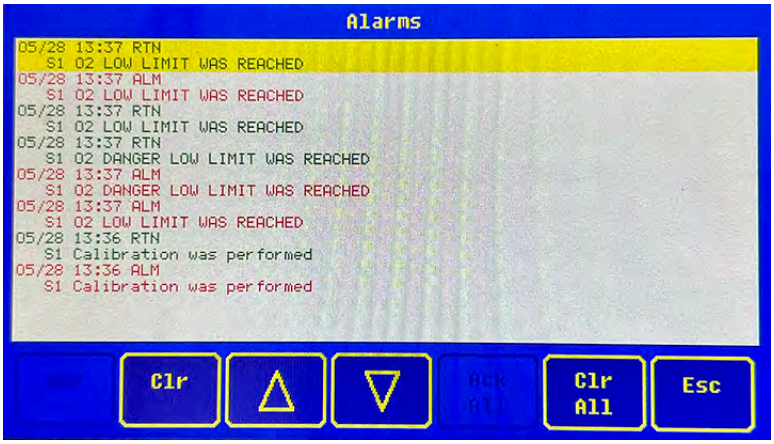
A. *Single Sensor Model*
   i. For Single Sensor models, all alarm logs will be labeled with “S1” to indicate Sensor 1.

B. *Multi-Sensor Model*
   i. For units that include an optional Multi-Sensor functionality, all alarm logs will be labeled with either “S1” for Sensor 1 or they will be labeled with “S2” for Sensor 2.

12. Main Menu

b. **Advanced Alarms Log**

The **Advanced Alarms Log** screen can be entered by selecting any item on the Alarms Log list.



i. In the Advanced Alarms Log screen, individual alarm logs can be accessed by selecting the desired alarm log item on the screen or by using the “up” or “down” arrow keys located along the bottom of the screen.

ii. Once an alarm log is selected, it can be removed by selecting the “Clr” button, or all alarm logs can be removed at one time by selecting the “Clr All” button.

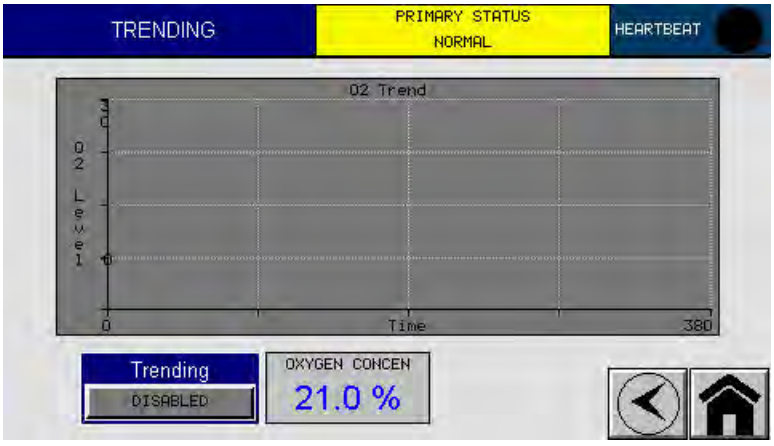
iii. Operators can return to the Alarms Log screen by selecting the “Esc” button in the bottom right corner of the Advanced Alarms Log screen.

iv. **Alarms Logs** and their corresponding Statuses [and recommended action] are as follows:

- **Sensor Fatal Fault** = Critical Malfunction [contact Factory]
- **Comm Failure Fault Alarm** = Fault Alarm [check connections then contact Factory]
- **Sensor is Working Outside of Spec** = Sensor Error [perform a calibration]
- **Sensor Requested Calibration** = Calibration Required [perform a calibration]
- **Calibration was Performed** = N/A [a calibration was performed]
- **O2 Danger Low Limit was Reached** = Low Latched Alarm
- **O2 Low Limit was Reached** = Low Alarm (*Life Safety – Model: OxyPro-LS-XX-XX-XX-XX*)
- **O2 High Limit was Reached** = High Alarm (*Percent O2 – Model: OxyPro-PO-XX-XX-XX-XX*)

2. **Trending Oxygen Values**

The Trending screen can be accessed by selecting the “Trending” menu option in the top right of the Main Menu screen.



a. The Trending function must be enabled manually and is <u>not</u> enabled by default upon initial start-up.

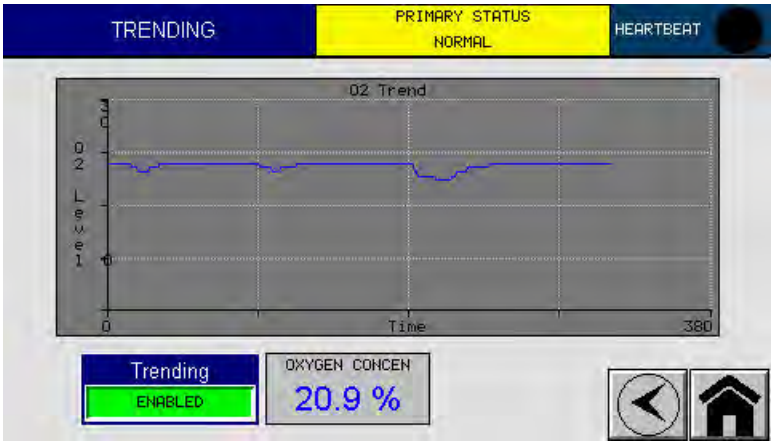
b. To enable the Trending function, toggle the “Trending” button in the lower left corner of the screen from “Disabled” to “Enabled.”

i. When the Trending button displays with a gray “Disabled” button, trending is disabled.

ii. When the Trending button displays with a green “Enabled” button, trending is enabled.

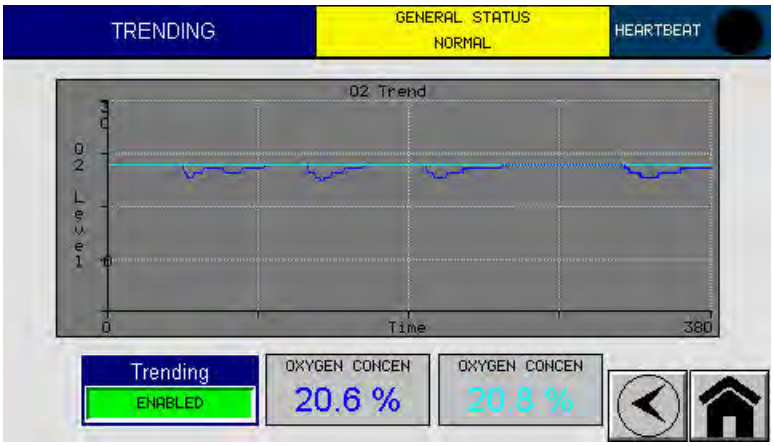
12. Main Menu

2. **Trending Oxygen Values** (*continued*)
   c. When enabled, the Trending screen allows operators to view oxygen concentration trends for the past six minutes as well as the current oxygen concentration value.
      i. Trends are <u>not</u> datalogged unless the Trending option is "Enabled", so the Trending chart will only show trends from the point of being enabled forward.



A. *Single Sensor Model*
   d. For Single Sensor models, only one trend line will appear on the chart.

B. *Multi-Sensor Model*
   d. For units that include optional Multi-Sensor functionality, current values for Sensor 1 will be visible in the left “Oxygen Concentration” box with matching dark blue trend line on the chart.
   e. Current values for Sensor will be visible in the right “Oxygen Concentration” box with matching light blue trend line on the chart.
   f. When only one line is visible, this means that the oxygen values of both sensors were equal and over lap on the chart.

