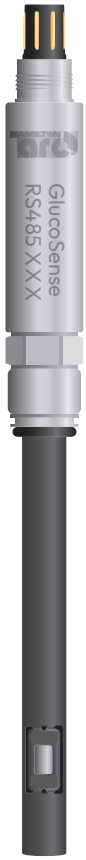

GlucoSense Sensors

Operating Instructions

REF 10192365/00

2025-11-24

HAMILTON®

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Liability

The liability of Hamilton Bonaduz AG is described in detail in the document "*General Terms and Conditions of Sale and Delivery*" in their current version. Hamilton expressly disclaims liability for direct or indirect damages resulting from the use of the sensors. Users are reminded that sensors have a limited-service life, which depends on the specific application and operating conditions. Malfunctions may therefore occur at any time.

The user is solely responsible for the calibration, maintenance, and regular replacement of the sensors. For critical sensor applications, Hamilton recommends the use of backup measuring points to avoid consequential damage. The user is responsible for taking appropriate precautions in the event of sensor failure.

To download the latest version of the *General Terms and Conditions of Sale and Delivery*, visit the Hamilton Process Analytics website: https://www.hamiltoncompany.com/general-terms-and-conditions#purchase

Table of Contents

Document History

Manual revision No.	Date of issue	Change summary
00	November 2025	The first release of the GlucoSense Sensor Operating Instructions.

Preface

Table 1. GlucoSense Sensor documentation suite

Document title	Description	Manual REF
GlucoSense *Sensors Operating Instructions (this manual)*	Provides detailed information about installing and setting up the sensor, as well as additional technical information.	10192365
GlucoSense *RS485 Sensors – Modbus RTU Programmer's Manual*	This manual is intended for software programmers. It provides detailed information about the GlucoSense Sensors Modbus RTU interface as well as general information about Modbus command structures and their implementation in the Hamilton Arc sensors family.	111009574
Hamilton Arc Operating Instructions	This manual provides detailed information about the Arc system which consists of the Arc sensors, the ArcAir application, accessories and their applications. The Arc sensors are designed to measure pH, dissolved oxygen, conductivity, carbon dioxide, cell density, and oxidation-reduction potential (ORP) in a liquid medium.	10071115

The latest version of the English manual, related documents, and translated manuals can be downloaded from the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics).

Conventions used in this guide/manual

Safety messages are displayed as follows:

⚠ WARNING

Alerts the user to the risk of injury, death, or other severe adverse reactions associated with the correct or incorrect use of the device.

⚠ CAUTION

Alerts the user to the possibility of a problem with the device associated with its use or misuse, such as device malfunction, device failure, damage to the device, or damage to other property.

NOTICE

Emphasizes information of particular importance.

In tables and some descriptive text, safety messages are indicated as follows:

⚠ WARNING!

⚠ CAUTION!

NOTICE!

Typographic conventions

Table 2. Overview of the typographic conventions used in this manual

Typographic effect	Example	Function
Bold	**Settings**	Indicate the name of an icon or a button in the software/application.
	Touch the **Settings** tab > **Measurement Settings** subtab	The notation **XX** > **XX** shows the sequence of buttons to touch to open the associated window in the software/application.
Italic	*Operating Instructions / Quick Start Guide*	Indicates the names of other documents.
	Moving Average: 50 / Measurement Interval: 3	Emphasizes information of particular importance.
`Software graphical user interface (GUI) text`	"`Initialization of the correlation point has been completed.`"	Indicates text or message quoted directly from the software/application window or screen.
Procedural sequence	1. Step 1 in a sequence 2. Step 2 in a sequence	Organizes a sequence of actions into steps.

Typographic effect	Example	Function
Illustration number sequence	1: Identifies part/item 1 of an illustration 2: Identifies part/item 2 of an illustration	• Used in illustrations/ graphics to identify the part/item for cross-referencing in a procedure or description. • It also relates to the specific part/item description in the legend table for the corresponding illustration/graphic.
Hyperlink text, for example, see Chapter 2 or see Figure 7-2	See Chapter 2 or see Figure 7-2	If you are viewing this file with PDF software, you can click on the hyperlinked text /reference number to instantly access the corresponding information in another part of this document.

Graphics or illustrations used in this manual

- The graphics or illustrations used in this manual are for illustrative purposes only.
- The colors used in the graphics or illustrations may not be an exact representation of the actual product.

In this manual:

- Some figures use callouts in a white circle with a blue border.

  ①: These figures may have an associated legend table or may describe a single item legend in the title of the figure. Callouts may be numerical or alphabetic. Callouts are unrelated to any nearby procedures and refer only to the figures themselves and their associated legend.

- Some figures use small dark blue callouts.

  Ⓐ: These callouts show the sequence of steps. They are not related to the numbering of any associated procedure.

The latest version of the English manual, related documents, and translated manuals can be downloaded from the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics).

1 Introduction

This chapter provides information about the intended use of the GlucoSense Sensor and the operating instructions.

Check the sensor and its spare parts for damage at the time of unpacking. A damaged sensor must be returned to your Hamilton dealer in the original packaging. You must follow the maintenance procedures by paying particular attention to cleaning and decontamination if you work with hazardous liquids. You must decontaminate the sensor if it becomes contaminated with a biohazardous, radioactive, or chemical substance

For safe and correct use of the GlucoSense Sensor and its spare parts, it is important that both operating and service personnel follow generally accepted safety procedures as well as the safety instructions given in this document, the GlucoSense Sensors Operating Instructions. Incorrect use or misuse can be dangerous. You must not exceed the temperature or pressure specification provided in the sensor Specification. For the sensor specification details and certificate, visit the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics).

The service life of the GlucoSense Sensor highly depends on the specific conditions of the application. Temperature, pressure and chemicals used may accelerate the aging of the sensor itself. See Chapter 6 for the maintenance procedures.

Cleaning, assembly and maintenance should be performed by personnel trained in such work. Always make sure that no process medium can be accidentally spilled before removing the sensor from the measuring setup. It is recommended to wear safety goggles and protective gloves when removing and cleaning the sensor.

The operator cannot repair the sensor. It must be returned to Hamilton for investigation, as described in Section 8.3. Necessary precautions should be taken when transporting sensors. To return the sensor to Hamilton for investigation, you must use the original reusable packaging for shipment. Every GlucoSense Sensor sent back for investigation must be decontaminated.

If the conditions described in these operating instructions are not adhered to or if there is any inappropriate interference with the equipment, all our manufacturer's warranties become void.

1.1 Intended use

⚠ WARNING

Intended use and safety precaution:

The GlucoSense Sensor is not intended for hazardous environments and/or explosive atmospheres.

The GlucoSense Sensors are intended for the measurement of glucose concentrations in liquid solutions.

If the sensor is used with organic solvents, the accuracy of the measurement in this application must be checked and validated separately by the user.

NOTICE

Sensor operation limits and electromagnetic compatibility (EMC):

- The measurement values transmitted over wireless communication are not intended to be used for Process Control System (PCS).
- The GlucoSense Sensors are intended for use in an industrial electromagnetic environment and comply with IEC / EN 61326-2-3.

1.2 About these operating instructions

The GlucoSense Operating Instructions are intended to guide users to operate the GlucoSense Sensor in combination with the ArcAir application (version 3.11 or higher) correctly and safely. The operating instructions also describe the different components and functions of the GlucoSense Sensor and the ArcAir application.

These operating instructions provide an in-depth description of both the hardware and software of the GlucoSense Sensor and how to operate the sensor in a bioprocess system.

Each section introduces various parts of the system, followed by step-by-step instructions on how to operate the GlucoSense Sensor with the ArcAir application. After reading this manual, the user should be able to install and operate the GlucoSense Sensor with the ArcAir application.

To quickly resolve some of the most common problems, see Chapter 8.

1.3 General precautions

⚠ WARNING

Requirements for safe sensor operation and maintenance:

- Only trained personnel are authorized to clean, install, operate, and maintain this sensor. Incorrect or unauthorized use of the sensor can result in sensor/equipment damage or personnel injury.
- Before you remove the sensor from a measuring setup for cleaning or maintenance:
  - ► Wear safety goggles and protective gloves.
  - ► Make sure that no process medium can accidentally spill.
  - ► Depressurize the bioreactor or vessel.
  - ► Allow the bioreactor or vessel to cool to a safe temperature.

⚠ CAUTION

Sensor handling:

Do not drop the sensor during handling. Dropping the sensor can cause damage to the sensing elements/components.

For safe and correct use of the GlucoSense Sensor, both operating and service personnel must follow the generally accepted safety procedures and the safety instructions given in the Operating Instructions of the GlucoSense Sensor. The specifications provided for temperature and pressure must not be exceeded.

If the sensor cannot be serviced by the operator, it must be sent back to Hamilton for investigation. You must take necessary precautions when transporting the sensors. The sensor must be sent back in the original reusable packaging box for shipment. Every sensor sent back to Hamilton for investigation must be decontaminated. Failure to comply with Operating Instructions or inappropriate use of the sensor can void all the manufacturer's warranties.

2 Safety Precautions and Hazards

This Section provides safety information and technical-related information about the GlucoSense Sensor.

If you have questions about any of the information in this manual, contact your Hamilton Process Analytics representative or technical service personnel.

⚠ CAUTION

Safety precautions and hazards:

- *Carefully read and observe the following safety precautions and hazards before installing, setting up, and operating the sensor.*
- *Failure to observe and follow through with the maintenance procedures can affect the reliability and correct function of the system.*
- *Failure to observe the safety precautions and hazards described in this manual, improper use of the sensor, and unauthorized interference with the sensor by external devices will void all warranties provided by the manufacturer.*
- *Do not expose the sensor to corrosive media or substances. This will help to protect the sensor from deterioration.*

Negative Temperature Coefficient (NTC) thermistors

⚠ CAUTION

Function of the Negative Temperature Coefficient (NTC) thermistors:

The GlucoSense Sensor includes several built-in Negative Temperature Coefficient (NTC) thermistors (NTC 47 kOhm) that compensate for the temperature effects on the optical elements caused by the environment and the light source. These temperature sensors are intended to monitor the status of the sensor, not to control the process temperature.

2.1 Operating precautions for GlucoSense Sensors

Adhere to the following guidelines when handling, operating, and maintaining the GlucoSense Sensor to ensure safety and optimal performance:

⚠ CAUTION

GlucoSense Sensor operating precautions:

- *Only authorized/trained service personnel can install, operate, clean, calibrate, or maintain the sensor or do other service-related tasks.*
- *The GlucoSense Sensor and its accessories (see Sections 11.2 and 11.3) must be used for their intended applications and under optimum safety and operational conditions. The customer is responsible for validating the sensor to confirm it is suitable for the intended application.*
- *Make sure that the PG 13.5 thread process connections and the O-rings are not damaged when installing a sensor into the process. The O-rings are consumable parts that must be exchanged regularly (at least once a year).*
- *Verify that the GlucoSense Membrane is not damaged when mounting it to the sensing element of the sensor before use. The GlucoSense Membrane is a single-use, consumable part and must be replaced before each new bioprocess. For detailed instructions on how to replace the GlucoSense Membrane, see Section 4.3.*
- *Always do a Manual Cleaning of the sensor sensing element immediately after removing the GlucoSense Membrane to eliminate any contamination risk. For detailed instructions on how to do a Manual Cleaning procedure, see Section 6.6*
- *Always wear protective eyewear and gloves before removing the sensor from the system (e.g., bioreactor) for maintenance. This is especially crucial in the event of a malfunction where there is a risk of contamination from spilled liquids.*
- *Always make sure that no process medium can accidentally spill before removing the sensor from the process setup. Gases or liquids can escape unnoticed wherever seals or screws are installed.*
- *Even when all required safety measures are followed, potential risks still exist regarding leaks or mechanical damage. Do not subject the system to stress such as vibration, bending, or torsion.*
- *The sensor can remain connected to a Process Control System (PCS), Supervisory Control and Data Acquisition (SCADA), or computer during Cleaning in Place (CIP) and Sterilization in Place (SIP). Stand clear of the sensor during the CIP and SIP, as the sensor can become very hot.*

⚠ CAUTION

To extend the service life of the sensor:

- *Prevent corrosive media contact with the sensor and the membrane.*
- *Put the protective cap on the VP8 connector head of the sensor after you have disconnected the VP8 cable for the sensor.*

Use only wired digital or analog connection for the process control. The Arc wireless interface is intended for sensor monitoring, maintenance, and service.

If the sensor or the GlucoSense membrane come into contact with gaseous or liquid organic solvents, the accuracy of the measurement must be checked specifically for that application and validated by the customer.

Always consider the resistance of the GlucoSense Sensor wetted parts (see Table 2-1) and the GlucoSense Membrane (see Table 2-2).

GlucoSense Sensor wetted parts resistance

NOTICE

Temperature specification and resistance:

Unless otherwise stated, resistance applies to temperatures up to 90°C.

Table 2-1. GlucoSense Sensor wetted parts resistance

GlucoSense Sensor wetted parts resistance	
Wetted parts resistant to	• Lipophilic compounds • Polar protic organic solvents such as ethanol, isopropyl alcohol, or polar organic non-chlorinated solvents such as acetone • Common surfactants • Diluted (1-2M) NaOH and KOH at room temperature • Diluted solutions of mineral acids at room temperature such as 1M HCl, 1M H_2SO_4, except for HF or strongly oxidating ones • Acetic acid at room temperature

GlucoSense Sensor wetted parts resistance	
Short-term exposure is possible*	• Concentrated (up to 5M tested) alkali metal hydroxide solutions at room temperature, CIP 100® • Diluted (1-2M) NaOH and KOH • Methanol • Chlorine (dry) at room temperature • Sodium/Calcium hypochlorite, ProChlor® at room temperature • Chlorine dioxide at room temperature
Avoid exposure to	• Concentrated strong acids (e.g., HCl, oleum), especially at elevated temperatures, red fuming nitric acid • HF and its derivatives • Peroxides (e.g., Spor-Klenz Cold Sterilant®)
Where: ** Must be avoided in the target process, but short-term usage is possible for cleaning purposes.*	

GlucoSense Membrane resistance

NOTICE

Temperature specification and resistance:

Unless otherwise stated, resistance applies to temperatures up to 90°C.

Table 2-2. GlucoSense Membrane resistance

GlucoSense Membrane resistance	
Wetted parts resistant to	• Polar protic organic solvents such as ethanol, isopropyl alcohol • Standard pH buffers and aqueous solutions of alkali metal chlorides • Up to 3M NaOH at room temperature • 1M HCl at room temperature • Common surfactants • Acetic acid
Short-term exposure is possible*	• Common mineral acids at low-medium concentrations at room temperature • Chlorine (dry) at room temperature • Sodium/Calcium hypochlorite, ProChlor® at room temperature • Chlorine dioxide at room temperature • Peroxides (e.g., Spor-Klenz Cold Sterilant®) at room temperature
Avoid exposure to	• Hot concentrated strong acids • Hot concentrated strong bases • Non-polar and polar aprotic organic solvents (GlucoSense Membrane can change dimensions due to swelling) • HF and its derivatives

Where:

** Must be avoided in the target process, but short-term usage is possible for cleaning purposes.*

2.2 Electrical safety precautions

⚠ CAUTION

Electrical safety precautions:

- *Before you remove/disconnect the sensor from the process tank, benchtop, or bioreactor, you must always turn off the power supply and disconnect the cable connector from the sensor.*
- *Only use the cables provided by Hamilton Process Analytics.*
- *Do not bend, step on, or place heavy objects on the cable/cord. A damaged cable/cord can pose a shock or fire hazard.*
- *Do not use a damaged power cord.*
- *Do not connect the sensor to a power source with an output voltage below or above the range stated in the specifications. For additional information, see the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics). Failure to do so can lead to malfunction or damage to the system or impair the safety of the user.*
- *The sensor must be installed at a location that is electrically conductive (< 1 MΩ).*
- *We recommend that you inspect the entire grounding (sensor or sensor with reactor) before use and after modifying the setup.*

NOTICE

Power supply requirements for the PCS:

If the 24 VDC power supply is turned off or disconnected, the PCS will show incorrect readings.

Minimize electromagnetic fields and static electricity

Keep the GlucoSense Sensor away from other devices that emit high-frequency electromagnetic fields and minimize static electricity in the immediate vicinity of the optical measuring parts.