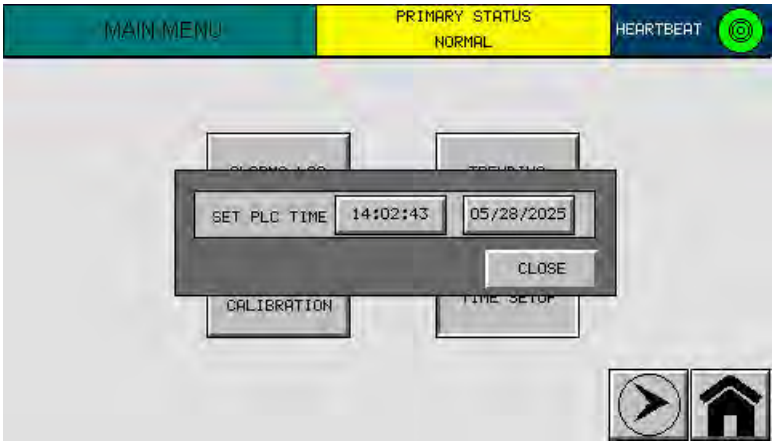


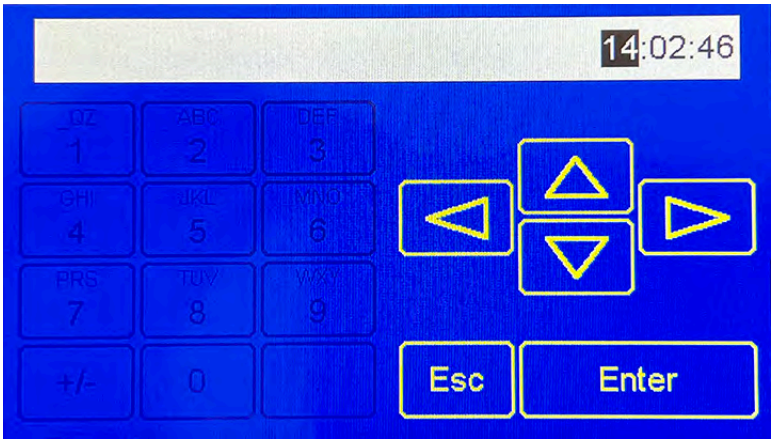
3. **Single Point Calibration**
   The Single Point Calibration screen can be accessed by selecting the “Single Point Calibration” menu option in the bottom left of the Main Menu screen.
   a. The Single Point Calibration screen allows operators to enter Calibration Mode and set a calibration to calibrate the oxygen sensor(s).

NOTE: *See Section 9 for more information about Single Point Calibration functions and procedures.*

12. Main Menu

4. **Time and Date Setup**
   The **Time and Date Setup** options can be accessed by selecting the “Time Setup” menu option at the bottom right of the Main Menu screen.

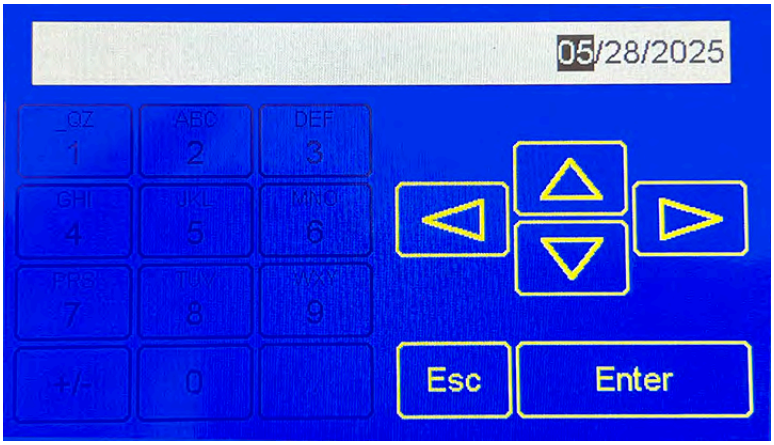




   a. The Time and Date Setup screen allows operators to modify the time and date displayed on the Home screen.
   b. To modify the **Time**, select the time input field on the left side of the Time and Date Setup screen.
      i. Operators can modify the time using the up/down arrows keys on the keypad to adjust the time value in a 24-hour time scale (military time) HH:MM:SS format.
      NOTE: *There is a number pad on the left side of the screen, but it does not function*.
      ii. To toggle between modifying hours, minutes, or seconds, use the left/right arrow keys on the keypad.
      iii. When finished, select the “Enter” button to input the new values and return to the Time and Date Setup screen.
      iv. To exit without modifying the time, select the “Esc” button.
      v. Upon returning to the Time and Date Setup screen, select the “Close” button to return to the Main Menu.

12. Main Menu

4. **Time and Date Setup** (*continued*)
   c. To modify the **Date**, select the date input field on the right side of the Time and Date Setup screen.
      i. Operators can modify the date using the up/down arrows keys on the keypad to adjust the value in a MM/DD/YYYY format.
      NOTE: *There is a number pad on the left side of the screen, but it does not function*.
      ii. To toggle between modifying the month, day, or year, use the left/right arrow keys on the keypad.



      iii. When finished, select the “Enter” button to input the new values and return to the Time and Date Setup screen.
      iv. To exit the keypad without modifying the date, select the “Esc” button.
      v. Upon returning to the Time and Date Setup screen, select the “Close” button to return to the Main Menu.

END OF SECTION

13. Alarms and Indicators

Key	Description
1A	Alarms - Single Sensor model
1B	Alarms - Multi-Sensor model
2	Acknowledge button
3	Remote Sensor option – *Model: OxyPro-XX-XX-RE-XX-XX*
4	Stack Light option – *Model: OxyPro-XX-XX-XX-XX-SL*
5	Hard Keys and LEDs option – *Model: OxyPro-XX-XX-XX-XX-HK*

Alarms and Indicators Functions

The OxyPro includes one fault alarm and two oxygen alarms along with a variety of on-screen or optional external alarms, hard keys, and LEDs.

1. **Alarms**

A. **Single Sensor Model**

a. **Normal**

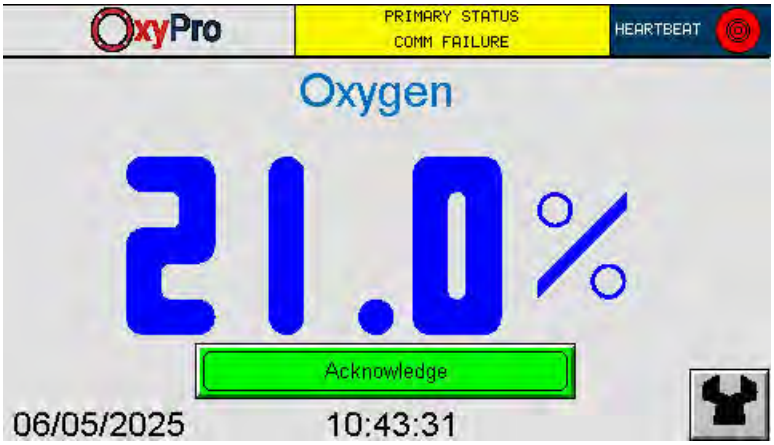
A **Normal Status** indicates that the device is working properly and there are no active alarm statuses.

i. This is indicated in the “Primary Status” section on the Home screen as “Normal.”

ii. When engaged in a Normal Status, the unit will display the Oxygen Concentration Value in solid blue and will not have any audible alarms engaged.

b. **Fault Alarm**

A **Fault Alarm** indicates that there is an error with the sensor and trouble-shooting is required. As the device is <u>not</u> working properly in a Fault Alarm status, operators should take caution and follow internal safety protocol for this alarm status. In the event of a Fault, the last measured oxygen concentration value will continue to be displayed on the Home screen.