Carefully follow the applicable setup in Figure 2-1 or Figure 2-2 and the instructions in Section 4.4 to prevent electrical damage to the GlucoSense Sensor. You must clean and dry the contact before you connect the sensor to the VP8 data/power cable.

Sensor data cable: VP8

Always use the Hamilton VP8 cable for safe connection. The VP8 cable is available in a wide range of lengths (see Section 11.3). Make sure the cable is not damaged, then plug it onto the sensor head correctly to prevent short circuit.

We recommend that you assign the sensor shaft and/or VP8 cable shield to ground or earth (potential equalization), especially in electromagnetically noisy environments. This significantly improves noise immunity and signal quality. The VP8 nut/thread is connected to the metallic housing of the GlucoSense Sensor.

There are two options for connecting the sensor to the process environment (see Figures 2-1 and 2-2).

⚠ CAUTION

Ground/earth safety precautions for the system setup:

- *Do not double ground/earth the sensor and the metallic bioreactor at the same time. This can create a grounding loop in the system and can cause damage to the sensor.*
- *You must ground only the metallic bioreactor for the Option A system setup.*
- ***Mandatory requirement for Option B:** Option B must be used if the glass or plastic tank bioreactor is not connected to earth.*

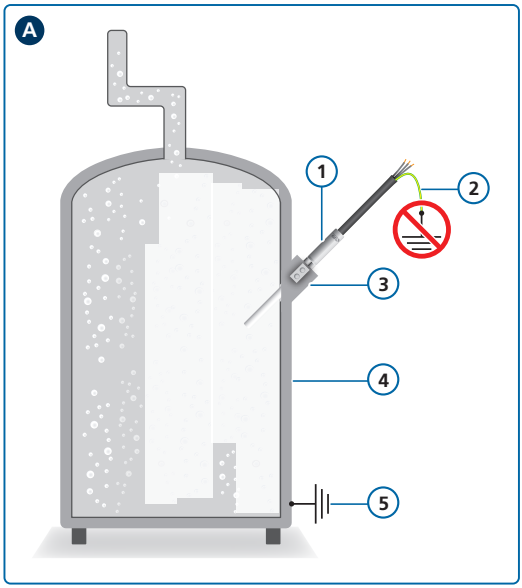
NOTICE

Earth/ground connection options:

- Option A: Metal tank/bioreactor with own earth/ground system (see Figure 2-1).
- Option B: Glass, plastic tank, or benchtop reactor not connected to earth/ground (see Figure 2-2).

Option A: Metal tank with earth/ground connection

Figure 2-1. Overview of the GlucoSense Sensor installed in a metallic bioreactor: Sensor is grounded via the bioreactor [Option A]



1. GlucoSense Sensor
2. Earth/ground cable (yellow/green) for the shaft of the sensor
3. Stainless steel PG 13.5 nut/thread to connect the sensor shaft to the metallic tank
4. Metallic bioreactor
5. Metallic bioreactor earth/ground

⚠ **CAUTION!** *Make sure you use only the ground/earth cable of the metallic bioreactor to ground/earth the entire system.*

Option B: Glass, plastic tank, or benchtop bioreactor without earth/ground connection

When the glass or plastic container is not grounded, the sensor shaft must be connected to earth

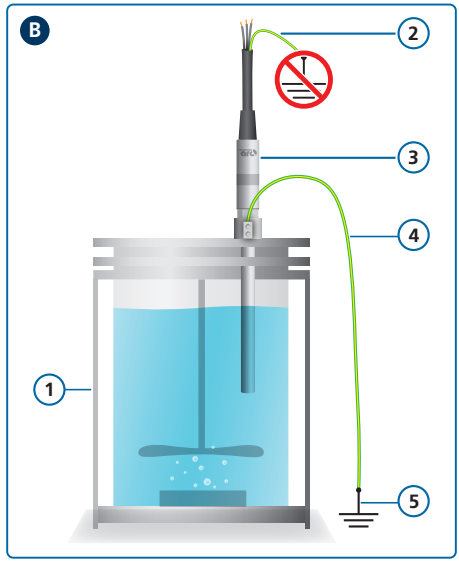
⚠ CAUTION

Option B system setup: Mandatory grounding/earthing for non-grounded bioreactors

If the glass or plastic container is not grounded, the sensor shaft must be connected to earth via a screw clamp installed on the stainless-steel PG 13.5 nut/thread or via the earth/ground cable (yellow/green) of the sensor data/power cable.

When the glass or plastic container is not grounded, the sensor shaft must be connected to earth The ground/earth connection can be achieved through one of the following two methods:

Figure 2-2. Overview of the GlucoSense Sensor installed in a glass, plastic tank, or benchtop reactor setup without earth/ground connection [Option B]

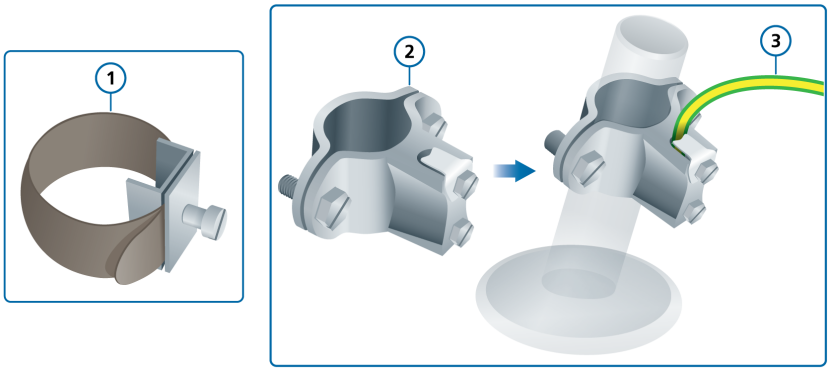


1. Glass, plastic tank, or benchtop reactor
2. VP8 earth/ground cable (yellow/green)
3. GlucoSense Sensor
4. Earth/ground cable (green/yellow) for the metallic parts (sensor shaft and clamp)
5. Metallic parts earth/ground

Examples of grounding clamps

Figure 2-3 shows several examples of clamps required for a setup with an earth/ground connection (Clamp 1) or a setup without an earth/ground connection (Clamp 2).

Figure 2-3. Examples of clamps required for installing the sensor to a glass/metal tank reactor, plastic tank, or benchtop reactor



1	Earth/ground strap for pipes	3	Clamp with earth/ground cable for the metallic parts (sensor shaft, clamp, and tank reactor)
2	Earth/ground clamp for pipes		

2.3 Chemical, radioactive, and biological hazard precautions

The user is solely responsible for selecting the appropriate biological safety level and implementing the required biosafety measures when working with the GlucoSense Sensor.

⚠ WARNING

Precautions for handling hazardous substances:

Always follow maintenance procedures of your organization /institution. If working with hazardous liquids, adhere to all cleaning and decontamination procedures. Prevent equipment contact with corrosive media

⚠ CAUTION

Maintenance requirements:

- *Clean the GlucoSense Sensor immediately if it becomes contaminated with biohazardous, radioactive, or chemical material.*
- *After removing the GlucoSense membrane, always manually clean the sensor sensing element to prevent contamination from biohazardous, radioactive, or chemical materials. For detailed instructions on cleaning the sensor and membrane, see Section 6.6.*
- *Failure to follow maintenance procedures can decrease the reliability and functionality of the system.*

3 Product Description

The GlucoSense Sensor is an infrared (IR) glucose sensor designed for process measurement. The optical sensing element, which comes into contact with the medium to be measured, is located in the shaft of the GlucoSense Sensor. The shaft incorporates an optical sensing element from Hamilton. The measuring components of the sensor are located at the tip, comprising the light source, IR detector, and solid-state sensing element (see Figure 3-1). The sensing element is covered by the GlucoSense membrane, which separates cells from the medium.

GlucoSense Sensor technology enables in-situ/in-line monitoring of glucose concentration in bioprocesses with animal cell cultures, and its design overcomes common problems such as cellular interference. For all wetted parts of the GlucoSense Sensor, refer to the Material Specification Declaration of Compliance according to EN 10204-2.1 Certificate for the Sensor (REF 111011993) and the Membrane: (REF 111011994).

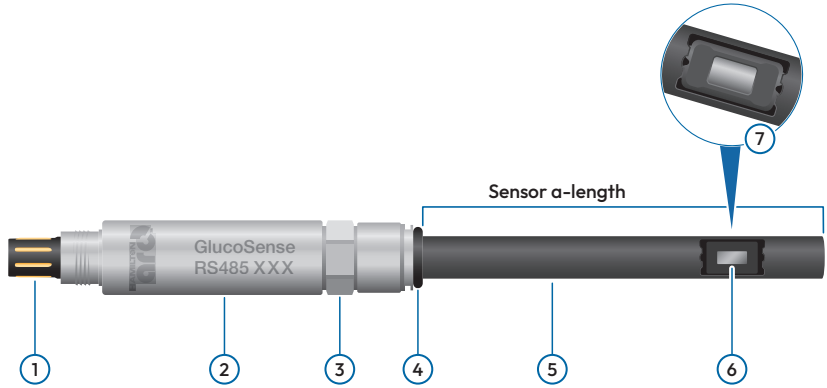
The microtransmitter also delivers reliable measurements directly to a PCS or via the Hamilton ArcAir application. All relevant sensor data, including calibration and diagnostic information, is stored within the microtransmitter, simplifying calibration and maintenance procedures. Integrated quality indicators predict remaining sensor service life and measurement quality.

The Arc Wi Adapter enables Bluetooth® wireless communication, allowing for sensor monitoring, configuration, and calibration. This saves time without compromising the quality of a wired connection. A GlucoSense Sensor equipped with an Arc Wi Adapter enables wireless communication with iOS/Android smartphones, tablets, and Windows® computers.

GlucoSense Membrane: Function and operating principle

The function of the GlucoSense Membrane is to prevent cells from interfering with the glucose measurement performed by the sensing element. The membrane creates a physical barrier, enabling only small molecules such as glucose to pass through and be measured.

Figure 3-1. Overview of the GlucoSense Sensor



1	VP8 connector	5	Sensor shaft
2	Sensor head with integrated transmitter, includes the REF number, serial number (SN), heat numbers, and certificate logos	6	Sensing element (infrared (IR) path)
3	Process connection with PG 13.5 nut/ thread, stainless steel	7	GlucoSense Membrane installed on the sensing element
4	O-ring		

GlucoSense Sensor: Key features and benefits

Table 3-1. Key features and benefits of the GlucoSense Sensor

Feature	Benefit
The sensor is compatible with any PG 13.5 bioreactor port, requiring no hardware modification. This ensures a straightforward integration process into your current setup.	Easy integration
• Enables real-time data collection for optimized feedback control. • Increases data frequency from daily sampling to real-time in-situ measurement, enabling more accurate process modeling and control.	Real-time monitoring
• Monitor cell cultures from day one, allowing immediate focus on process improvement. • No prolonged calibration required (no MVDA). Reduces errors commonly associated with manual off-line analysis.	Ready to use & time-saving
The GlucoSense Sensor provides accurate measurements through a combination of built-in factory calibration and straightforward in-situ product calibration.	Easy to operate
• Reduces the need for extensive scale-up or scale-down studies. • Decrease expenses associated with off-line analytics (e.g., cartridges).	Cost savings
• Fiber-optic free design, eliminating costs and complexities associated with high-throughput spectrometers. • Proven compatibility with numerous Autoclave cycles (R&D) and Sterilization-in-Place (SIP) / Cleaning-in-Place (CIP) procedures (Production).	Robust design
The compact design of the GlucoSense Sensor saves valuable laboratory space by removing the need for large external spectrometers, all while maintaining highly accurate measurements.	Small footprint

3.1 Hardware description

Sensor's material specification and standard

The GlucoSense Sensor shaft is made from medical-grade titanium (Ti Grade 2) with a diamond-like carbon coating (DLC) to further increase its resistance to harsh process conditions and mechanical wear.

NOTICE

Variation in manufacturing process:

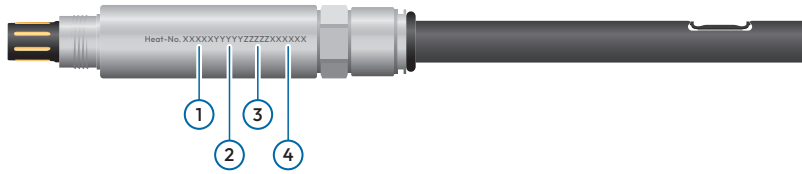
Due to minor variations in the manufacturing process, different titanium heat numbers may be used. These heat numbers are engraved on the sensor head. Figure 3-2 explains the different heat numbers engraved on the sensor.

The GlucoSense Sensor shaft comprises multiple medical-grade titanium components. As a result, four titanium heat numbers, corresponding to each part, are engraved on the sensor head to enable easy retrieval of the respective 3.1 material certificates.

Material Inspection Certificates (EN 10204–3.1) for wetted titanium surfaces exceeding 1% are available for download from the Hamilton Process Analytics website: https://www.hamiltoncompany.com/process-analytics.

The PG 13.5 nut/thread is the standard connector for installing the sensor into the ports of different bioreactors. The **Reference Number**, **Serial Number**, and **Heat Numbers** of the sensor can be found on the sensor head (see Figure 3-2).

Figure 3-2. Overview of the GlucoSense Sensor heat numbers explanation



1	Shaft Heat No.	3	Frame Heat No.
2	Cap Heat No.	4	Closure plug Heat No.

3.2 GlucoSense Sensor: Optical measurement principle

The GlucoSense Sensor's optical measurement principle is based on molecular infrared (IR) spectroscopy. Molecules such as glucose absorb IR radiation at specific wavelengths. The amount of absorbed radiation follows the Beer–Lambert law, which relates absorbance to the concentration of the absorbing species.

The higher the glucose content, the more IR radiation is absorbed. Measuring the absorption of IR radiation (optical IR signal) as glucose concentration allows the amount of glucose to be quantified. The data points fall on a straight line, indicating a direct, linear relationship between glucose concentration and IR absorption.

Sensor operating principle and measurement accuracy

⚠ CAUTION

GlucoSense Membrane: Single-use requirement

Each new bioprocess requires a new GlucoSense Membrane. These membranes are designed for a single process and must not be reused. Reuse may compromise measurement accuracy and is therefore not permitted.

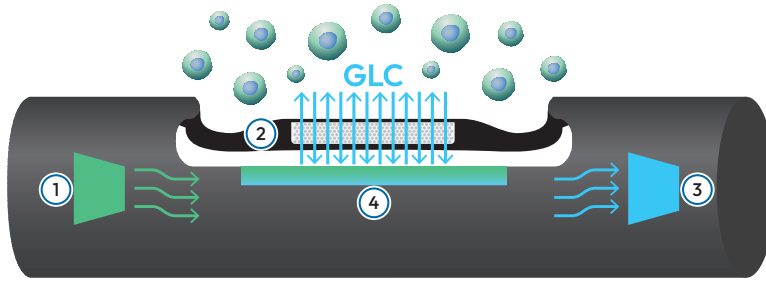
⚠ CAUTION

GlucoSense Membrane shelf life:

- *Information on the shelf life of the GlucoSense Membrane can be found on the membrane packaging label. For accurate measurement of glucose concentration in the liquid (media), you must use the GlucoSense Membrane within the specified shelf life.*
- *The accuracy of glucose concentration measurements can be affected if you use the GlucoSense Membrane beyond its shelf life.*

The solid-state element of the GlucoSense Sensor enables precise measurement of the glucose concentration in the liquid phase when a light source irradiates the sensing element. After the light source interacts with the medium, the reflected radiation is measured by integrated detectors. These detectors ensure a high signal-to-noise ratio and optimize measurement accuracy for quantifying of glucose molecules dissolved in the cell culture media. For accurate measurements, the measuring principle requires a Product Calibration before cell inoculation. For detailed instructions on how to do the Product Calibration, see Section 6.2.

Figure 3-3. Overview of the GlucoSense Sensor sensing element



1	Light source	3	IR detectors
2	GlucoSense membrane	4	Sensing element

NOTICE

GlucoSense Sensor stabilization time:

After the GlucoSense Sensor is turned on, it takes approximately 600 s (10 min) to stabilize and adjust to the process, solution, or ambient temperature.

GlucoSense Sensor operational requirements:

⚠ **CAUTION**

Product Calibration for accurate glucose quantification:

To ensure accurate in-situ quantification of glucose, it is important to do a Product Calibration using the current glucose concentration before inoculation. For detailed instructions on how to do the Product Calibration, see Section 6.2.

GlucoSense Sensors are factory calibrated. However, product-specific calibration is required to eliminate background interference from cell culture media, which can vary depending on the formulation used.

3.3 GlucoSense Sensor with an integrated microtransmitter

The GlucoSense Sensor features an integrated microtransmitter located in the sensor head, which provides a fully compensated signal directly to the Process Control System (PCS).

Communication protocols include digital Modbus and an optional 4–20 mA analog interface, which requires the use of the Arc Wi 2G Adapter BT (REF 243470).

The microtransmitter is designed to simplify calibration and maintenance by storing all relevant sensor data, including calibration and comprehensive diagnostic information.

3.4 Using the GlucoSense Sensor in a GMP environment

For additional information about using the GlucoSense Sensor in a Good Manufacturing Processes (GMP) environment, see the *Hamilton Arc Operating Instructions* (REF 10071115).

4 Hardware and Software Installation

This chapter provides information and instructions on how to install and set up the GlucoSense Sensor and its hardware as well as the ArcAir application.

4.1 Unpacking the sensor

⚠ CAUTION

Sensor handling and support:

- *Always handle the sensor with care.*
- *Verify the functionality of the sensor before use if it is accidentally dropped while outside its original Hamilton packaging. For troubleshooting details, see Chapter 6.*
- *Contact Hamilton Technical Support if you experience warnings and errors messages with the sensor (see Section 8.3).*

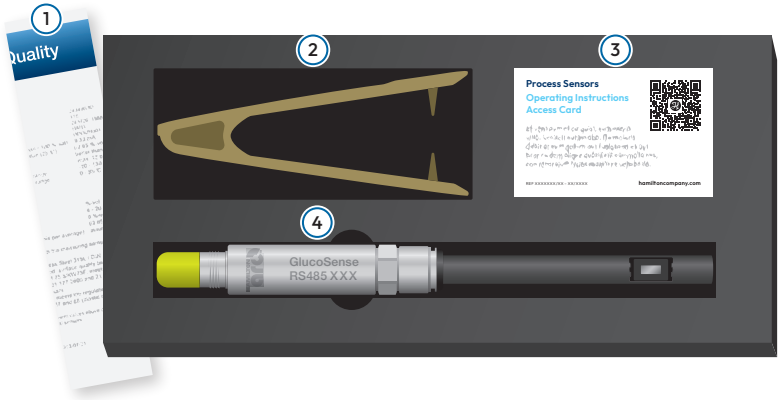
NOTICE

Sensor documentation:

- The Material Certificate 3.1 for the titanium can be accessed via a URL link or a QR code provided on the printed DoQ.
- The EU and UKCA Declaration of Conformity document for the GlucoSense Sensor can be downloaded from Hamilton website (https://www.hamiltoncompany.com/process-analytics).
- The Operating Instructions for the GlucoSense Sensor can be accessed by scanning the QR code on the Information Access Card included in the product packaging.

1. Carefully unpack the GlucoSense Sensor. Inside the packaging, you will find the GlucoSense Sensor, Declaration of Quality (DoQ), and GlucoSense Membrane Tool.
2. Inspect the sensor for transport damage or missing parts.

Figure 4-1. Overview of the GlucoSense Sensor delivery package contents



1	GlucoSense Sensor Declaration of Quality (DoQ)	3	GlucoSense Sensor Operating Instructions Access Card with QR code
2	GlucoSense Membrane Tool (REF 10197760)	4	GlucoSense Sensor

NOTICE

GlucoSense Membrane Tool:

The packaging contains the GlucoSense Membrane Tool (REF 10197760) required to remove the membrane from the GlucoSense Sensor after every use in bioprocess. For details on how to remove the GlucoSense Membrane from the GlucoSense Sensor, see Section 4.3.

4.2 ArcAir application

The ArcAir application provides a secure and efficient communication platform for monitoring, validating, and managing Arc sensors and user accounts. It seamlessly integrates Arc sensors into the bioprocess setup, making the system cost-effective and reliable. You can easily configure Arc sensors using a mobile device or computer with the ArcAir application installed.

Users can benefit from the automated standard calibrations and configurations in the laboratory, as well as product calibrations and validations in process environments. The reporting feature allows users to manage validation, verification, configuration, and communication reports. User profiles for all Arc sensors can be managed in compliance with GMP regulatory requirements.

The ArcAir application can be installed on various devices, including computers, tablets, and mobile phones to provide users with an overview of all the Arc sensors in the operational environment. The ArcAir mobile version only supports the most important workflow. Note that data recording and display of the experiment are not available in the ArcAir mobile version.

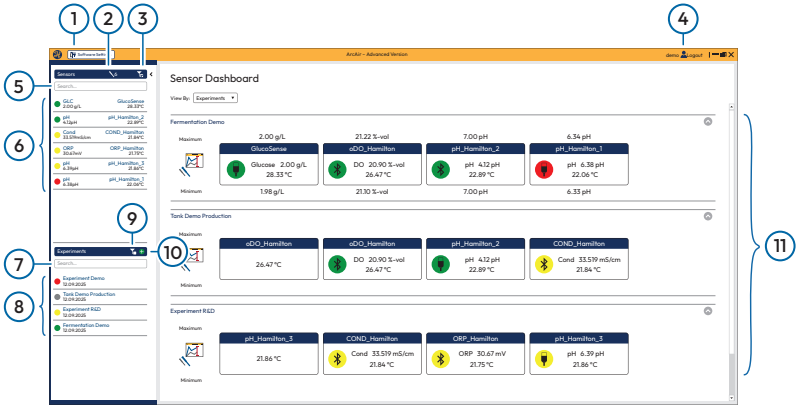
NOTICE

ArcAir application requirements and resources:

- ArcAir v3.11 or higher is required to use the GlucoSense Sensor.
- A minimum screen/display resolution of 1280 x 768 pixels is recommended.
- For additional information about the ArcAir application and its general workflow, refer to the *Hamilton Arc Operating Instructions* (REF 10071115).

Overview of the ArcAir application (PC version) main screen

Figure 4-2. ArcAir application (PC version): Overview of the ArcAir main screen



1 Backstage tab: You can access the user profile, manage passwords, sensor groups, mobile connection, Firmware update, audit trail, and electronic signatures

2 Number of sensors online

3 Filter icon: Use the filter to specify or refine your search for the sensor list

4 User profile name/account

7 Experiment search field: Use the field to search for sensors used in an experiment

8 Overview of the list of sensors used in an experiment

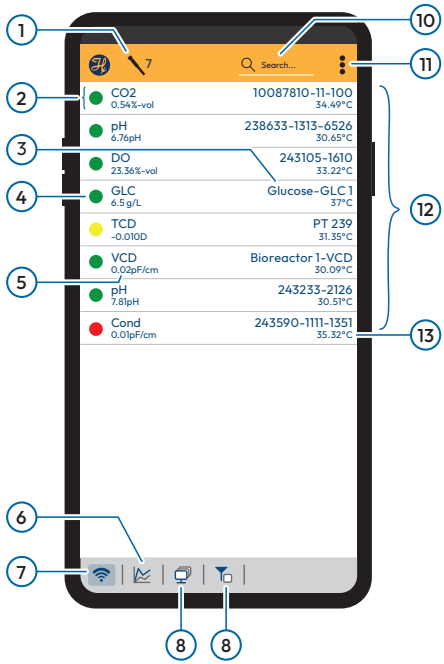
9 Filter icon: Use the filter to specify or refine your search for the sensor list under experiment

10 Creating a new experiment

5	Search field: Use the search field to search for sensors connected to the ArcAir application	11	Sensor dashboard: Provides an overview of the sensors connected to the ArcAir application, including the sensor status, type of connection and status, measurement parameters, and measured value with the corresponding units.
6	Sensor list: Provides an overview of the sensors connected to the ArcAir application, including the sensor status, measurement parameters, and measured value with the corresponding units.		

Overview of the ArcAir application (mobile version) main screen

Figure 4-3. ArcAir application (mobile version): Overview of the ArcAir main screen



1 Number of sensors online

2 Primary sensor: Provides an overview of the sensor status, measurement parameter, and measured value with the corresponding units

3 Measuring point: The default measuring information is set to show the reference number (REF) and serial number (SN) of the sensor.

NOTICE! The user can change the default measuring point information to differentiate between the sensors. For example, Glucose-GLC 1.

8 Computer connection

9 Filter icon: Use the filter to specify and refine your search for the sensors connected to the ArcAir application

10 Search field: Use the search field to search for sensors connected to the ArcAir application

4	Sensor status indicator: • **Green:** Indicates that there are no warnings or errors • **Yellow:** Indicates that at least one warning has been registered • **Red:** Indicates that at least one error has been registered • **Gray:** Indicates that the sensor is offline	11	ArcAir licenses and other information related to the sensor
5	Current measurement point	12	Sensor dashboard: Provides an overview of the sensors connected to the ArcAir application, including the sensor status, measurement parameters, and measured value with the corresponding units.
6	Experiment view: Touch to view the list of sensors used in an experiment	13	Current temperature reading
7	Wi-Fi icon: Touch to view the list of sensors connected via Wi-Fi to the ArcAir application		

NOTICE

Troubleshooting: Sensor warnings and errors

For additional information about the Sensor Status Indicator, see Chapter 8.

4.2.1 Installing ArcAir on a computer

Download the latest software version of ArcAir from the Hamilton website: www.hamiltoncompany.com.

For details about the ArcAir application installation and configuration, refer to the *Hamilton Arc Operating Instructions* (REF 10071115).

4.2.2 Installing ArcAir on a mobile or tablet

Download the latest software version of ArcAir from the App Store or Google Play.

For details about the ArcAir application installation and configuration, refer to the *Hamilton Arc Operating Instructions* (REF 10071115).

4.2.3 Creating user accounts in ArcAir

NOTICE

ArcAir application: Initial setup and administrator access

- By default, ArcAir operates in Laboratory Mode, which allows access to all licensed functions without a login password.
- The first user account created is automatically designated as the Administrator, who has all user rights by default.

1. Launch the ArcAir application on the computer.
2. Click the **Settings** button at top left corner of the display.
3. Select **User Management**.
4. Click the **Add** button to open the **User Editor**.
5. Enter the user details and password.
6. Select the specific rights for the user.

4.2.4 ArcAir application update

⚠ **CAUTION**

Sensor data backup and export:

Before installing a new software version, export and save all configurations and experimental data.

1. Download the latest software version of ArcAir from the Hamilton website (www.hamiltoncompany.com).
2. Save the software file on a USB drive or the computer on which the software is to be installed.
3. Install the software.

4.2.5 Accessories

The GlucoSense Sensor can be combined with different hardware accessories from the Arc portfolio for specific applications.

All listed accessories for the GlucoSense Sensor must be ordered directly from Hamilton. Contact the Hamilton Application Specialists team if you need support with finding and selecting the right accessories required to complete your application setup with the GlucoSense Sensor.

Accessories overview

- **Device**

  Arc View Mobile Basic (REF 10071111) / Arc View Mobile Advanced (REF 10071113), or ArcAir application on a computer is required to configure the Arc sensors.

- **Wireless**
  - Arc Wi 2G BT Adapter (REF 243470): Enables 4-20 mA, Modbus, and Bluetooth® connection for Arc sensors
  - Arc Wi 1G BT Adapter (REF 243460): Enables Bluetooth® connection for Arc sensors

- **Wired/external power**

  External Power Supply with Arc USB Power Cable:
  - Arc USB Power Cable (REF 243490-01): USB / VP8 for direct connection to the sensor
  - Arc USB Power Cable (REF 243490-02): USB / M12–8 pole for connection to the sensor with Arc Wi 2G BT Adapter

For a detailed overview of what is required to connect your sensor to the existing control system, see Section 4.4.

4.3 Installing the GlucoSense Sensor in a bioreactor

There are different ways of installing the GlucoSense Sensor into the reactor depending on the type of bioreactor. There are various housings available to custom-fit the sensor in every installation.

Step 1: Mounting the GlucoSense Membrane

⚠ CAUTION

GlucoSense Membrane installation and handling:

- *For the GlucoSense Membrane installation, use deionized (DI) water only to wet both the membrane and the membrane installation slot on the sensor shaft. Before use, verify that no air bubbles are trapped under the membrane.*
- *Immediately after installing the membrane on the GlucoSense Sensor, immerse the sensing element with the membrane in DI water, medium, or saline solution to prevent the membrane from drying.*

⚠ CAUTION

GlucoSense Sensor immersion requirements:

- ***Immersion during sterilization***

  ► *Before sterilization, mount theGlucoSense Sensor in a bioreactor containing liquid (e.g., water or medium).*

  ► *Make sure that the sensing element is fully submerged.*

  ► *The sensing element must remain immersed in liquid throughout the sterilization process.*

- ***Immersion during operation***

  ► *Make sure the sensing element remains fully submerged in the media during operation in a bioreactor.*

  ► *The recommended depth for consistent and accurate measurement is at least 2 cm above the sensing element.*

⚠ CAUTION

Autoclaving precautions:

- *Make sure that the sensor is not exposed to conditions that cause liquids to boil during the autoclaving cycles.*
- ***Risk and consequence:*** *Rapid pressure drops at elevated temperatures can generate vapor bubbles and trap gas under the GlucoSense Membrane, which can compromise the signal accuracy.*
- ***Control measures:*** *Use controlled pressure ramps during cooling and avoid sudden depressurization to maintain sensor integrity and ensure reliable measurements following sterilization.*

1. Inspect the GlucoSense Sensor:
   - Check the O-ring on the sensor shaft.
   - Verify the sensing element (optical path) is free of damage and dirt particles.
2. Mount the GlucoSense Membrane (REF 10190449) in the designated slot on the sensor shaft (see Figure 4-4).

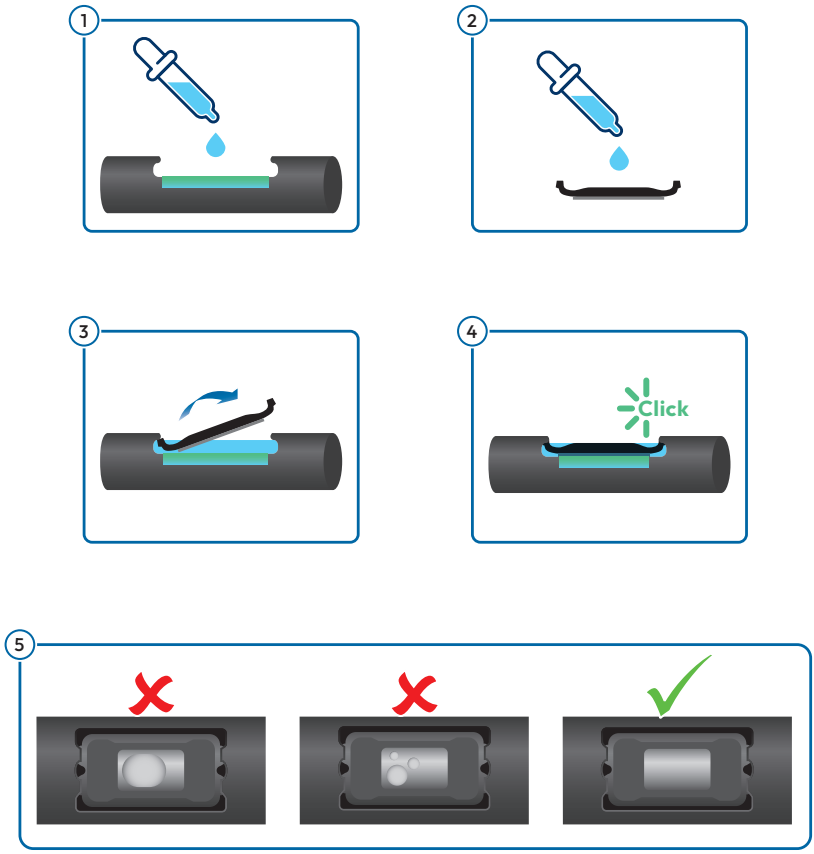
NOTICE

GlucoSense Membrane: Mounting instructions video

For additional information on how to install the membrane, refer to the instructional video via the QR code on the "GlucoSense Membrane: *Mounting Instructions Access Card*" included in the membrane packaging. Membrane mounting instructions video link: https://www.hamiltoncompany.com/knowledge-base/article/glucosense-membrane-mounting-instructions.