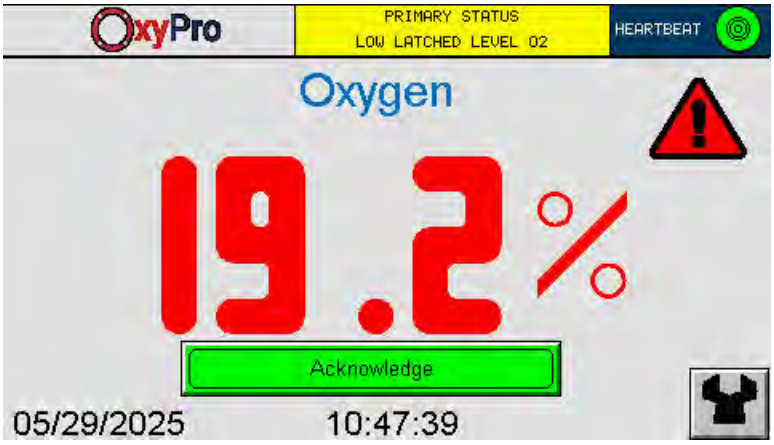


13. Alarms and Indicators

b. **Fault Alarm** (*continued*)
   i. A **Fault Alarm** is indicated with an audible alarm and with an alternately blinking empty and blue Oxygen Concentration Value.
   ii. In addition, the “Primary Status” section in the top center of the Home screen will indicate as a “Comm Failure” and the “Heartbeat” icon will indicate in solid red.
   iii. Troubleshooting is required. A Fault Alarm indicates that there is a communication issue between the oxygen sensor and the control unit. Ensure all connections are properly in place and contact technical support for guidance to resolve the issue.

c. **Low Latched Alarm** (*Default Alarm Value = 19.5% O2*)

A **Low Latched (Low Low) Alarm** indicates that oxygen levels have dropped critically low and internal safety protocol should be followed immediately.

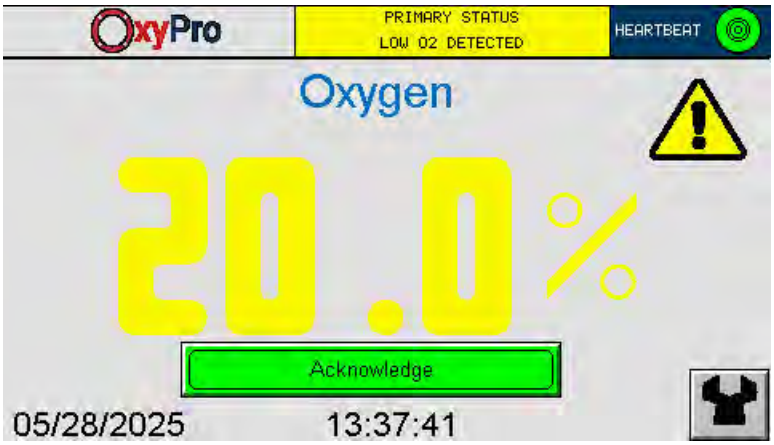


   i. A Low Latched Alarm is indicated with an audible alarm and with an alternately blinking red and blue Oxygen Concentration Value along with a red blinking warning symbol on the Home screen.
   ii. In addition, a Low Latched Alarm is indicated in the “Primary Status” section at the top of the Home screen as “Low Latched Level O2."

Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX

d. **Low Alarm** (*Default Alarm Value = 20.0% O2*)

A **Low Alarm** indicates that oxygen concentration has dropped below normal levels and caution should be taken while following internal safety protocol.



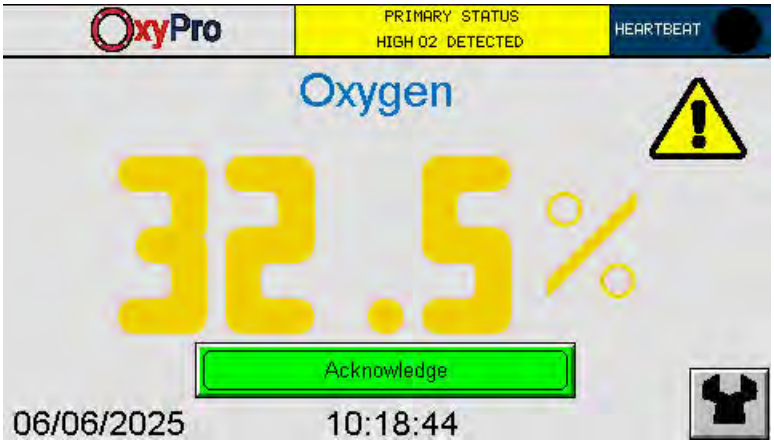
   i. A Low Alarm is indicated with an audible alarm and with an alternately blinking yellow and blue Oxygen Concentration Value along with a blinking yellow warning symbol on the Home screen.
   ii. In addition, a Low Alarm is indicated in the “Primary Status” section at the top of the Home Screen as “Low O2 Detected."

13. Alarms and Indicators

Percent Oxygen Version – Model: OxyPro-PO-XX-XX-XX-XX

d. **High Alarm** (*Default Alarm Value = 23.5% O2*)

A High Alarm indicates that oxygen concentration has risen above normal levels and caution should be taken while following internal safety protocol.



i. A High Alarm is indicated with an audible alarm and with an alternately blinking yellow and blue Oxygen Concentration Value along with a blinking yellow warning symbol on the Home screen.

ii. In addition, a High Alarm is indicated in the "Primary Status" section at the top of the Home Screen as "High O2 Detected."

B. **Multi-Sensor Model**

a. **Normal**

A **Normal Status** indicates that the device is working properly and there are no active alarm statuses.

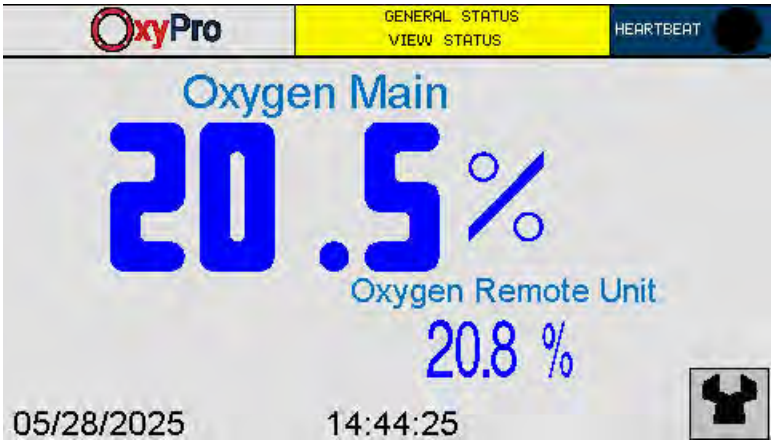
i. This is indicated in the "General Status" section on the Home screen as "Normal."

ii. When engaged in a Normal Status, the unit will display oxygen concentration values in solid blue and will not have any audible alarms engaged.

b. **View Status**

An engaged alarm status is indicated in the "General Status" section in the top center of the Home screen as "View Status." Operators can select the "View Status" option to open the Sensor Status screen to view all alarm statuses on each sensor to determine which alarms are engaged.