3. Verify that no air bubbles are trapped under the membrane after the mount (see Figure 4-4).

Figure 4-4. Mounting the GlucoSense Membrane on the sensor shaft



1 Place the GlucoSense Sensor on a flat, horizontal surface with the membrane slot facing up. Then, apply drops of deionized (DI) water to the GlucoSense Membrane installation slot on the sensor shaft.

2 Apply drops of DI water on the exposed surfaces of the membrane.

3 Position the membrane in the designated slot on the sensor shaft.

4 Gently press down on the membrane into the groove until you hear an audible click.

5 Verify that no air bubbles are trapped under the membrane.

NOTICE

Removing the GlucoSense Membrane:

For further information on removing the GlucoSense Membrane, see Section 6.6.

Step 2: Install the GlucoSense Sensor in a bioreactor

⚠ CAUTION

GlucoSense Sensor installation and operational precautions:

- *When installing the GlucoSense Sensor via the side wall port (stainless steel PG 13.5 thread) on the bioreactor, hand-tighten the sensor. The tightening torque must not exceed **2 Nm**.*
- *Prevent the sensor from rotating out of its defined position when connecting the power cable.*
- *Gas bubbles from the media can interfere with the GlucoSense Sensor measurements during operation. Regularly revalidate and adjust the position of the sensor to prevent this interference.*

⚠ CAUTION

Avoid using mechanical tools for installation/removal of the sensor:

Do not use a manual or mechanical tool to install or remove the GlucoSense Sensor. Using a manual or mechanical tool can cause damage to the sensor.

1. Carefully install the sensor in the port on the bioreactor and adjust if necessary (see Figure 4-5).
2. Tighten the sensor by hand. The torque must not exceed 2 Nm.

GlucoSense Sensor installation configurations

- **Installation configuration A: Angle mount**

  The GlucoSense Sensor is installed via the side wall of the bioreactor (stainless steel or single-use bioreactors). See Figure 4-5 – Configuration A.

- **Installation configuration B: Vertical mount**

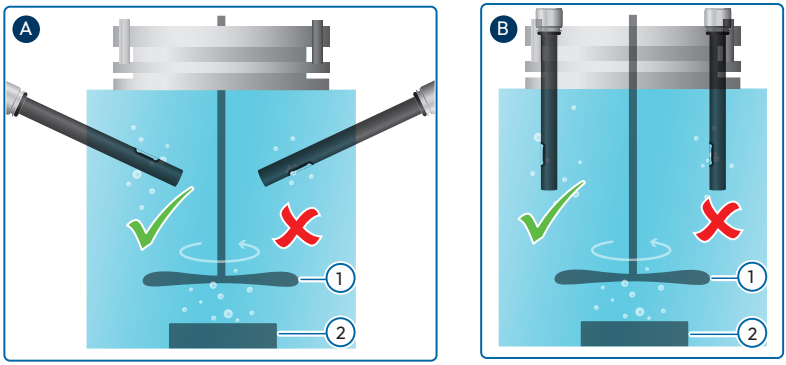
  The GlucoSense Sensor is installed via the top ports relative to the stirring and gas systems of the benchtop bioreactor. See Figure 4-5 – Configuration B.

NOTICE

GlucoSense Sensor connector alignment: VP8 connector and Arc Wi adapter

- The notch on the VP8 connector of the sensor head serves as an alignment guide for the sensor and determines the connection orientation when combined with the Arc Wi Adapter (see Section 4.4.1).
- When connecting the sensor with the Arc Wi Adapter, align the notch on the sensor head to determine the connection orientation. Adjust the orientation as needed to optimize signal quality or maintain clearance from other components connected to the bioreactor.

Figure 4-5. GlucoSense Sensor installation configurations: Angle Mount (A) and Vertical Mount (B)



1	Stirrer	2	Sparger

4.4 Connecting GlucoSense Sensor to a process control system (PCS)

Hamilton offers a wide range of options for integrating the sensors into a variety of process setups. For additional information about the GlucoSense Sensor integration options, see Sections 4.4.1, 4.4.2, and 4.4.3.

Sensor installation tips

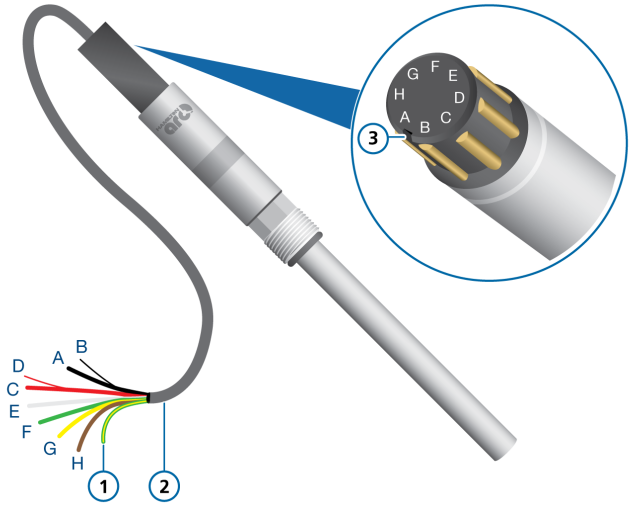
- Before you install the housing, you must test the seal for tightness and the functionality of the sensor parts.
- Make sure that there is no damage to the sensor or the housing.
- Make sure that each O-ring is in the appropriate groove and not damaged.
- To prevent mechanical damage to O-rings, apply a small amount of grease to the O-rings before you install the sensor in a bioreactor.

4.4.1 VP8 or M12 Pin assignment

Always use Hamilton VP8 sensor cable for safe connection. The VP8 sensor cables are available in different lengths (see Chapter 11). The GlucoSense Sensor is fitted with a VP8 male connector by default.

The VP8 head has a notch to denote the Pin position and prevent incorrect pairing with the cable connectors (see Figure 4-6).

Figure 4-6. GlucoSense Sensor electrical connection: VP8 connector Pin assignment



1 VP8 earth/ground cable (yellow/green)

⚠ **CAUTION!** *Do not ground/earth the sensor via the VP8 earth/ground cable if the sensor is grounded via the metallic bioreactor.*

2 Cable shield (double coaxial open-end cable and data cable conductor)

3 A notch on the VP8 head for the sensor connector alignment

Table 4-1 provides an overview of the VP8 connector Pin assignment for the GlucoSense Sensor electrical connection.

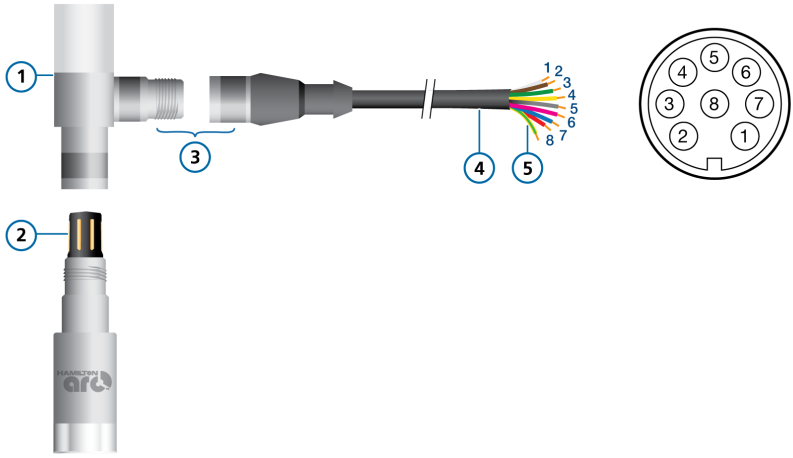
Table 4-1. Arc sensor head connector: VP8 connector Pin assignment

VP Pin	Function	Double coaxial cable description	Data cable description
A	Not used	Coaxial core, black transparent	Yellow
B	Not used	Coaxial shield, black	Green
C	Power supply: +10 V to +27 V	Coaxial core, red transparent	Red
D	Power supply ground/ earth: 0 VDC	Coaxial shield, red	Blue
E	Not used	White	Brown
F	Not used	Green	White
G	RS-485 A	Yellow	Gray
H	RS-485 B	Brown	Pink

4.4.2 Connecting the GlucoSense Sensor via 4-20 mA analog interface

Connecting an Arc Wi 2G BT Adapter (REF 243470) to the GlucoSense Sensor head makes it possible to output an analog signal of 4-20 mA from the Modbus digital communication protocol. Always use the Hamilton M12 sensor cable for a safe connection. The Hamilton M12 sensor cables are available in different lengths (see Chapter 11).

Figure 4-7. Arc sensor setup with Arc Wi 2G BT adapter and M12-8 pole open-end cable



1	Arc Wi 2G BT adapter	4	Cable shield
2	VP8 male connector	5	Green/Yellow cable: Connected to the housing including the VP8 female connector
3	M12-8 pole connection		

Table 4-2 provides an overview of the M12 (A coded) Pin assignment for the Hamilton M12-8 pole sensor cable connector.

Table 4-2. M12 (A coded) Pin assignment for the Hamilton M12-8 pole sensor cable connector

M12 Pin	Function	Cable description	Description
1	+4 to +20 mA, #1	White	• The 4-20 mA two-wire interface functions as a current sink and needs to be powered. It regulates the input current according to the measurements of the sensor. • The 4-20 mA two-wire is galvanically isolated from the power supply.
2	-4 to +20 mA, #1	Brown	
3	+4 to +20 mA, #2	Green	
4	-4 to +20 mA, #2	Yellow	
5	RS-485 (A)	Gray	Modbus RTU RS-485
6	RS-485 (B)	Pink	Modbus RTU RS-485
7	GND	Blue	Ground/earth: 0 VDC
8	+24 VDC	Red	Power supply: +10 V to +27 V **NOTICE!** The power supply can be external but not from the PCS.

4.4.3 Electrical connection: Setup for 4-20 mA analog interface

The 4–20 mA interface enables direct connection of the GlucoSense Sensor to a data recorder, indicator, control unit, or PCS with an analog Input/Output (I/O). In this configuration, the Wi 2G BT Adapter works as a current sink in a passive state.

The 4–20 mA interface setup consists of the Arc Wi Adapter and GlucoSense Sensor. The interface has to be configured according to the requirements of the user. The GlucoSense Sensor is pre-configured with default values for the 4-20 mA and measurement unit.

Connect the sensor according to the Pin assignments (see Sections 4.4.1 and 4.4.2).

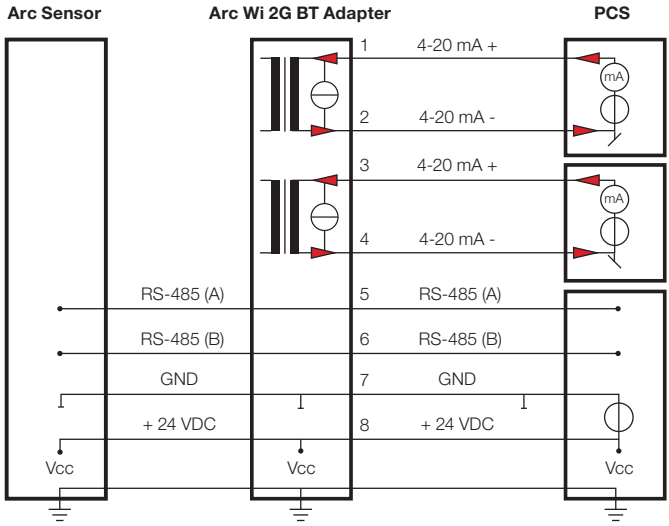
⚠ CAUTION

Wiring and connecting an Arc sensor to a PCS:

The most reliable and safest way to wire an Arc sensor is through a Process Control System (PCS) that has an active 4-20 mA input card. The Arc Wi 2G BT Adapter (REF 243470) includes internal galvanic isolators to improve the analog signal quality and simplify the connection to the PCS.

PCS configuration with an active 4-20 mA input card

Figure 4-8. Typical PCS configuration with an active 4-20 mA input card: Setup with an Arc Wi 2G BT Adapter (REF 243470)



4.4.4 Connecting the GlucoSense Sensor via Modbus

The digital RS-485 interface enables communication with the Arc sensor for performing measurements, monitoring the status of the sensor, and changing the configuration parameters of the sensor.

Arc sensors are always connected to digital controlling devices such as a Modbus server. The Arc sensors require a power supply via the VP8 Pins **C** and **D** to function correctly (see Section 4.4.1).

Additional information: Modbus RTU communication protocol

- The Modbus RTU communication protocol corresponds to the Modbus-IDA standard. For more information, refer to the Modbus organization website (https://modbus.org/). The Modbus physical layer is described in detail with requirements on cabling and line termination in the *Modbus Serial line Protocol and Implementation Guide*. For more information on the Modbus physical layer, refer to the *Modbus Serial Line Protocol and Implementation Guide* > *Technical Resources* > *Modbus Specifications.*
- For details on how to configure the GlucoSense Sensor via Modbus, refer to the GlucoSense RS485 Sensors *Programmer's Manual* (REF 111009574).

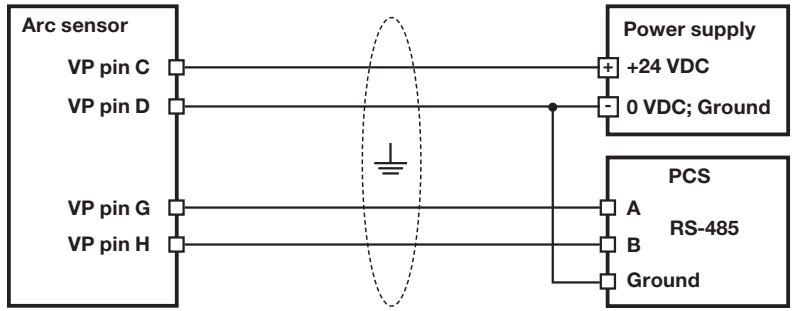
⚠ CAUTION

Sensor configuration and noise reduction:

- *All the sensors are delivered with the factory-default setting. Each sensor must be configured for its specific application before first use (see Chapter 4).*
- *In an electromagnetically noisy environment, you must connect the VP cable shield to earth (see Section 2.2). This significantly reduces noise interference and improves the signal quality.*

Example of the circuit arrangement

Figure 4-9. Wiring diagram for the RS-485 interface

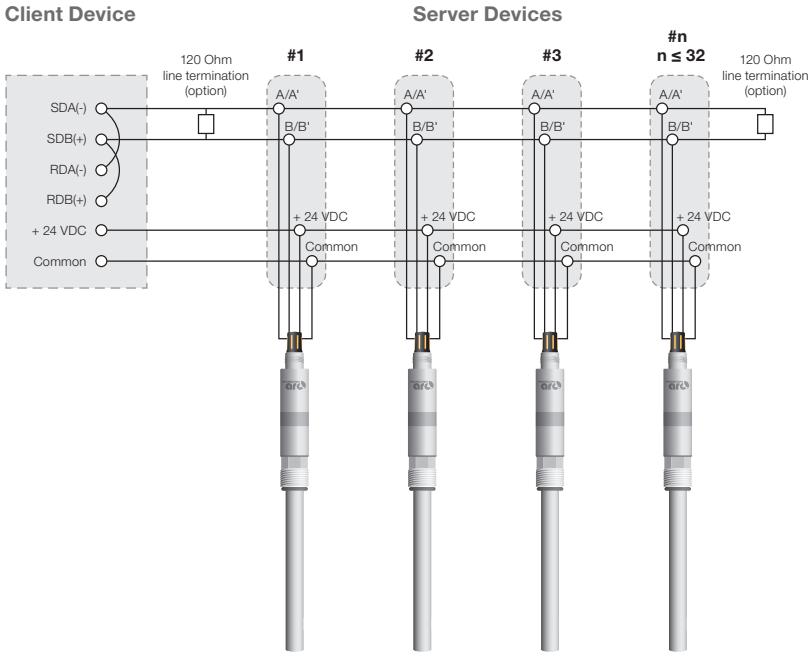


⚠ CAUTION

Modbus address assignment:

You must assign a unique Modbus device address to each sensor for the correct communication in the wiring configuration shown in Figure 4-10.

Figure 4-10. Multi-drop bus wiring: Two-wire mode for the Modbus connection



NOTICE

Modbus communication guidelines:

- Each sensor functions as a Modbus server.
- Only one sensor can communicate with the client at a time.
- To prevent signal reflection on the lines, use a 120 Ω line termination resistor on each line.
- Signal reflection effects become noticeable with long cables and/or high baud rates.
- The serial Modbus connection between the client's RS-485 port and the sensor interfaces must comply with the EIA/TIA RS-485 standard.

4.4.5 Mechanical process connection

⚠ CAUTION

Sensor and housing installation precautions:

- *Make sure that the sensor or the housing are not damaged.*
- *Make sure the O-rings/seals are tight and that all parts are working correctly before you install the sensor in the housing.*
- *Check that all O-rings are seated correctly in the corresponding grooves and are not damaged.*
- *To prevent mechanical damage to the O-rings during assembly, apply a light coat of grease. After the installation, thoroughly clean the sensor to remove any remaining residue of grease.*

NOTICE

Wetted parts: O-ring and lubricant compliance:

The O-rings are wetted parts, and lubricant compounds must comply with FDA application requirements.

For additional information on how to install the sensor in the Hamilton Hygienic Socket (REF 242535), refer to the *Hygienic Socket Operating Instructions* (REF 624178).

4.4.6 Electrical connection for the digital RS-485 interface

The digital RS485 interface enables communication with the Arc sensors to measure, monitor the status of the Arc sensor, and change the configuration parameters of the sensor. The Arc sensors are always connected to a digital control device such as Modbus server. The Arc sensor requires a power supply (VP 8 Pins C and D) to function, see Section 4.4.1. For additional information about operating the sensor via digital mode, see Section 4.5.

4.5 Connecting the Arc sensors to ArcAir application

Hamilton's Arc Sensor family of intelligent sensors enables operators to monitor and adjust the process parameters in bioprocess to their requirements. The GlucoSense Sensor has an integrated microtransmitter that enables direct communication with the Process Control System (PCS) using Modbus digital communication protocol or via a 4-20 mA interface (optional) using the Arc Wi 2G Bluetooth® (BT) Adapter (REF 243470).

NOTICE

Sensor power cable:

The Arc USB Power Cable (REF 243490-XX) is required to supply power to the GlucoSense Sensor.

A wired connection can be established using an Arc USB Power Cable (REF 243490–XX) and a computer (see Figure 4-11). With the integrated microtransmitter, the GlucoSense Sensor provides more reliable measurements directly to the PCS or ArcAir application.

Bluetooth® wireless communication can be used with the Arc Wireless Adapter for configuring and troubleshooting the Arc sensors. This saves time without compromising the quality of the wired connection (see Figure 4-11). Wireless communication is available via a smart phone, tablet, or computer.

NOTICE

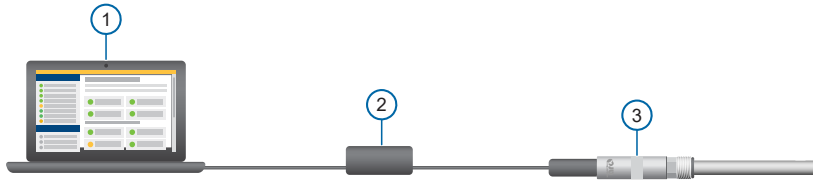
ArcAir user password setting: Global Operator Level S password

For automatic sensor login, a unique and global Operator Level S password for all intelligent sensors is required. Make sure you add the same Operator Level S Password for all Arc sensors in the ArcAir application under ArcAir Settings ► Settings ► Operator Level S Password.

Key benefits of connecting the GlucoSense Sensor to the ArcAir application

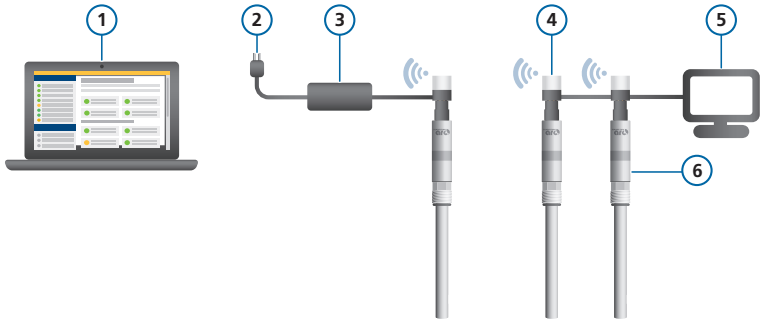
- Direct Optical IR measurement of glucose concentration with a compensated digital signal, preventing interference common with analog connections or transmitters.
- Easy to install.
- No separate transmitter required – saving space.
- ArcAir provides recording functionality with data export from ArcAir experiments.
- Direct digital Modbus or analog 4-20 mA communication via Arc Wi 2G BT Adapter (REF 243470).
- Full wireless connectivity via Bluetooth® 4.0 for diagnostics and easy configuration (via Arc Wi 2G Adapter).
- User-friendly maintenance with robust industrial design.
- High resistance to high temperatures (SIP / autoclaving).
- Comprehensive reporting and centralized data management for users and validation reports covering sensor calibration, verification, configuration, and communication. This enables compliance with GMP regulations such as FDA CFR21, Part 11, and Eudralex Volume 4 Annex 11 (requires ArcAir Advanced App).

Figure 4-11. Arc system setup: Wired connection to ArcAir application on a PC



1	ArcAir application installed on PC/ Notebook	3	GlucoSense Sensor
2	Arc USB power cable (REF 243490-XX)		

Figure 4-12. Arc sensor system setup: Wireless connection to ArcAir application



1	ArcAir application installed on a PC/ Notebook	4	Arc wireless BT adapter
2	Power supply plug	5	Process control system (PCS)
3	Arc USB power cable	6	GlucoSense Sensor

NOTICE

Wireless communication limitations:

Wireless communication is not intended to be used for process control applications.

To connect the Arc sensor to the ArcAir application, follow these steps:

⚠ CAUTION

Generate a communication validation report for the sensor via ArcAir app:

You must generate a Communication Validation Report from the ArcAir application if the GlucoSense Sensor is connected to the PCS via 4-20 mA: Navigate to the Communication Validation tab in ArcAir and follow the on-screen instructions.

1. Connect the VP8 connector of the Arc USB Power Cable (REF 243490-XX) to the VP8 head of the GlucoSense Sensor and the USB connector to the USB port on the computer.

NOTICE

Sensor identification in ArcAir application:

The ArcAir application automatically recognizes and displays connected sensors on the Sensor Dashboard. The connection type, for example, Bluetooth® or USB power cable is indicated next to each sensor (see Figure 4-13).

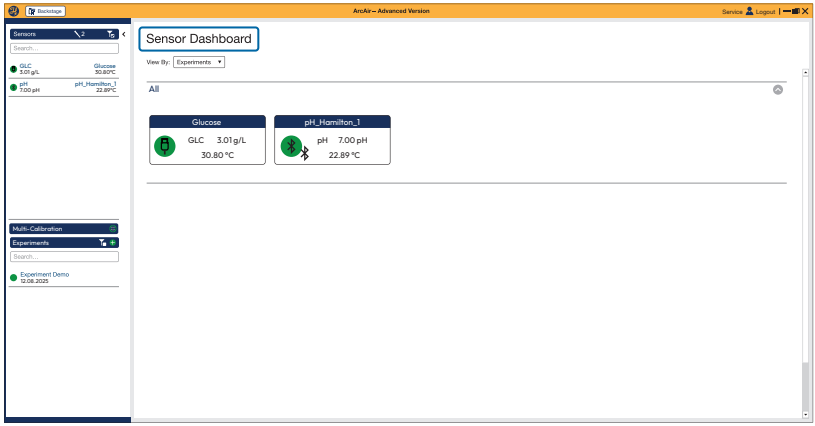
2. To connect to the GlucoSense Sensor: click the **GlucoSense** on either the **Sensor Dashboard** or select the applicable **Sensor** list on the left pane of the display (see Figure 4-13). When the sensor is connected, the **Info** tab of the sensor will be shown on the display.
3. Verify the functionality and status of the sensor on the computer, mobile device, or PCS via the ArcAir application: select the **Sensor Quick View** tab or the **Info** tab to view the functionality and status information.

NOTICE

Resolving the sensor connection issues:

For details on how to resolve connection issues, refer to Chapter 8.

Figure 4-13. Overview of the ArcAir application dashboard: View of the Arc sensors connected



4.6 Configuring the GlucoSense Sensor with ArcAir

GlucoSense Sensor requires application specific configuration. To configure and set up the GlucoSense Sensor, you require an Arc View Mobile Basic (REF 10071111) / Arc View Mobile Advanced (REF 10071113), or a PC/Notebook with ArcAir Basic/Advanced application installed. Table 4-3 provides an overview of the different ArcAir application licenses and their functionality.

Table 4-3. Overview of the ArcAir App versions and functionality

ArcAir version	ArcAir application functionality				
	Read	Calibrate	Configure	Documentation	Remark
Basic	✓	✓	✓	–	• Free download from Hamilton website or App Store / Play Store • Intended for PC, mobile phone, or tablet • Basic functions, including: – Measuring, – Sensor status – Experiment function – Configuration – Firmware update
Advanced	✓	✓	✓	✓	• Update from the basic version • Intended for PC, mobile phone, or tablet • Offers all the ArcAir Basic functions, including: – Verification – Communication validation – User management – Audit trail – Report functionality

4.7 Configuring GlucoSense Sensor parameters

1. Start the ArcAir application.
2. Select the desired sensor.
3. Open the **Settings** tab. Make sure you have the user rights to configure the **Sensor Settings**.
4. Configure the sensor. For additional information, see Section 4.7.1.

4.7.1 Configuring the measurement settings

Table 4-4 provides an overview of the *Measurement Settings* in ArcAir application.

Table 4-4. Overview of the measurement units and settings

Parameter	Description	Option / Default Value	Configuration	Software navigation
Measurement Unit: Glucose	Measurement physical units	• g/L • mg/L. • mg/dL • mmol/L	Required	Settings ▸ Measurement Settings
Temperature Unit	Temperature physical units	• K • °F • °C	Required	Settings ▸ Measurement Settings
Min. / Max. Custom Measurement Temperature	It is possible to set a minimum and maximum measurement temperature	0 °C to 80 °C	Default parameter	Settings ▸ Measurement Settings
Moving Average	The measurement interval for calculating glucose concentration values from the sensor is configurable between 1 to 3 seconds (s), when a moving average function is applied. This moving average is used to smoothen the glucose and temperature readings	600 s (Default)	Default parameter recommended	Settings ▸ Measurement Settings ▸ Moving Average

Units of measurement for glucose

Table provides an overview of glucose measurement units in liquid or aqueous solutions, including common cell culture media.

Table 4-5. Overview of glucose measurement units in liquid or aqueous solutions

Glucose units	g/L	mg/L	mg/dL	mmol/L*
g/L	1	1000	100	5.55
mg/L	0.001	1	0.1	0.00555
mg/dL	0.01	10	1	0.0555
mmol/L*	0.18	180.16	18.016	1

Where:

** Molecular Weight (MW) of anhydrous D-glucose (MW ≈ 180.16 g/mol).*

Conversion formula: Mass concentration to Molar concentration

To support the conversion factors provided in Table 4-5 and to allow for flexible conversion between **Mass Concentration** (e.g., g/L, mg/L, or mg/dL) and **Molar Concentration** (e.g., mol/L or mmol/L), use the following fundamental formula:

Where:

- 1 g = 1000 mg
- 1 mol = 1000 mmol

$$\text{Molar Concentration (mmol/L)} = \frac{\text{Mass Concentration (mg/L)}}{\text{Molar Mass (mg/mmol)}}$$

To convert 1 g/L to mmol/L, use the following formula:

$$\mathbf{1\ g/L = 1000\ mg/L}$$

$$\text{Molar Concentration (mmol/L)} = \frac{1000\ \text{mg/L}}{180.16\ \text{mg/mmol}} \approx \boxed{5.55\ \text{mmol/L}}$$

NOTICE! The conversions presented utilizes the molecular weight of anhydrous D-glucose (MW ≈ 180.16 g/mol).

4.7.2 Configuring the temperature settings for SIP/CIP processe

Table 4-6 provides an overview of the *Temperature Settings* in ArcAir application.

Table 4-6. Overview of the temperature settings in ArcAir application

Parameter	Description	Default Value	Configuration	Location
SIP process definition	User defines conditions for the SIP counter	Temp. Min.: 120°C Temp. Max.: 140 °C Time span: 20 min	Default parameter recommended	Settings ▸ Cleaning Cycles
CIP process definition	User defines conditions for the CIP counter	Temp. Min.: 80 °C Temp. Max.: 100 °C Time span: 20 min	Default parameter recommended	Settings ▸ Cleaning Cycles

4.7.3 Configuring the analog interface for a PCS

⚠ CAUTION

Arc Wi 2G Adapter Bluetooth® specification:

The Arc Wi 2G Adapter BT (REF 243470) is required to output analog 4-20 mA signals from the digital Modbus communication.

Table 4-7 provides an overview of the analog interface parameters and configuration settings in ArcAir application for PCS.

Table 4-7. Overview of the analog interface parameters and configuration settings for a PCS

Parameter	Description	Default value	Configuration	Location
Interface Mode	The output of 4–20 mA can be configured linearly or with a fixed value	4–20 mA linear	Default parameter recommended	mA Interface No. 1 and / or No. 2
Assigned Measurement Channel	The measurement channel can be configured as Glucose or Temperature	Glucose / Temperature	Required	mA Interface No. 1 and / or No. 2
Value at 4 mA	Defined measurement value for 4 mA output	0.00 g/L / 20 °C	Required	mA Interface No. 1 and / or No. 2
Value at 20 mA	Defined measurement value for 20 mA output	25.00 g/L / 40°C	Required	mA Interface No. 1 and / or No. 2
Warning Mode	Current output mode in case of warnings	Off	Default parameter recommended	mA Interface No. 1 and / or No. 2
Error Mode	Current output mode in case of errors	Continuous Error	Default parameter recommended	mA Interface No. 1 and / or No. 2
Warning Value	Current output in case of warnings	3.5 mA	Default parameter recommended	mA Interface No. 1 and / or No. 2

Parameter	Description	Default value	Configuration	Location
Error Value	Current output in case of errors	3.5 mA	Default parameter recommended	mA Interface No. 1 and / or No. 2
Temperature out of range value	Current output in case of the temperature is outside the limit	3.5 mA	Default parameter recommended	mA Interface No. 1 and / or No. 2

4.7.4 Defining a measuring point name for the process identification

1. Start the ArcAir application.
2. Select the desired sensor.
3. Open the **Info** tab. Make sure you have the user rights to configure the **Sensor Settings**.
4. Edit the name of the **Measuring Point** for the process identification.

Table 4-8. Process identification: Define a measuring point name

Parameter	Description	Default value / setting	Parameter remark	ArcAir configuration location
Measuring point	The user can define a sensor name to identify the measuring point.	Sensor REF. No.-Serial No.: 12345678-1234	Optional	Info ► Measuring Point

5 Operation: Integrating the GlucoSense Sensor via a PCS

This chapter provides a detailed description of the recommended setup and integration of the GlucoSense Sensor in a PCS. This chapter is brief because it contains cross-references to previous chapters/sections where the detailed settings and procedures are described.

Integrating and setting up and the GlucoSense Sensor via a PCS

⚠ CAUTION

Operational limits and sensor configuration:

- *Only use the sensor within the specifications. Failure to do so can cause damage to the sensor or incorrect measurement. For additional information about the sensor specification, see the Hamilton Process Analytics website (www.hamiltoncompany.com).*
- *Do not measure glucose at a temperature higher than 80°C. The sensing elements of the GlucoSense Sensor will shut off or cease measurement when the temperature exceeds 80°C, as a built-in protective measure to protect the optoelectronics and enhance the sensor service life.*

1. Remove the protective cap from the GlucoSense Sensor VP8 sensor head.
2. Inspect the sensor: Check that the O-ring on the sensor shaft is seated correctly and that the sensing element and other parts are not damaged (see Section 3.1).
3. Verify the functionality of the sensor (see Section 4.5).
4. Mount the GlucoSense Membrane (see Section 4.3).
5. Install the sensor in a bioreactor (see Section 4.3).
6. Connect the sensor to the Process Control System (PCS) (see Section 4.4).

NOTICE

PCS connection:

Detailed instructions on connecting the sensor to a specific PCS are not provided as the configuration varies widely between different control systems. Section 4.4 provides general electrical wiring guidance.