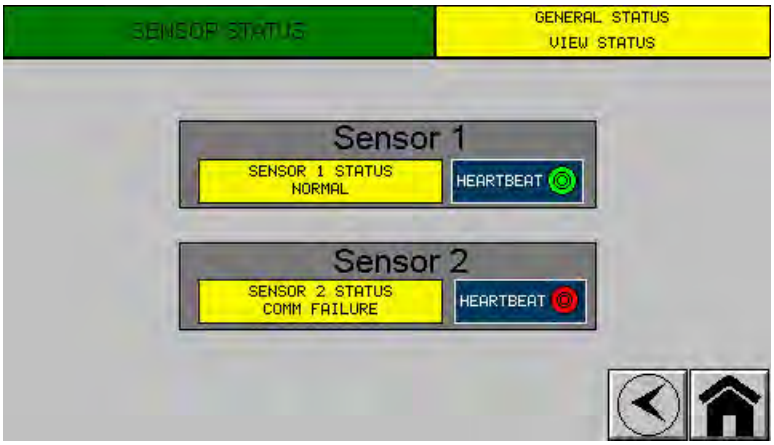
NOTE: Any engaged alarm status will take priority over a Normal status to alert the operator that one of the sensors is engaged in an alarm.



13. Alarms and Indicators

c. **Fault Alarm**

A **Fault Alarm** indicates that there is an error with the sensor and troubleshooting is required. As the device is <u>not</u> working properly in a Fault Alarm status, operators should take caution and follow internal safety protocol for this alarm status. In the event of a Fault, the last measured oxygen concentration value will continue to be displayed on the Home screen.



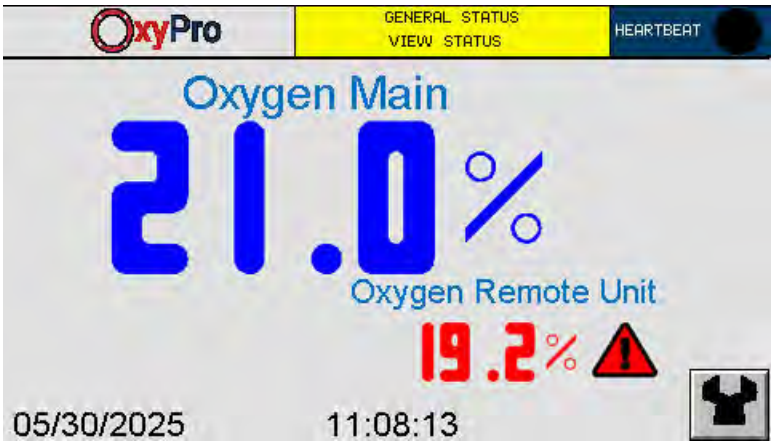
i. A Fault Alarm is indicated with an audible alarm and with an alternately blinking empty and blue Oxygen Concentration Value.

ii. In addition, the “General Status” section in the top center of the Home screen will indicate as “View Status” and the “Heartbeat” icon will indicate in solid red. Operators will need to select the “View Status” option to open the Sensor Status screen to determine which sensor is engaged in a Fault Alarm – indicated with the message “Comm Failure."

iii. During a Fault Alarm, troubleshooting is required. A Fault Alarm indicates that there is a communication issue between the oxygen sensor and the control unit. Ensure all connections are properly in place and contact technical support for guidance to resolve the issue.

d. **Low Latched Alarm** (*Default Alarm Value = 19.5% O_2*)

A **Low Latched (Low Low) Alarm** indicates that oxygen levels have dropped critically low and internal safety protocol should be followed immediately.



i. A Low Latched Alarm is indicated with an audible alarm and with an alternately blinking red and blue Oxygen Concentration Value along with a red blinking warning symbol for the corresponding sensor that is engaged in a Low Latched Alarm.

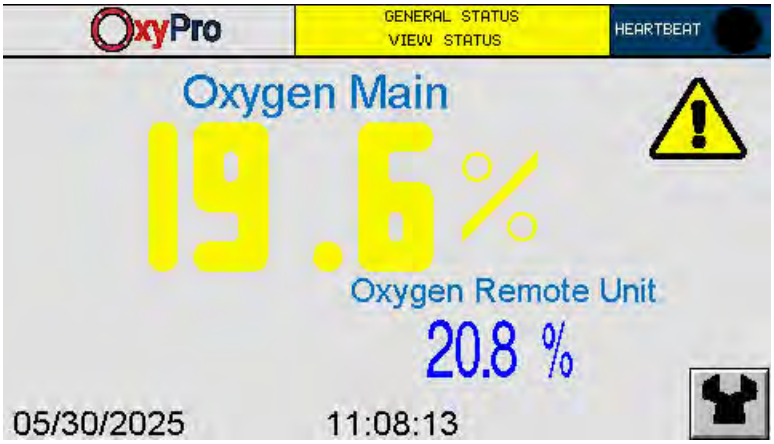
ii. In addition, “View Status” will be indicated in the “General Status” section on the Home screen. Operators will need to select the “View Status” option to open the Sensor Status screen to determine which sensor is engaged in a Low Latched Alarm – indicated with the message “Low Latched Level O_2."

13. Alarms and Indicators

Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX

e. **Low Alarm** (*Default Alarm Value = 20.0% O_2*)

A **Low Alarm** indicates that oxygen concentration has dropped below normal levels and caution should be taken while following internal safety protocol.



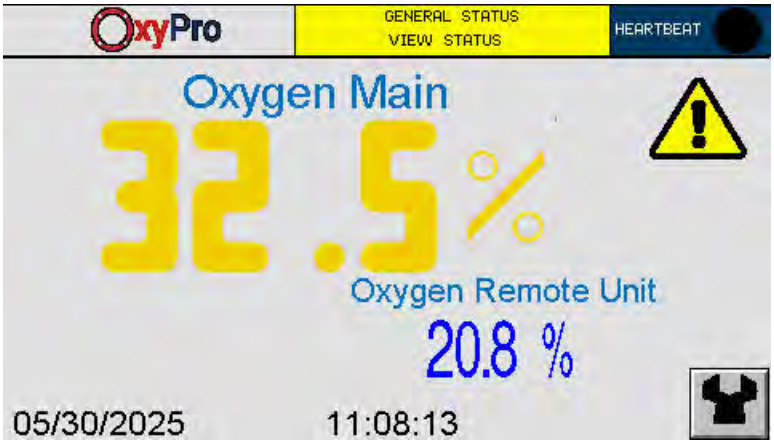
i. A Low Alarm is indicated with an audible alarm and with an alternately blinking yellow and blue Oxygen Concentration Value along with a yellow blinking warning symbol for the corresponding sensor that is engaged in a Low Alarm.

ii. In addition, "View Status" will be indicated in the "General Status" section on the Home screen. Operators will need to select the "View Status" option to open the Sensor Status screen to determine which Sensor is engaged in a Low Alarm – indicated with the message "Low O_2 Detected."

Percent Oxygen Version – Model: OxyPro-PO-XX-XX-XX-XX

e. **High Alarm** (*Default Alarm Value = 23.5% O_2*)

A **High Alarm** indicates that oxygen concentration has risen above normal levels and caution should be taken while following internal safety protocol.



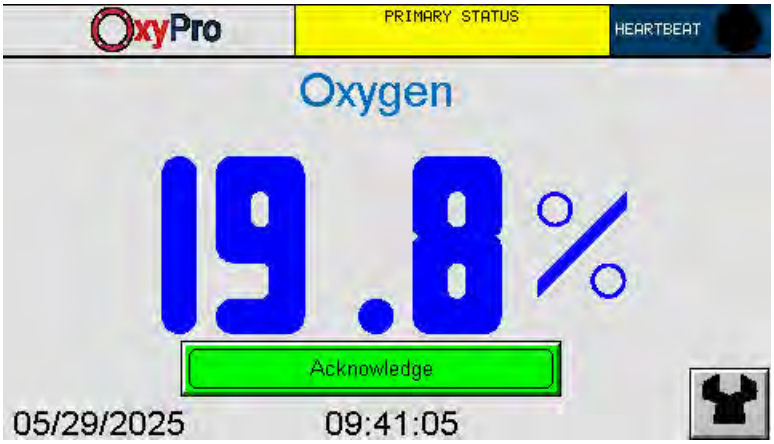
i. A High Alarm is indicated with an audible alarm and with an alternately blinking yellow and blue Oxygen Concentration Value along with a yellow blinking warning symbol on the Home screen for the corresponding Sensor that is engaged in a High Alarm.

ii. In addition, "View Status" will be indicated in the "General Status" section on the Home screen. Operators will need to select the "View Status" option to open the Sensor Status screen to determine which Sensor is engaged in a High Alarm – indicated with the message "High O_2 Detected."