6 Maintenance

⚠ CAUTION

Safety prerequisite for maintenance:

You must read the Safety Precautions and Hazards in Chapter 2 before you start with the maintenance tasks.

This chapter provides information about the sensor maintenance procedures, including verification, product calibration, cleaning, and firmware update instructions.

All procedures in this chapter must be performed by the operator. For additional maintenance requirements, contact Hamilton Technical Support (see Section 8.3).

6.1 Preventive maintenance

The purpose of preventive maintenance is to identify measurement drifts, detect mechanical issues, and assess whether corrective action is necessary. Regular preventive maintenance includes sensor verification, combined with monitoring the signal from the Quality Indicator (QI). The combination of both verification and QI monitoring ensures that the performance and accuracy of the sensor remain consistent with its specifications over time.

To start the preventive maintenance process via the ArcAir Advanced application, follow these steps:

1. Power the sensor: Connect the GlucoSense Sensor to a power supply via the Arc USB Power Cable (REF 243490) and the USB connector to a standard USB Port on a PC/Notebook.
2. Launch the ArcAir application to connect the GlucoSense Sensor to ArcAir.
3. Navigate to the **Info** tab ▸ **Sensor Quick View** ▸ **Sensor Health** in ArcAir application to check status of the sensor (see Chapter 8).
4. Follow through the troubleshooting procedures to resolve the error if the sensor status indicator is not green (see Section 8.2).
5. Check the quality of the sensor or measurement in ArcAir under the **Info** tab ▸ **Status** or **Sensor Health**.
6. Calibrate the GlucoSense Sensor if required (see Section 6.2).

NOTICE

Sensor service life and Quality Indicator (QI)

- The service life of the GlucoSense Sensor is dependent on the specific conditions of the application. For example, the temperature, pressure, and chemicals used can accelerate the aging of the sensor.
- A "`Sensor Replacement`" warning message will remain active as long as the sensor quality is below 40%. The measurement of the quality status considers warnings and errors associated with the sensor.
- Avoid corrosive media contact with the sensor.

6.2 Product calibration principle

Product calibration eliminates the influence of the background when using user-specific media. The GlucoSense Sensor is factory-calibrated to measure relative changes in glucose concentration in cell culture media. The initial calibration enables the conversion of relative glucose signals into absolute concentration values by compensating for the specific contribution of the cell culture medium. Figure 6-1 provides an overview of the effect of cell media composition on glucose signal: Default Medium vs. User-specific Medium.

Spectral graphs analysis: Default Medium vs. User-specific Medium (see Figure 6-1)

The set of graphs compares the absorption spectra obtained in the sensor's Default medium (e.g., deionized (DI) water) with the spectra obtained in a User-specific medium (e.g., cell culture broth).

Both graphs plot Absorbance (in arbitrary units, AU) against Wave number (in cm^{-1}).

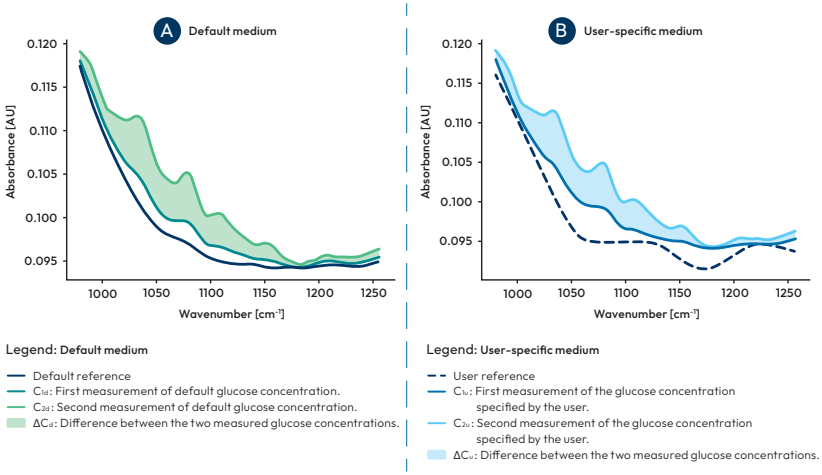
Graph A: Default medium

- Shows the spectral curves for the **Default Reference** and the two measured concentrations, $\mathbf{C}_{1d}$ and $\mathbf{C}_{2d}$.
- The difference between these two measured concentrations is represented by the shaded area, $\Delta\mathbf{C}_{d}$.

Graph B: User-specific medium

- Shows the spectral curves for the **User Reference** and the two measured concentrations, $\mathbf{C}_{1u}$ and $\mathbf{C}_{2u}$.
- The difference between these two measured concentrations is represented by the shaded area, $\Delta\mathbf{C}_{u}$.

Figure 6-1. Spectral graphs showing Product Calibration effect of cell media composition on glucose signal: Default medium (A) vs. User-specific medium (B, Product Calibration)



Significance and Product Calibration

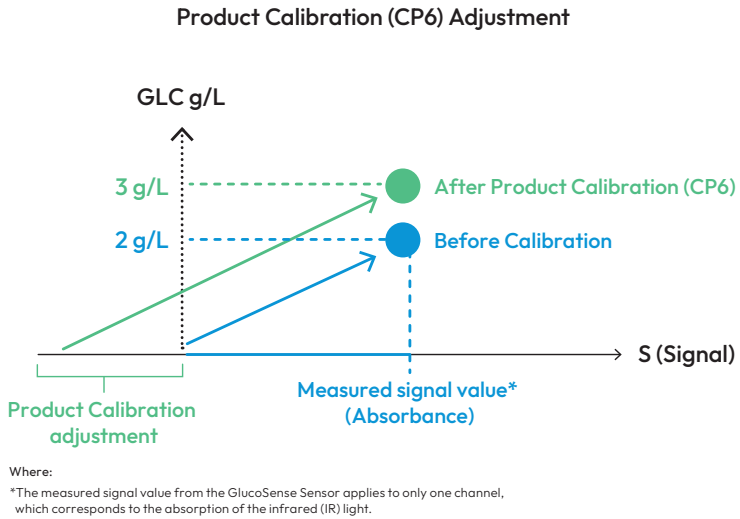
- **Medium dependence:** The absolute concentrations determined from the absorption spectra (C_{1u} , C_{2u} , C_{1d} , C_{2d}) depend on the cell medium composition (reference). Therefore, the spectral curves for the User-specific Medium (Graph B) look significantly different from those in the Default Medium (Graph A).
- **Calibration principle:** The sensor operates on the principle that while the absolute curves change, the differences between the two measured concentrations (ΔC_u and ΔC_d) remain equal ($\Delta C_u = \Delta C_d$) regardless of the background medium.
- **Product Calibration:** The purpose of **Product Calibration** is to perform a transformation using this principle, thus, converting the measurements from the Default Medium (DI water) to the User-specific Cell Medium. This allows the GlucoSense Sensor to report accurate concentration values despite the spectral differences caused by the unique components of the cell culture medium.

Product Calibration adjustment: Calibration Point (CP6)

Figure 6-2 shows a conceptual graph illustrating how a single measured signal is converted into the final glucose concentration. This highlights the need for calibration when switching from a standard medium (e.g., DI water) to a custom medium.

The graph (see Figure 6-2) demonstrates that the **Product Calibration** (**CP6**) effectively offsets the raw signal measurement from the sensor to accurately reflect the actual glucose concentration in the user'-specific medium. This results in a corrected reading of **3 g/L**, which is higher than the uncalibrated reading of **2 g/L** for the same absorption signal.

Figure 6-2. Conceptual graph showing the Product Calibration adjustment: Before Product Calibration vs. After Product Calibration (CP6)



Where:

*The measured signal value from the GlucoSense Sensor applies to only one channel, which corresponds to the absorption of the infrared (IR) light.

Product Calibration conditions and requirements

The Product Calibration procedure compensates for drift that occurs during a process. It is accessed from the **Process** tab in the ArcAir application.

If Product Calibration is activated in ArcAir, the GlucoSense Sensor factory calibration is adjusted with the Product Calibration data (see Figure 6-1).

NOTICE

First use calibration: Sensor setup and Product Calibration reminder

After you have unpacked the GlucoSense Sensor and connected it to the ArcAir application, the sensor will display a calibration reminder message via the ArcAir application and prompt the user to complete the `Product Calibration` before using the sensor for the first measurements.

⚠ **CAUTION**

Mandatory Product Calibration conditions

Product Calibration must be performed in the following cases:

- ***Before cell inoculation:*** *Product Calibration is mandatory before starting the core bioprocess.*
- ***New measurement mode/process:*** *Before using the GlucoSense Sensor for a new measurement mode or process.*
- ***Medium change:*** *When a new medium is added that is different from the medium that was in the bioreactor during the last Product Calibration.*
- ***pH stability/change:*** *When the target pH value of the process changes.*

6.3 Product calibration

GlucoSense Product Calibration requirements and procedure

⚠ CAUTION

Product Calibration requirements

To perform Product Calibration (CP6) correctly and obtain a valid glucose measurement, the following mandatory requirements must be met:

- ***Reference value knowledge:*** *The actual glucose concentration (reference value) in the bioreactor medium at the time of Product Calibration (CP6) must be known. This value is essential for adjusting the sensor output with the specific process conditions.*
- ***Before cell inoculation:*** *Product Calibration is mandatory before starting the core bioprocess.*
- ***Stability check:*** *The calibration can only be completed successfully if the glucose and temperature measurements are stable within predefined limits which can be accessed in ArcAir under* ***Sensor Settings****.*
- ***Default output interpretation:*** *In the absence of a valid Product Calibration, the sensor output over time must be interpreted solely as a concentration deviation relative to the default background value.*

⚠ CAUTION

Product Calibration: Mandatory requirements and precautions

The following Mandatory technical requirements and precautions must be strictly followed when during the Product Calibration (CP6):

- ***Measuring range:*** *Product Calibration is only possible for glucose values in the measuring range of****0–25 g/L****.*
- ***Antifoam addition:*** *If an antifoam agent is added after the first Product Calibration, then a new Product Calibration is required to make sure that the sensor readings remain accurate in the modified cell culture medium.*

NOTICE

Recommended best practices for Product Calibration:

- **Sensor stabilization time:** Allow the GlucoSense Sensor to operate and collect data in the user-specific cell culture media for at least **30 minutes** before you do the Product Calibration. This time ensures that:
  - ► The temperature is stable.
  - ► The moving average has stabilized.
  - ► Sufficient data points have been collected for an accurate calibration.
- **Reference method quality:** For the best results, use a reference value from a validated reference method. The accuracy of this reference method directly affects the measurement accuracy of the GlucoSense Sensor.

To do a Product Calibration via ArcAir application, follow these steps:

1. Mount the membrane: Mount the GlucoSense Membrane as described in Section 4.3.
2. Power the sensor: Connect the GlucoSense Sensor to a power supply using the Arc USB Power Cable (REF 243490) and connect the USB connector to a standard USB port on a PC/Notebook.
3. Launch ArcAir app: Launch the ArcAir application to establish a connection with the GlucoSense Sensor.
4. Select sensor: Select the applicable sensor under the **Sensor** list.
5. Start Wizard: Navigate to the **Process Settings**, then click the **Start** button to start the **Product Calibration Wizard**.
6. Wait for at least **30 minutes** for the GlucoSense Sensor to operate and collect data in the user-specific cell culture media before you do the Product Calibration.
7. Complete Product Calibration: Follow the on-screen instructions in the ArcAir application to complete the **Product Calibration**.

NOTICE

Product Calibration overwrite:

A new Product Calibration overwrites the existing Product Calibration.

NOTICE

On-site Product Calibration via a field mobile device:

Alternatively, the Product Calibration can be performed on-site at the measuring point using a field mobile device. The following Hamilton IP67-rated tablets can be used for the Product Calibration:

- Arc View Mobile Basic (REF 10071111)
- Arc View Mobile Advanced (REF 10071113)

6.4 Product calibration status

Table 6-1. Overview of the Product Calibration status in ArcAir application

Troubleshooting: Product calibration status		
Warning description	Possible cause	Corrective action
Temperature is too low	Temperature during the calibration is below 5°C.	Adjust the temperature accordingly and repeat the calibration process.
Temperature is too high	Temperature during the calibration is above 50°C.	Adjust the temperature accordingly and repeat the calibration process.
Drift temperature	The temperature is unstable during the calibration process.	Stabilize the temperature and repeat the calibration process.
Drift measurement	The Glucose value is unstable during the calibration process.	Stabilize the Glucose value and repeat process.
Assigned value is out of calibration range	The value entered by the user for the calibration limits is outside the acceptable range.	Make sure the value entered for the Calibration is within the acceptable calibration limit.

6.5 Verification

GlucoSense Sensor verification can be done using one of the following methods:

- Hamilton's GlucoSense Verification Kit (REF 10190604-5), which contains:
  - 5 x Setup Solution (Single-use, Sterile-filtered)
  - 5 x Glucose Solution (Single-use, Sterile-filtered)

  NOTICE! Hamilton's standards are verified relative to water baseline.

- Certified glucose solutions in deionized (DI) water, with no other substances present.

To do a GlucoSense Sensor verification, follow these steps:

NOTICE

Recommended verification standards:

We recommend that you use Hamilton's GlucoSense Verification Kit (REF 10190604-5, see Chapter 11) or a certified and traceable glucose standard solution to do the verification.

NOTICE

Sensor verification solutions:

The sensor verification requires two solutions:

- A zero-glucose solution, such as the Hamilton Verification Setup Solution, DI water, or a medium with a **0 g/L** glucose concentration.
- Recommended glucose standard:

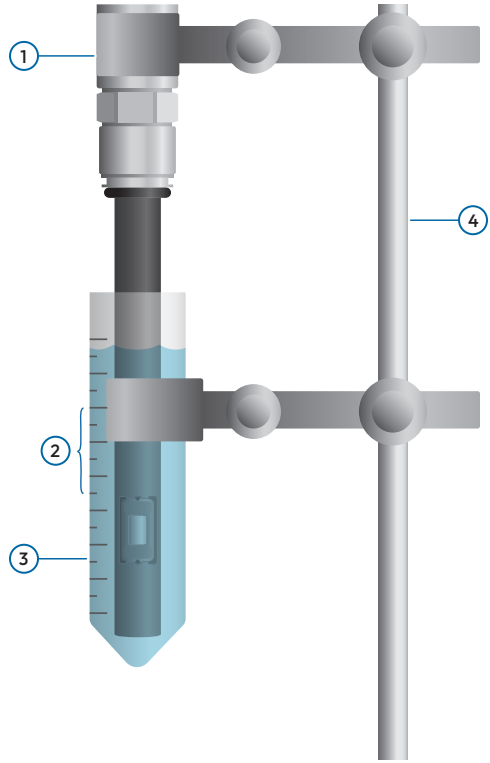
► Hamilton's GlucoSense Verification Kit (REF 10190604-5), see Section 11.2).

► A certified standard solution with a glucose concentration between **0–20 g/L**.

1. Make sure the temperature of the GlucoSense Sensor is stable (ambient condition) before the sensor verification.
2. Secure the Falcon Tube containing the Verification Solution (2) using a Laboratory Stand (4) (see Figure 6-3).
3. Place the GlucoSense Sensor (1) in the Verification Solution (3) and secure it with a Laboratory Stand (4).
4. Make sure that the Verification Solution (3) is at least **2 cm** above the sensing element for consistent and accurate measurement (see Figure 6-3).
5. Power the sensor: Connect the GlucoSense Sensor to a power supply via the Arc USB Power Cable (REF 243490) and the USB connector to a standard USB Port on a PC/Notebook.

6. Launch the ArcAir application to connect the GlucoSense Sensor to ArcAir.
7. Select the applicable sensor under the **Sensor** list.
8. Open the **Verification** tab.
9. Click the **Start** button to start the `Product Verification` wizard
10. First, do the verification preparation using the **Hamilton Setup Solution** or use an alternative **0 g/L** glucose solution.
11. Next, verify the glucose value using the **Hamilton Standard Solution** or a certified and traceable glucose solution.
12. Specify the verification value and tolerance (recommended value: **± 1 g/L**).
13. Follow the on-screen instructions in the ArcAir application to complete the **Verification** procedure.