NOTE: For custom Alarm Values, contact Factory for additional information.

13. Alarms and Indicators

2. **Acknowledge Button**



The **Acknowledge button** is an on-screen button that appears once an alarm has engaged and is used to clear Alarm Notifications from the unit.

a. **Fault Alarm**
During a **Fault Alarm**, the Acknowledge button will appear.
   i. Operators can select the Acknowledge button before the fault is resolved to silence the audible alarm for 30-seconds – this does <u>not</u> disengage the blinking blue Oxygen Concentration Value or alarm lights (if included).
   ii. After 30-seconds, the audible alarm will re-engage and operators would need to select the Acknowledge button again to silence the alarm for an additional 30 seconds.
   iii. Once the Fault Alarm is resolved, all alarm notifications will disengage automatically, but operators must select the Acknowledge button (even if it's already been selected to silence the audible alarm) to clear the Home screen of the Acknowledge button.

b. **Calibration**
After a **Calibration**, the Acknowledge button will appear.
   i. During a Calibration, the audible alarm will engage.
   ii. Once a Calibration has completed successfully, the audible alarm will disengage, but operators must select the Acknowledge button to clear the Home screen of the Acknowledge button.

c. **Low Latched Alarm**
During a **Low Latched Alarm**, the Acknowledge button will appear.
   i. Operators can select the Acknowledge button before the Low Latched Alarm is resolved to silence the audible alarm for 30-seconds – this does <u>not</u> disengage the alternately blinking red and blue Oxygen Concentration Value, red warning symbol, or alarm lights (if included).
   ii. After 30-seconds, the audible alarm will re-engage and operators would need to select the Acknowledge button again to silence the alarm for an additional 30 seconds.
   iii. Once the Low Latched Alarm is resolved, all alarm notifications will disengage automatically, but operators must select the Acknowledge button (even if it's already been selected to silence the audible alarm) to clear the Home screen of the Acknowledge button.

13. Alarms and Indicators

Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX

d. **Low Alarm**
During a **Low Alarm**, the Acknowledge button will appear.
   i. Operators can select the Acknowledge button before the Low Alarm is resolved to silence the audible alarm for 30-seconds – this does not disengage the alternately blinking yellow and blue Oxygen Concentration Value, yellow warning symbol, or alarm lights (if included).
   ii. After 30-seconds, the audible alarm will re-engage and operators would need to select the Acknowledge button again to silence the alarm for an additional 30 seconds.
   iii. Once the Low Alarm is resolved, all alarm notifications will disengage automatically, but operators must select the Acknowledge button (even if it's already been selected to silence the audible alarm) to clear the Home screen of the Acknowledge button.

Percent Oxygen Version – Model: OxyPro-PO-XX-XX-XX-XX

d. **High Alarm**
During a **High Alarm**, the Acknowledge button will appear.
   i. Operators can select the Acknowledge button before the High Alarm is resolved to silence the audible alarm for 30-seconds – this does not disengage the alternately blinking yellow and blue Oxygen Concentration Value, yellow warning symbol, or alarm lights (if included).
   ii. After 30-seconds, the audible alarm will re-engage and operators would need to select the Acknowledge button again to silence the alarm for an additional 30 seconds.
   iii. Once the High Alarm is resolved, all alarm notifications will disengage automatically, but operators must select the Acknowledge button (even if it's already been selected to silence the audible alarm) to clear the Home screen of the Acknowledge button.

NOTE: *See Section 13.5.d. for information about the External Acknowledge button*.

3. **Remote Sensor Option** – *Model: OxyPro-XX-XX-RE-XX-XX*
Remote Sensor Units feature a Status LED.

   a. **Status LED**
      i. The **Status LED** will continuously emit a solid light to indicate that the Remote Sensor is properly functioning and communicating with the Control Unit.

   b. **No Tubes or Pumps Required**
      i. Unlike other oxygen monitoring devices, the Remote Sensor for the OxyPro measures oxygen concentration in situ then sends the signal to the Control Unit via M12 cable. There are no tubes or pumps required.

13. Alarms and Indicators

4. **Stack Light Option** – *Model: OxyPro-XX-XX-XX-XX-SL*

If the optional Stack Light is included, the function of the on-screen Current Oxygen Concentration Value and on-screen Alarm Status notifications remain unchanged, but additional lights and an external audible alarm will be utilized to notify of operating conditions as follows:

a. **Normal**
   i. In addition to the standard on-screen status notifications, the Stack Light will also emit a solid green light to indicate that the unit is engaged in a Normal Status.

b. **Calibration Mode**
   i. In addition to the standard on-screen status notifications, the Stack Light will also emit a solid yellow light, a flashing red light, and an alarm to indicate that the unit is in Calibration Mode. Once a calibration has been successfully completed, the flashing red light, solid yellow light, and audible alarm will disengage.

c. **Fault Alarm**
   i. In addition to the standard on-screen status notifications, the Stack Light will also emit a flashing red light and an audible alarm to indicate that the unit is engaged in a Fault Alarm Status.

d. **Low Latched Alarm**
   i. In addition to the standard on-screen status notifications, the Stack Light will also emit a flashing red light and an audible alarm to indicate that the unit is engaged in a Low Latched Alarm Status.

Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX

e. **Low Alarm**
   i. In addition to the standard on-screen status notifications, the Stack Light will also emit a flashing red light and an audible alarm to indicate that the unit is engaged in a Low Alarm Status.

Percent Oxygen Version – Model: OxyPro-PO-XX-XX-XX-XX

e. **High Alarm**
   i. In addition to the standard on-screen status notifications, the Stack Light will also emit flashing red light and an audible alarm to indicate that the unit is engaged in a High Alarm Status.

13. Alarms and Indicators

5. **Hard Keys and LEDs Option** – *Model: OxyPro-XX-XX-XX-XX-HK*
   a. **O2 Low (1)**
   O2 Low is an optional blue LED light located on the front of the unit.
      i. In a **Low Latched Alarm** status, the O2 Low LED will emit a solid blue light. Once the Current Oxygen Concentration Value returns to normal levels, the O2 Low LED will automatically disengage.

Life Safety Version – Model: OxyPro-LS-XX-XX-XX-XX
      ii. In a **Low Alarm** status, the O2 Low LED will emit a flashing blue light. Once the Current Oxygen Concentration Value returns to normal levels, the O2 Low LED will automatically disengage.

Percent O2 Version – Model: OxyPro-PO-XX-XX-XX-XX
      ii. In a **High Alarm** status, the O2 LED will emit a blinking blue light until the alarm status resolves. Once the Current Oxygen Concentration Value returns to normal levels, the O2 Low LED will automatically disengage.
      NOTE: On Percent Oxygen Versions, the label will appear as “O2”, instead of “O2 Low."

   b. **Fault (2)**
   Fault is an optional red LED light located on the front of the unit.
      i. In a Fault Alarm status, the Fault LED will emit a solid red light until the alarm status resolves. Once the Fault Alarm is resolved, the Fault LED will automatically disengage.

   c. **Calibrate (3)**
   Calibrate is an optional yellow LED light located on the front of the unit.
      i. While in Calibration Mode, the Calibrate LED will emit a solid yellow light. Once a Calibration has been successfully completed, the yellow LED will automatically disengage.

   d. **Acknowledge Button (4)**
   In addition to the standard on-screen **Acknowledge button** (software release version 25.06.05 or later), an optional physical Acknowledge button may be included.
      i. The physical Acknowledge button functions in the same manner as the on-screen button.
      NOTE: See Section 13.2 for more information about the Acknowledge button.

13. Alarms and Indicators

WARNING

IT IS HIGHLY RECOMMENDED THAT MONITORING SYSTEMS EMPLOY LATCHING ALARMS THAT REQUIRE MANUALLY RESET AND ACKNOWLEDGEMENT ONLY AFTER THE HAZARD HAS BEEN DETECTED, EVALUATED, AND RESOLVED.

END OF SECTION

14. Storage and Disposal

1. **Storage**
   a. Replace any protective covering or wrapping that arrived with the unit.
   b. Place the device and any other components in the original packaging to ensure safe storage.
   c. If original packaging is not available, seal the OxyPro in an air-tight, anti-static bag and place it into a well-fitted, padded storage container or box.
   d. Keep the device stored in a UV and temperature-controlled environment.
   e. If stored properly, the OxyPro may be stored indefinitely without requiring replacement of the sensor upon restarting the unit.
   f. After long-term storage, follow start-up procedure (See Section 8) to continue use.

2. **Disposal**
   a. When disposing of the device and other components, contact local, state, and federal safety and environmental agencies to ensure safe and legal disposal.
   b. If in the EU, this device may be subject to disposal in accordance to the Waste Electrical and Electronic Equipment (WEEE) Directive.
   c. It is recommended to contact your local electronic waste recycling agency for assistance and guidance for proper disposal.

Note

This device is not suitable for disposal in municipal waste streams such as waste management and landfill sites.

Note

Certain components such as Battery Backup (-BB), if included, may require special disposal due to its fuel cell.

Note

If desired, an Return Material Authorization (RMA) may be granted to return the unit to the Factory for proper disposal.

END OF SECTION

15. Repairs and Warranty

1. **Product Failure During Warranty**
   Process Solutions Corp. provides a 5-year manufacturer warranty and will repair or replace free of charge any OxyPro that fails whilst under warranty, providing the root cause of failure is due to faulty materials, design, or manufacture. Failures due to misuse will not be considered for replacement under warranty. Examples of failures resulting from misuse include, but are not limited to, failures due to excessive flow or pressure, failures due to contamination or condensate in the oxygen sensor or enclosure, or improper operating and/or storage conditions. Under these conditions, Process Solutions Corp. reserves the right to charge for replacement or repair at its sole discretion.

2. **Product Failure Out of Warranty**
   Process Solutions Corp. will always examine OxyPro returns on request to determine the root cause for a reported product failure, but accepts no obligation to replace or repair the unit under the terms of the warranty.

3. **Maintenance and Servicing**
   Maintenance and servicing of the OxyPro is available by submitting a Return Material Authorization (RMA) to Process Solutions Corp. and returning the unit for diagnostics. A fee will be applied for diagnostics services. A quote will be provided if maintenance or repair is required, which will include a credit for the diagnostics fee if the end-user agrees for services to be performed.

   The Paracube Modus oxygen sensor has been designed such that the gas port may be cleaned using "Steriwipes," or similar, as part of a regular maintenance schedule. Ensure filter assembly is in place prior to wiping.
   NOTE: It is important that only general purpose alcohol based cleaning agents be applied to the external surfaces of the Paracube Modus oxygen sensor.

WARNING

DO NOT PERFORM REPAIRS OR MAINTENANCE BEYOND WHAT IS INDICATED IN THIS USER MANUAL. DOING SO MAY VOID ALL WARRANTY AND MAY CAUSE DAMAGE TO THE DEVICE.

Note

It is the responsibility of the user to read all instructions in this manual and to ensure constant maintenance of operating conditions within the limitations of this warranty.

15. Repairs and Warranty

Note

Users must only use the device within approved operating conditions and limitations as described in this manual.

Note

"Misuse" means using the device in a manner other than as described in this manual or under operating conditions which differ from those described herein.

END OF SECTION

A1. Certifications

1. **ISO 9001:2015 Certificate (Process Solutions Corp.)**
   Certificate of Registration for ISO 9001:2015 standards for Process Solutions Corp.

2. **RoHSII Directive 2011/65/EU Declaration (Paracube Modus sensor only)**
   Certificate of Declaration for RoHS II (2011/65/EU) for Servomex-Hummingbird (manufacturer of the Paracube Modus oxygen sensor).

A1.1. ISO 9001:2015 Certificate (Process Solutions Corp.)

QAS International

Certificate of Registration

Process Solutions Corp.

4134 Bluebonnet Drive, Suite 111, Stafford, TX 77477, USA

have been assessed and approved to:

ISO 9001:2015

Quality Management System

The approved management system applies to the following scope:

A representative and distributor for automation and control for the oil, gas, water and wastewater markets in Texas.

Original Approval:	15th April 2014
Current Certificate:	30th August 2025
Certificate Expiry:	30th August 2026
Certificate Number:	US3736

Signed: Certification Officer

QAS INTERNATIONAL REGISTERED COMPANY

This certificate remains valid while the holder maintains their administration systems in accordance with the standards and guidelines stated above, which will be audited annually by QAS International. The holder is entitled to display the above registration mark for the duration of this certificate, which should be returned to QAS International upon reasonable request.

Tel: 020 31989788 - info@qas-international.com - https://www.qas-international.com
Issuing Office: QAS International, 20 Grosvenor Place, London, England, SW1X 7HN

A1.2. RoHSII Directive 2011/65/EU (Paracube Modus sensor only)

Appendix 7.6 RoHSII Directive 2011/65/EU Declaration

SERVOMEX

HUMMINGBIRD SENSING TECHNOLOGY

Servomex Material Declaration - RoHS II (2011/65/EU)

Equipment covered by this declaration — 01120 and variants

Equipment serial numbers covered by this declaration — Database records from 01/10/15

Under the EU RoHS II Directive (2011/65/EU), electrical and electronic equipment included within its scope shall not contain any of the following substances at above the given MCV (Maximum Concentrations Values), unless the application is included in a valid and current exemption listed in Annex III or IV of the Directive:

Restricted substance	MCV (% by weight of a homogeneous material)
Lead	0.1
Mercury	0.1
Cadmium	0.01

Restricted substance	MCV (% by weight of a homogeneous material)
Hexavalent chromium	0.1
Polybrominated biphenyls (PBB)	0.1
Polybrominated diphenyl ethers(PBDE)	0.1

Management Systems (Servomex Technical Centre, Crowborough, England)

Quality: ISO 9001:2008 — Environmental: ISO 14001:2004

Servomex declares that the equipment covered by this declaration does not contain any of the substances restricted by the RoHS II Directive (2011/65/EU) at above the given MCVs

Servomex has relied upon information provided by suppliers in completing this declaration which may or may not have been independently verified by a third party. However, where the information has not been independently verified, as a minimum, it has been assessed by Servomex's own internal processes set up in accordance with Servomex Management Systems.

08/12/15

J. Hobby, Chief Scientific Officer

Dated:

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A2. Supplemental Documentation

1. **Reliability Report (Paracube Modus sensor only)**
   This document, from Hummingbird (manufacturer of Paracube Modus oxygen sensor), describes root cause analysis for product failures and indicates the expected Mean Time to Failure (MMTF).