Figure 6-3. GlucoSense Sensor setup for the verification procedure



1	GlucoSense Sensor secured with a laboratory stand	3	Falcon tube containing verification solution
2	Recommended minimum immersion depth above sensing element: 2 cm	4	Laboratory stand / support stand

6.6 Manual cleaning of the sensor

⚠ CAUTION

General cleaning precautions:

- *Only authorized/trained service personnel can install, operate, clean, calibrate, or maintain the sensor or do other service-related tasks.*
- *Always make sure that the system is depressurized, cold, and free from any potential accidental spillage of the process medium before you remove the sensor from the measuring system.*
- *Always wear protective eyewear and gloves before you remove the sensor from the system (bioreactor) for maintenance, especially in the event of a malfunction where there is a risk of contamination from spilled liquids.*
- *Do not use abrasive tissues or cleaning agents/solutions other than the recommended standard cleaning agents/solutions to clean the Sensor.*
- *We recommend using ethanol and isopropanol to clean the sensor.*
- *You must decontaminate every sensor or product before shipping it back to Hamilton Process Analytics for investigation.*

⚠ CAUTION

Sensing element cleaning and maintenance:

- *The sensing element of the GlucoSense Sensor must be manually cleaned after membrane removal and before starting every new process.*
- *While CIP and other standard cleaning procedures effectively remove cells and debris, they may not completely remove all residues of smaller molecules, for example, protein, DNA, or RNA. To minimize the risk of cross-contamination and maximize the measurement accuracy, additional manual cleaning of the sensing element is required before each new process.*
- *For all procedures, make sure the optical window is clean and free from interfering with particles or scratches. Correct cleaning and maintenance are essential for optimal sensor performance.*

This section outlines the care and maintenance procedures for the GlucoSense Sensor, including a manual cleaning procedure for the sensing element after the removal of the membrane.

The GlucoSense Sensor can be cleaned of cells and sterilized using standard Clean-in-Place (CIP) and Sterilize-in-Place (SIP) procedures. Alternatively, the sensor can be autoclaved, then manually cleaned.

To remove the GlucoSense Membrane, follow these steps:

Refer to Figure 6-4 for the GlucoSense Membrane removal steps.

1. Place the GlucoSense Sensor on a flat, horizontal surface with the membrane facing up.

⚠ CAUTION

GlucoSense Membrane removal safety precautions:

- ***Eye protection:*** *Operators must wear safety goggles before removing the GlucoSense Membrane. This protects the eyes from the potential risk of the membrane flying out from the slot on the sensor shaft.*
- ***Procedural safety:*** *To prevent the GlucoSense Membrane from hitting the operator, the operator must place their thumb over the GlucoSense Membrane during removal. This physical action prevents the component from flying toward the operator.*

⚠ CAUTION

GlucoSense Membrane tool orientation for the membrane removal

- ***GlucoSense Membrane removal: Option A***

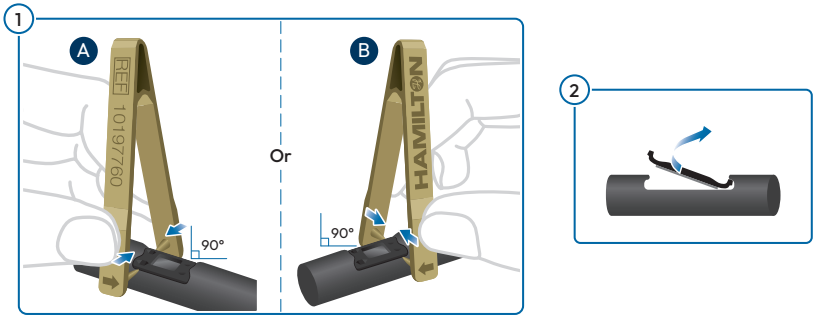
  To remove the membrane from the GlucoSense Sensor shaft using Option A, make sure to position the tool over the membrane at 90° angle, so that the arrows on the sides of the tool point toward the sensor head (see Figure 6-4 – Option 1A).

- ***GlucoSense Membrane removal: Option B***

  To remove the membrane from the GlucoSense Sensor shaft using Option B, make sure to position the tool over the membrane at 90° angle, so that the arrows on the sides of the tool point toward the sensor tip (see Figure 6-4 – Option 1B).

2. Remove the GlucoSense Membrane: place one thumb over the Membrane, then use the GlucoSense Membrane Tool to grip the sides of the Membrane at **90° angle**, and gently squeeze the sides of tool to release the Membrane from the slot on the sensor shaft.

Figure 6-4. Removal of the GlucoSense Membrane from the GlucoSense Sensor



Manual cleaning of the GlucoSense Sensor

To manually clean the GlucoSense Sensor and membrane, follow these steps:

Refer to Figure 6-5: Overview of the cleaning procedure for the GlucoSense Sensor and membrane

1. Remove the sensor from the process setup.
2. Use the GlucoSense Membrane Tool (REF 10197760) to remove the membrane from the sensor (see Figure 6-4).

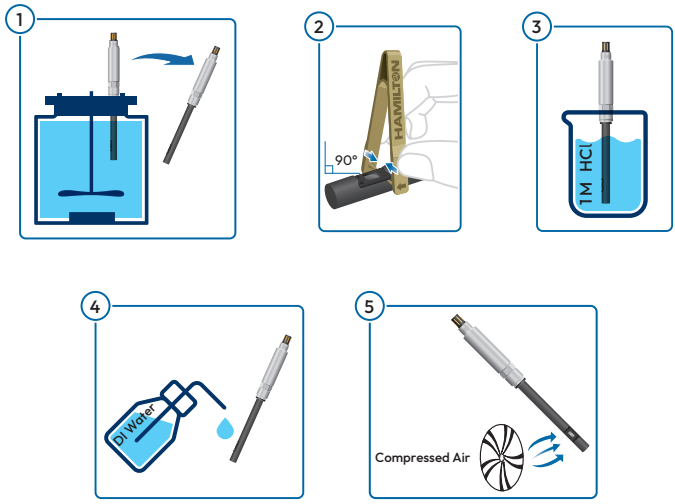
NOTICE

GlucoSense Membrane disposal:

Properly dispose of the used membrane according to the guidelines or protocol of your facility or institution.

3. Dispose of the used membrane.
4. Immerse the sensing element of the GlucoSense Sensor in 1 M HCl for approximately 15 minutes.
5. Rinse the sensor with deionized (DI) water.
6. Carefully clean the Sensing Element Window: Wrap a paper towel around the tip of the tweezer, then use the tweezer to gently clean the corners and edges of the Sensing Element Window.
7. Rinse the Sensing Element with DI water.
8. Use a soft brush to clean the Optical Window.
9. Rinse the Sensing Element with DI water again.
10. Dry all wetted parts, except for the Sensing Element, with a clean, lint-free cloth or tissue.
11. Blow dry the Window of the Sensing Element using compressed air that is dust-free or nitrogen. This will prevent water spots on the Optical Window.
12. Store the GlucoSense Sensor in a dry condition and dry environment.

Figure 6-5. Manual cleaning procedure of the GlucoSense Sensor and Membrane



1	Remove the sensor from the process setup.	4	Rinse the sensor with DI water
2	Use the GlucoSense Membrane Tool (REF 10197760) to remove the membrane from the sensor and dispose of it.	5	Dry the sensing element window with compressed air that is dust-free and oil-free.
3	Immerse sensing element in 1M HCl for approximately 15 minutes		

7 ArcAir Experiment

The ArcAir application allows users to record data measured by the GlucoSense Sensor during operation. This is a common feature for all Hamilton Arc sensors, and the full instructions are provided in the Hamilton Arc Operating Instructions (REF 10071115).

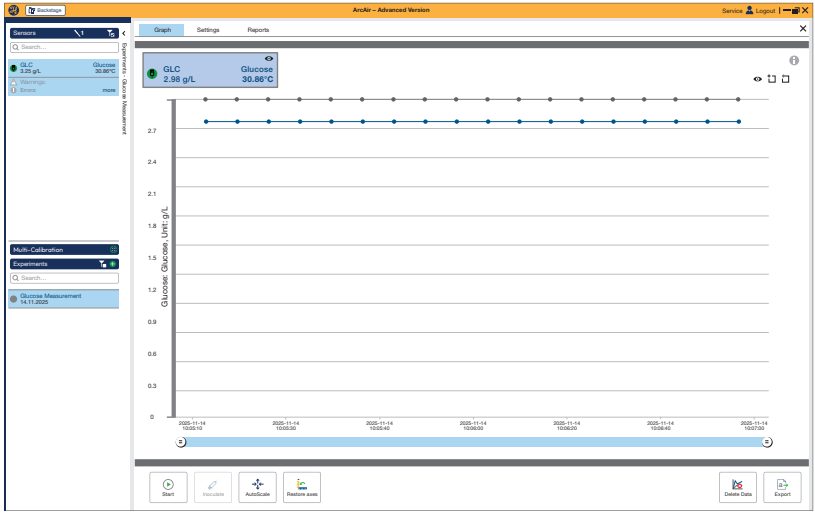
Provided that the ArcAir application is launched (running) on PC/Notebook, the GlucoSense Sensor is connected to the ArcAir application (see Section 4.5), an experiment can be executed. The results can be exported in `.xlsx format`.

7.1 Creating a new experiment

To create a new experiment in the ArcAir application, follow these steps:

1. Start the experiment in ArcAir application by clicking the **Add** button,
2. Configure the experiment by:
   - selecting the applicable sensor(s)
   - naming the experiment (batch name)
   - setting up the data recording parameters (enable or disable).
3. Select the specific parameters like sampling time and temperature source for the GlucoSense Sensor.
4. Define the file path for the data export (`.xlsx format`).
5. Save the settings and parameters, and the experiment starts automatically.

Figure 7-1. Example of ArcAir Experiment feature with GlucoSense Sensor



7.2 Edit an experiment

To edit an experiment in the ArcAir application, follow these steps:

1. Select **Settings** in the **Experiment View**.
2. Adjust the settings according to your requirements.
3. Save the settings.

NOTICE

ArcAir experiment and data export:

- The ArcAir Experiment feature allows users to view sensor measurements in real time, including glucose concentration and the internal temperature of the GlucoSense Sensor. Data from the entire experiment can be exported in an `.xlsx` file.
- In addition to the glucose and temperature measurements, the exported file will also include the absorption signals measured by the detectors of the GlucoSense Sensor (see Chapter 3).

8 Troubleshooting

This chapter provides information on troubleshooting guidelines, tips for self-diagnosis, technical support contact details, and Hamilton's product return procedures.

You must do periodic maintenance routines to ensure safe and reliable operation and measurement with the Arc sensor and its accessories. Make sure that there is no mechanical damage to the sensor tip.

The status/condition of the sensor is indicated by the traffic light identification (ID) system (see Table 8-1).

Table 8-1. Sensor status indicator in ArcAir application: Overview of the traffic light ID system

Sensor status indicator: Traffic light ID system	Description
Green 	• The sensor is functioning correctly. • No errors or warnings have been registered.
Yellow 	• At least a warning has been registered. • Verify the warnings of the sensor under `Sensor Status`.
Red 	• At least an error has been registered. • Verify the error of the sensor under `Sensor Status`.
Gray 	The sensor is offline.

NOTICE

The quality of the sensor is affected by the following factors:

- Warnings
- Errors
- Verification procedure running in ArcAir application.

To resolve a warning or an error, follow these steps:

1. Connect the GlucoSense Sensor by using the Arc USB Power Cable (REF 243490) on a standard USB port.
2. Investigate and resolve the warning or error under the **Sensor Quick View** or **Sensor** list in the ArcAir application.

8.1 Sensor self-diagnostic

⚠ **CAUTION**

Corrective actions for warning and error:

- *You must acknowledge* `Warnings` *by following through with the recommended corrective actions. The required corrective action will vary for each warning depending on the root cause. The warning will be displayed continuously until the corrective action is completed.*
- *You must address sensor* `Errors` *by following through with the recommended corrective actions.*

Arc sensors have an integrated self-diagnostic function that can detect and identify the most common sensor malfunctions. These malfunctions can trigger warning and error messages through various interfaces, including the analog 4–20 mA, digital Modbus, or PC/Notebook connection.

The analog 4–20 mA interface can be configured based on NAMUR recommendations to indicate abnormal events (see Section 4.7.3).

8.2 Sensor status

Sections 6.4, 8.2.1, and 8.2.2 provide an overview of the condition of the sensor via the `Sensor Status` indicator.

NOTICE

Reference manual for troubleshooting the GlucoSense Sensor:

For additional information about the sensor status and the diagnostics features refer to the Troubleshooting chapter of the GlucoSense *RS485 Sensors Programmer`s Manual* (REF 111009574).

8.2.1 Warnings associated with sensor use and routine measurements

The status indicator of the sensor lights up **Yellow** when a warning is registered.

Table 8-2. Overview of the warnings associated with sensor calibration and routine measurements

Troubleshooting warnings: Sensor use and routine measurements		
Warning description	Possible cause	Corrective action
Glucose reading is below lower limit	Glucose reading is too low (possible interference from air bubbles).	• Remove and discard the existing GlucoSense Membrane from the GlucoSense Sensor (see Section 6.6). • Clean the sensing element, and install a new membrane (see 4.3).
Glucose reading is above upper limit	Glucose reading is too high (Glucose value > 25 g/L).	• Remove and discard the existing GlucoSense Membrane from the GlucoSense Sensor (see Section 6.6). • Clean the sensing element, and install a new membrane (see Sections 6.6 and 4.3).
New product calibration recommended	Glucose readings are outside of 0-25 g/L.	Repeat the Product Calibration (see Section 6.2).

Troubleshooting warnings: Sensor use and routine measurements		
Warning description	Possible cause	Corrective action
Product calibration not active	Sensor power cable disconnect from power supply.	⚠ **CAUTION!** *After each initial power-up (power cycle), you must do a Product Calibration for the GlucoSense Sensor.* Repeat the Product Calibration (see Section 6.2).
Temperature reading is below lower limit	The temperature is below the predefined lower temperature limit. If the process temperature is outside this range, the sensor will not perform glucose measurements.	Adjust the lower temperature limit to the predefined temperature value. **NOTICE!** The warning disappears when the temperature of the sensor exceeds the minimum permissible temperature.
Temperature reading is above upper limit	The temperature is above the predefined upper temperature limit. If the process temperature is outside this range, the sensor will not perform glucose measurements.	Adjust the lower temperature limit to the predefined temperature value . **NOTICE!** The warning disappears when the temperature of the sensor falls below the maximum allowable temperature.
Measurement is not running	The applied voltage is too high or too low. **NOTICE!** The operating voltage range of the sensor is between 10 to 27 VDC, or the temperature measurement is outside the user-defined temperature range.	Make sure the sensor operating voltage range is between **10** to **27 VDC**.

Troubleshooting warnings: Sensor use and routine measurements		
Warning description	Possible cause	Corrective action
Sensor supply voltage too low	The applied voltage is too low. **NOTICE!** The operating voltage range of the sensor is between 10 to 27 VDC, or the temperature measurement is outside the user-defined temperature range.	Make sure the sensor operating voltage range is between **10** to **27 VDC**.
Sensor supply voltage too high	The applied voltage is too high. **NOTICE!** The operating voltage range of the sensor is between 10 to 27 VDC, or the temperature measurement is outside the user-defined temperature range.	Make sure the sensor operating voltage range is between **10** to **27 VDC**.
Replace sensor	The sensor is defective, or the sensor Quality Indicator (QI) is below 10%. The quality of the sensor is not sufficient for reliable measurement.	Replace the sensor. For assistance, contact Hamilton Technical Support (see Section 8.3).

8.2.2 Errors associated with sensor calibration and routine measurements

The status indicator of the sensor lights up **Red** when a warning is registered.

Table 8-3. Overview of the warnings associated with sensor calibration and routine measurements

Troubleshooting errors: Sensor calibration and routine measurements		
Error description	Possible cause	Corrective action
Glucose reading failure	Glucose measurement failure.	For assistance, contact Hamilton Technical Support (see Section 8.3).
Temperature sensor defective	The internal temperature sensor is defective.	For assistance, contact Hamilton Technical Support (see Section 8.3).
Temperature reading below minimum	The measured temperature is below the operating temperature.	For assistance, contact Hamilton Technical Support (see Section 8.3).
Temperature reading above maximum	The measured temperature is above the operating temperature.	For assistance, contact Hamilton Technical Support (see Section 8.3).
Sensor is defective	The sensor Quality Indicator (QI) is below 40%. The quality of the sensor is not sufficient for reliable measurement.	We recommend replacing the sensor. For assistance, contact Hamilton Technical Support (see Section 8.3).
Internal communication error	Internal communication error.	For assistance, contact Hamilton Technical Support (see Section 8.3).
Internal communication failure front-end	Internal communication failure front-end.	For assistance, contact Hamilton Technical Support (see Section 8.3).
Internal memory failure. Restart the sensor.	Internal memory failure.	For assistance, contact Hamilton Technical Support (see Section 8.3

8.3 Request for technical support

If a problem persists after you have attempted to correct it, contact Hamilton Technical Support via email (contact.pa.ch@hamilton.ch) or phone (+41-58-610-10-10).