2. **Reliability Calculations (Paracube Modus sensor only)**
   This document, from Hummingbird (manufacturer of Paracube Modus oxygen sensor), describes the calculations used for root cause analysis for product failures.

3. **Mechanical Vibration and Shock Testing (Paracube Modus sensor only)**
   This document, from Hummingbird (manufacturer of Paracube Modus oxygen sensor), describes mechanical vibration and shock testing procedure and results.

4. **Sample Gas Cross Sensitivity Guide (Paracube Modus sensor only)**
   This document, from Hummingbird (manufacturer of Paracube Modus oxygen sensor), describes the effect of background gases on oxygen concentration measurement.

A2.1. Reliability Report (Paracube Modus)

Hummingbird
SENSING TECHNOLOGY

The quality management process implemented by Hummingbird Sensing Technology requires that all product failures be returned for detailed root cause analysis. The records of this process allow accurate "mean time to failure" MTTF calculations to be made.

This report calculates the reliability figures for the Paracube® Micro & Modus transducers using data collected in the period: January 2015 to December 2015 inclusive.

In this period 3,939 transducers were shipped to OEM customers.

In this period OEM customers returned 61 transducers as 'failed product'.

Using this data and assuming a constant failure rate, values for Instantaneous failure rate per hour (λ), probability of a unit surviving the first year of operation (ρ) and Mean Time To Failure (MTTF) may be calculated using the equations below.

$$\lambda = \frac{\sum \text{units failed}}{\sum \text{units} \times \text{hours of operation}}$$

$$p = \frac{\sum units - \sum units\ failed}{\sum units}$$

$$\text{MTTF} = 1/\lambda$$

λ = 1.548 x 10^{-6} failures / hour
p = 98.4%
MTTF = 65 years

However, the root cause analysis process identified that of the 61 transducers returned: 9 units when tested were found to be fully functional, and 28 units had failed in service due to misuse or incorrect application.
To obtain λ, ρ and MTTF figures, which would be representative of product failures due to faulty materials, workmanship or design, these two failure categories, should be removed and the reliability calculations repeated:

λ = 0.609 x 10^{-6} failures/hour.
p = 99.4%
MTTF = 164 years

A2.2. Reliability Calculations (Paracube Modus)

Hummingbird
SENSING TECHNOLOGY

The standard product development process implemented by Hummingbird requires the field failure rate of all new product designs to be assessed. These assessments are based upon standard engineering reliability calculation techniques, combined where possible with relevant observed field failure rate data.

The product reliability assessments conducted for the Paracube Micro & Modus (catalogue numbers 01117 & 01121) are summarised below.

Electrical
Whilst the design and function of the 1117 & 1121 control electronics is comparable with that of previous generations, the implementation is sufficiently different such that any comparison with field failure data is not valid. Hence, using standard industry reference material* and recognised failure rate estimation techniques, the estimated failures per million hours (fpmh) figure for the Paracube 1117 & 1121 design = 0.07 fpmh

Mechanical
The designs of the 1117 & 1121 mechanics, optics and sensing element are considered comparable to previous generations such that a comparison to observed field failure rate data for previous generations is considered valid.
The Hummingbird business processes require that all returned products are investigated, the root cause of failure identified and where practicable a preventive action implemented. During the 12-month period preceding March 2019, the failure rate observed for 1115 & 1120 sensors categorised as failures due to faulty materials, workmanship or design = 0.4102 fpmh

Transducer
Standard system reliability theory states that if a system operation is dependent upon all components functioning correctly, then that system reliability can be expressed as the sum of the component failure rates. Hence the predicted reliability figures for both the Paracube 1117 & 1121 can be calculated as 0.07 + 0.4102 = 0.4802 fpmh

* Component failure data figures calculated using the FARADIP tool compiled from sources including: US MIL HDBK 217, UK BT HRD, OREDA DATA BOOK, US NPRD. Further details available upon request.

A2.3. Mechanical Vibration and Shock Resistance (Paracube Modus)

Appendix 7.4 Mechanical Vibration and Shock Resistance

The sensors described in this manual have been vibration and shock tested to the following medical electrical equipment standards and sub-clauses and *1maintain basic safety and essential performance:

Shock in accordance with IEC 60068-2-27:2008
Broadband vibration in accordance with IEC 60068-2-64:2008

BS EN ISO 80601-2-55 2011 (Respiratory Gas monitors)
Testing covered the requirements of both statically located ventilators and ventilators intended for mobile use within the healthcare facility as follows;

Shock and vibration to sub-clause 201.15.3.5.101.1:
Peak acceleration: 150ms-2 (15g); Duration: 11ms; Pulse shape: half sine; Number of shocks: 3 shocks per axis (18 total)

Acceleration amplitude vibration:
10Hz to 100Hz: 1.0 (m/s2)2/Hz.
100Hz to 200: -3db per octave.
200Hz to 2000: 0.5 (m/s2)2/Hz.
Duration: 10 minutes per perpendicular axis (3 Total)

Shock and vibration for a mobile ventilator to sub-clause 201.15.3.5.101.2:
Peak acceleration: 300ms-2 (30g); Duration: 11ms; Pulse shape: half sine; Number of shocks: 3 shocks per axis (18 total)

Acceleration amplitude vibration;
10Hz to 100Hz: 5.0 (m/s2)2/Hz.
100Hz to 200: -7db per octave.
200Hz to 2000: 1.0 (m/s2)2/Hz.

Duration: 30 minutes per perpendicular axis (3 Total)

BS EN ISO 80601-2-12: 2011 (Critical Care Ventilators).
Testing covered the requirements of RGMs not intended for use during transportation of a patient outside a healthcare facility and for the professional transportation of patients as follows;

Shock and vibration to sub-clause 201.15.3.5.101.1
Peak acceleration: 50ms-2 (5g); Duration: 6ms; Pulse shape: half sine; Number of shocks: 3 shocks per axis (18 total)

Acceleration amplitude vibration;
10Hz to 100Hz: 0.33 (m/s2)2/Hz.
100Hz to 500: -6db per octave.
Duration: 30 minutes per perpendicular axis (3 Total)

A2.3. Mechanical Vibration and Shock Resistance (Paracube Modus)

Shock and Vibration for professional transportation to sub-clause 201.15.3.5.101.2
Peak acceleration: 150ms-2 (15g); Duration: 11ms; Pulse shape: half sine; Number of shocks: 3 shocks per axis (18 total)

Acceleration amplitude vibration;
10Hz to 100Hz: 1.0 (m/s2)2/Hz.
100Hz to 500: -6db per octave.

Duration: 10 minutes per perpendicular axis (3 Total)

*1: Sensors exposed to extended periods of excessive shocks and/or vibration may be subject to zero offsets. These can be calibrated out at any time.

A2.4. Sample Gas Cross Sensitivity Guide (Paracube Modus)

Appendix 7.5 Sample Gas Cross Sensitivity Guide

The example below demonstrates how the effect of background gases may be calculated.

Sample gas composition at 50°C

10% CO_2
5% CO
5% HCCH
78% N_2

Calculation:

CO^2	$-0.29 \times 10^{-2} \times 10$	=	-0.029
CO	$0.07 \times 10^{-2} \times 5$	=	0.004
HCCH	$-0.28 \times 10^{-2} \times 5$	=	0.014
N2	$0.00 \times 10^{-2} \times 78$	=	0.000
Net background effect		=	-0.039

This offset may be removed during calibration by setting the zero point to +0.039% O_2.

			Zero Error / % of interfering gas		
Gas	Formula	χM x 10-6	20°C x 0.01%	50°C x 0.01%	60°C x 0.01%
Acetaldehyde	CH_2CHO	-22.70	-0.31	-0.34	-0.35
Acetic Acid	CH_3CO_2H	-31.50	-0.56	-0.62	-0.64
Acetone	CH_3COCH_3	-33.70	-0.63	-0.69	-0.71
Acetylene	HCCH	-20.80	-0.25	-0.28	-0.29
Acrylonitrile	CH_2=CHCN	-24.10	-0.35	-0.39	-0.40
Allyl Alcohol	CH_2CHCH_2OH	-36.70	-0.71	-0.79	-0.81
Ammonia	NH_3	-18.00	-0.17	-0.19	-0.20
Argon	Ar	-19.60	-0.22	-0.24	-0.25
Benzene	C_6H_6	-54.84	-1.24	-1.36	-1.41
Bromine	Br_2	-73.50	-1.78	-1.96	-2.02
1,2 Butadiene	C_4H_6	-35.60	-0.68	-0.75	-0.77
1,3 Butadiene	C_4H_6	-30.60	-0.54	-0.59	-0.61
N-Butane	C_4H_{10}	-50.30	-1.11	-1.22	-1.26
Iso-Butane	$(CH_3)_2CHCH_2$	-51.70	-1.15	-1.26	-1.30
N-Butyl Acetate	$CH_3COOC_4H_9$	-77.50	-1.89	-2.09	-2.15
Iso-Butylene	$(CH_3)_2CH$=CH_2	-44.40	-0.94	-1.03	-1.06
Carbon Dioxide	CO_2	-21.00	-0.26	-0.29	-0.30
Carbon Disulphide	CS_2	-42.20	-0.87	-0.96	-0.99
Carbon Monoxide	CO	-9.80	0.06	0.07	0.07
Carbon Tetrachloride	CCl_4	-66.60	-1.58	-1.74	-1.79

A2.4. Sample Gas Cross Sensitivity Guide (Paracube Modus)

Gas	Formula	χM x 10-6	Zero Error / % of interfering gas		
			20°C x 0.01%	50°C x 0.01%	60°C x 0.01%
Chlorine	Cl_2	-40.50	-0.82	-0.91	-0.94
Chloro-Ethanol	$ClCH_2CH_2OH$	-51.40	-1.14	-1.25	-1.29
Chloroform	$CHCl_3$	-59.30	-1.37	-1.51	-1.55
Cumene	$(CH_3)_2CHC_6H_5$	-89.53	-2.24	-2.47	-2.55
Cyclohexane	C_6H_{12}	-68.13	-1.62	-1.79	-1.84
Cyclopentane	C_5H_{10}	-59.18	0.35	0.38	0.39
Desflurane	$CHF_2OC_2HF_4$	-84.40	-2.09	-2.37	-2.73
Dichloroethylene	$(CHCl)_2$	-49.20	-1.07	-1.18	-1.22
Diethyl Ether	$(C_2H_5)_2O$	-55.10	-1.25	-1.37	-1.41
Enflurane	$C_3H_2F_5ClO$	-80.10	-1.97	-2.17	-2.57
Ethane	C_2H_6	-26.80	-0.43	-0.47	-0.49
Ethanol	C_2H_5OH	-33.60	-0.62	-0.69	-0.71
Ethyl Acetate	$CH_3COOC_2H_5$	-54.20	-1.22	-1.34	-1.39
Ethyl Chloride	C_2H_5Cl	-46.00	-0.98	-1.08	-1.12
Ethylene	C_2H_4	-18.80	-0.20	-0.22	-0.22
Ethylene Glycol	$(CH_2OH)_2$	-38.80	-0.77	-0.85	-0.88
Ethylene Oxide	$(CH_2)_2O$	-30.70	-0.54	-0.60	-0.61
Freon 11	CCl_2F_2	-52.20	-1.16	-1.28	-1.32
Freon 12	CCl_3F	-58.70	-1.35	-1.49	-1.53
Freon 113	$CHCl_2CH_2Cl$	-66.20	-1.57	-1.73	-1.78
Freon 114	$C_2Cl_2F_4$	-77.40	-1.89	-2.08	-2.15
Furan	C_4H_4O	-43.09	-0.90	-0.99	-1.02
Halothane	$C_2HBrClF_3$	-78.80	-1.93	-2.13	-2.19
Helium	He	-1.88	0.29	0.32	0.33
N-Heptane	C_7H_{16}	-85.24	-2.12	-2.33	-2.40
N-Hexane	C_6H_{14}	-73.60	-1.78	-1.96	-2.02
Hydrogen	H_2	-3.98	0.23	0.26	0.26
Hydrogen Chloride	HCl	-22.60	-0.31	-0.34	-0.35
Hydrogen Sulphide	H_2S	-25.50	-0.39	-0.43	-0.44
Isoflurane	$C_3H_2F_5ClO$	-80.10	-1.97	-2.17	-2.24
Krypton	Kr	-28.80	-0.49	-0.54	-0.55
Methane	CH_4	-17.40	-0.16	-0.17	-0.18
Methanol	CH_3OH	-21.40	-0.27	-0.30	-0.31
Methyl Acetate	CH_3COCH_3	-42.60	-0.88	-0.97	-1.00
Methyl Ethyl Ketone	$CH_3COCH_2CH_3$	-45.50	-0.97	-1.07	-1.10
Methyl Isobutyl Ketone	$C_4H_9COCH_3$	-69.30	-1.66	-1.82	-1.88
Monochlorobenzene	C_6H_5Cl	-70.00	-1.68	-1.85	-1.90
Nitric Oxide	NO	1461.00	42.56	42.96	42.94
Nitrogen	N_2	-12.00	0.00	0.00	0.00
Nitrogen Dioxide	NO_2	150.00	5.00	16.00	20.00
Nitrous Oxide	N_2O	-18.90	-0.20	-0.22	-0.23
N-Octane	C_8H_{18}	-96.63	-2.45	-2.70	-2.78
Oxygen	O_2	3449.00	100.00	100.00	100.00
Ozone	O_3	6.70	0.54	0.60	0.61
Iso-Pentane	C_5H_{12}	-64.40	-1.51	-1.67	-1.72
Phenol	C_6H_5OH	-60.21	-1.39	-1.54	-1.58

A2.4. Sample Gas Cross Sensitivity Guide (Paracube Modus)

Gas	Formula	χM x 10-6	Zero Error / % of interfering gas		
			20°C x 0.01%	50°C x 0.01%	60°C x 0.01%
Propane	C_3H_8	-38.60	-0.77	-0.85	-0.87
Iso-Propanol	$(CH_3)_2CHOH$	-47.60	-1.03	-1.13	-1.17
Propylene	C_3H_6	-31.50	-0.56	-0.62	-0.64
Isopropyl Ether	$(CH_3)_4CHOCH$	-79.40	-1.95	-2.15	-2.21
Pyridine	$N(CH)_5$	-49.21	-1.08	-1.19	-1.22
Styrene	$C_6H_5CH=CH_2$	-68.20	-1.62	-1.79	-1.85
Sevoflurane	$CFH_2OCH(CF_3)_2$	-111.20	-2.86	-3.15	-3.25
Sulphur Dioxide	SO_2	-18.20	-0.18	-0.20	-0.20
Tetrachloroethylene	$Cl_2C=CCl_2$	-81.60	-2.01	-2.22	-2.28
Tetrahydrofuran	C_4H_8O	-52.00	-1.16	-1.27	-1.31
Toluene	$C_6H_5CH_3$	-66.11	-1.56	-1.72	-1.78
Vinyl Chloride	$CH_2=CHCl$	-35.60	-0.68	-0.75	-0.77
Xenon	Xe	-43.90	-0.92	-1.02	-1.05
Xylene	$(CH_3)_2C_6H_4$	-77.78	-1.90	-2.09	-2.16

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