8.4 Returning the sensor for investigation

⚠ WARNING

Sensor decontamination and return procedure:

- Decontaminate the GlucoSense Sensor to remove hazardous materials such as radiation, chemicals, or infectious agents before returning the sensors to Hamilton.
- Provide a complete description of any hazardous materials that have contacted the sensor.

⚠ CAUTION

Returning sensors to Hamilton: Policy and procedure

- *Do not return a sensor to Hamilton without a valid Return Merchandise Authorization (RMA) number. The RMA number ensures that your sensor can be tracked and handled by the correct department.*
- *GlucoSense Sensors returned without an RMA number will be sent back to the customer without investigation.*

Before returning the sensor to Hamilton for investigation, you must contact our Customer Service (see Section 8.3) and request an RMA (Returned Material Authorization) number.

9 Disposal

⚠ CAUTION

Product disposal and recycling:

- *Do not dispose of products at an unsorted waste disposal point.*
- *Hamilton products that are worn out or no longer required must be sent to a dedicated collection point for electrical and electronic devices.*

NOTICE

Return product to Hamilton for disposal:

You can also send the product to Hamilton for disposal.

The design of the Hamilton products optimally considers environmental compatibility and regulations compliance (see Table 9-1).

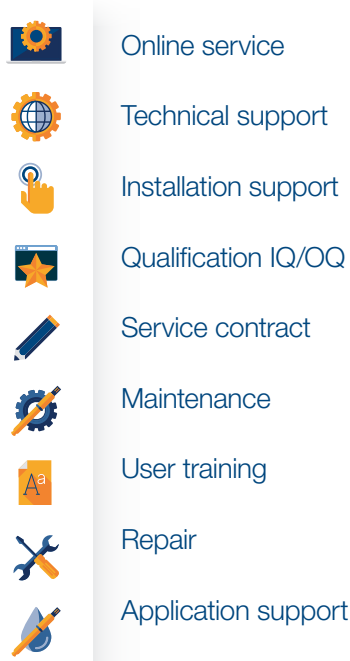
Table 9-1. Symbols used on the product labels and packaging

Symbol	Definition
	Dispose of in accordance with the EU Directive 2012/19/EU or WEEE (Waste Electrical and Electronic Equipment)
	有關危險物質的列表，請參閱 Hamilton Process Analytics 符合性聲明。如需了解更多信息，請訪問 Hamilton 的網站：www.hamiltoncompany.com。 For a list of hazardous substances, see the Hamilton Process Analytics Declaration of Conformity. For additional information, visit the Hamilton website: www.hamiltoncompany.com.

10 Services

This chapter provides an overview of the services offered by Hamilton Process Analytics (see Figure 10-1).

Figure 10-1. Overview of the services provided by Hamilton Process Analytics



Complete service portfolio

To access our complete service portfolio and offering, scan the following QR code:

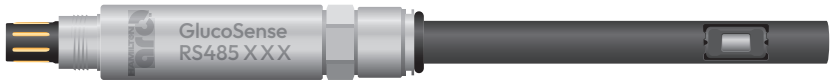
Figure 10-2. QR code for the complete service portfolio of Hamilton Process Analytics

You can also access our complete service portfolio via this link: https://www.hamilton-company.com/process-analytics/services-and-support.

11 Ordering Information

This chapter provides an overview of the different types of GlucoSense Sensors available to order (see Table 11-1).

Figure 11-1. GlucoSense Sensor with Membrane



11.1 GlucoSense Sensors

Table 11-1. GlucoSense Sensor family: Ordering information

Ordering Information			
10184106	GlucoSense Sensor RS485		
	Code	Interface	
	11	Arc (Modbus RS-485)	
		Code	Sensor Length (mm)
		1	120
		3	160
		4	225
		5	325
		6	425
REF 10184106-			Ordering code: REF No. - Code No.

11.2 GlucoSense Accessories

GlucoSense Membrane:

⚠ CAUTION

GlucoSense Membrane: Single-use requirement and replacement

- *The GlucoSense Membrane is designed for a single bioprocess. To ensure the highest measurement accuracy and reproducibility, a new membrane must be installed before starting a new bioprocess.*
- *Replace the membrane according to the instructions in Section 4.3 to ensure the highest measurement accuracy and reproducibility.*

Figure 11-2. GlucoSense Membrane

Table 11-2. GlucoSense Membrane: Ordering information

Ordering Information			
10190449	GlucoSense Membrane		
		Code	GlucoSense Membrane Package
		5	5 x Membrane
REF 10190449-			Ordering code: REF No. - Code No.

GlucoSense Membrane Tool

Figure 11-3. GlucoSense Membrane Tool

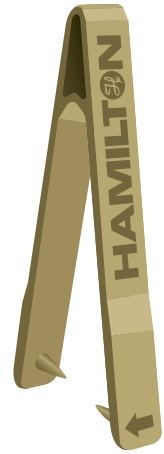


Table 11-3. GlucoSense Membrane Tool: Ordering information

Ordering Information	
10197760	GlucoSense Membrane Tool
	GlucoSense Membrane Tool
	1 x Membrane Tool
REF 10197760	Ordering code: REF No.

GlucoSense Verification Kit: Ordering information

Figure 11-4. GlucoSense Verification Kit

Table 11-4. GlucoSense Verification Kit: Ordering information

Ordering Information			
10190604	GlucoSense Verification Kit		
		Code	GlucoSense Verification Kit
		5	• 5 x Setup Solution (Single-use, Sterile-filtered)* • 5 x Glucose Solution (Single-use, Sterile-filtered)**
REF 10190604-			Ordering code: REF No. - Code No.

***Setup Solution:** The Falcon tubes containing the Setup Solution are identified by a white/neutral screw cap.

****Glucose Solution:** The Falcon tubes containing the Glucose Solution are identified by a red screw cap.

11.3 Parts, accessories, and software

⚠ CAUTION

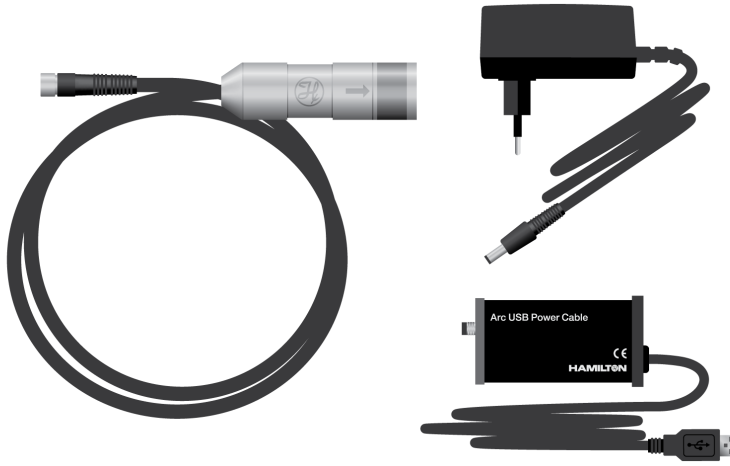
Use original spare parts only:

The following components must be replaced with original spare parts only.

Arc USB Power Cable: USB/VP8 and USB/M12-8 Pole

The Arc USB Power Cable provides power via a USB port for the Arc sensors and digital communication with the ArcAir application for monitoring, configuration, calibration, and firmware updates.

Figure 11-5. Arc USB power cable: USB/VP8 and USB/M12-8 pole connector



REF	Product description
243490-01	Arc USB power cable: USB/VP8 for direct connection to the sensor
243490-02	Arc USB power Cable: USB/M12–8 pole for connection to the sensor with Arc Wi 2G BT Adapter

NOTICE

An additional power supply is supplied with the Arc USB Power Cable in case the PC/Notebook does not provide enough power to power the sensor. A PC/Notebook with a USB 2.0 port or higher can provide sufficient power to the sensor.

Arc View Tablet

The pre-configured Arc view tablet is Hamilton`s solution for monitoring measurement values, calibrating Arc sensors, and configuring various parameters with the unified user interface for pH, DO, Conductivity, VCD, TCD, ORP, CO_2. and Glucose.

The Basic Arc View runs on the Samsung Galaxy Tab Active tablet, and it comes pre-configured with the ArcAir basic software and an app blocker application. The Basic Arc View tablet is supplied with a Power Supply Cable, Operating Instructions, and Hamilton's Quick Start Guide.

The pre-configured Advanced Arc View tablet is Hamilton`s solution for monitoring measurement values, calibrating Arc sensors, and configuring various parameters with the unified user interface for pH, DO, Conductivity, VCD, TCD, ORP, and Glucose.

The Advanced Arc View runs on the Samsung Galaxy Tab Active tablet, and it comes pre-configured with the advanced ArcAir application, including features for CFR 21 Part 11 and Eudralex Volume 4, Annex 11 Compliance, and app blocker application. The Advanced Arc view tablet is supplied with a power supply cable, a manual and Hamilton's Quick Guide.

Figure 11-6. Basic Arc view tablet for non-Ex environments

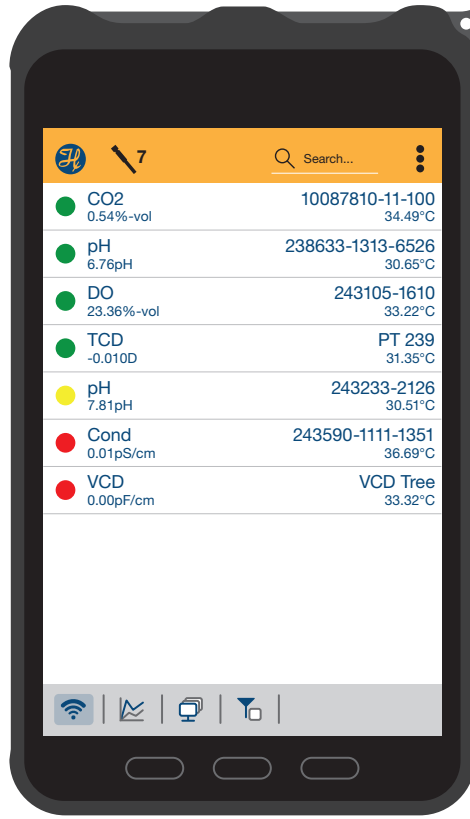


Table 11-5. Arc View Mobile

REF	Product description
10071111	Basic Arc view tablet for non-Ex environments
10071113	Advanced Arc view tablet for non-Ex environments

Arc Wi 2G BT Adapter

The Arc Wi 2G BT Adapter converts Modbus digital communication protocol to 4-20 mA signals and enables Bluetooth® communication for sensor configuration and monitoring.

Figure 11-7. Arc Wi 2G BT adapter

REF	Product description
243470	Arc Wi 2G BT adapter

Phased Out / Discontinued Products:

- Arc Wireless BT Converter (REF 243499)
- Arc Wireless BT Converter Advanced (REF 242333)

The Arc Wireless BT Converter (REF 243499) and Arc Wireless BT Converter Advanced (REF 242333) are no longer offered by Hamilton Process Analytics. We have phased out (discontinued) these two products.

The latest version of the ArcAir application with Bluetooth® update can be downloaded from the Hamilton Process Analytics website (https://www.hamiltoncompany. com/process-analytics). This software update is available for free.

If you require the Arc Wireless BT Converter Advanced (REF 242333) and have ArcAir version 3.8.2 or higher installed, you can use the ArcAir Advanced USB License Key (REF 10155643) to activate the functionality.

NOTICE

Arc sensors configuration via PC/Notebook internal Bluetooth®:

Arc sensors can be configured by using the internal Bluetooth® functionality on a PC / Notebook:

- **Software requirements:** ArcAir versions 3.8.2 and higher support this functionality.
- **Hardware support:** The Arc sensor configuration can be done using the internal Bluetooth® chip on the PC or by connecting a third-party USB Bluetooth® device.

Sensor Data Cable: VP8 Double Coaxial / Open-end Data Cable

The VP8 Sensor Data Cable with open-end wires is designed to enable interface connection between the sensor and a data recorder, indicator, control unit, or PCS with an analog I/O (input/output).

Figure 11-8. Arc sensor data cable: VP8 double coaxial / open-end wiring

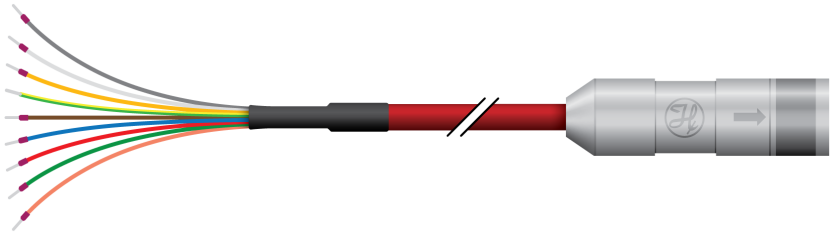


Table 11-6. VP8 double coaxial / open-end data cable

REF	Product description	Length (m)	Interface
355263	VP8 double coaxial / open-end data cable	1 m	4-20 mA/Modbus
355264	VP8 double coaxial / open-end data cable	3 m	4-20 mA/Modbus
355265	VP8 double coaxial / open-end data cable	5 m	4-20 mA/Modbus
355266	VP8 double coaxial / open-end data cable	10 m	4-20 mA/Modbus
355267	VP8 double coaxial / open-end data cable	15 m	4-20 mA/Modbus
355268	VP8 double coaxial / open-end data cable	20 m	4-20 mA/Modbus

Sensor Data Cable: VP8 Open-end / 4-Wire Data Cable

Table 11-7. VP8 open-end / 4-wire data cable

REF	Product description	Length (m)
10109026	VP8 open-end / 4-Wire data cable	1 m
10109251	VP8 open-end / 4-Wire data cable	3 m
10109250	VP8 open-end / 4-Wire data cable	5 m

M12-8 Pole Open-end Cable

The M12 8-pin sensor cable with open ends serves as an important interface between the sensor and various data processing devices. It enables the sensor to be connected to systems such as data recorders, display devices, control units, or process control systems (PCS) with analog inputs/outputs (I/O).

Figure 11-9. M12 8-Pole with open-end cable

REF	Product description	Length (m)
355320	M12 8-pole / open-end cable	3 m
355321	M12 8-pole / open-end cable	5 m
355322	M12 8-pole / open-end cable	10 m

ArcAir application download

Download the ArcAir application from the App Store or Google Play.

Figure 11-10. ArcAir application download from the App Store or Google Play

autoclave

Autoclaving is a sterilization process that uses pressurized, saturated steam or water at high temperatures (typically 121 ◦ C for 20 minutes) to eliminate viable microorganisms on the sensor before use.

CIP

Cleaning in Place (CIP) is a cleaning procedure used for cleaning the interior or contact surfaces of process pipes, vessels, and processing equipment without disassembly. The CIP helps remove debris and microorganisms from the pipework and processing equipment.

CP6

CP6 (Calibration Point 6) is a product calibration adjustment to the initial factory calibration (CP 1-5) done at Hamilton premises.

DLC

Diamond-like carbon (DLC) is an amorphous carbon material with properties similar to diamond, such as high hardness, chemical inertness, and low friction. It is often applied as a protective coating to other materials to improve their wear resistance and performance.

IR

Infrared (IR) refers to light at the red end of the electromagnetic spectrum (set of colors into which light is separated), which cannot be seen by human beings, and which gives out heat

MVDA

Multivariate Data Analysis (MVDA) refers to a set of statistical techniques used to analyze dataset that contains multiple variables to identify patterns, relationships, and interactions among these variables simultaneously.

PCS

A Process Control System (PCS) is a computerized system that provides autonomous control of the process at a process plant on the customer's site.

SCADA

Stands for Supervisory Control and Data Acquisition (SCADA). It is a control system architecture with layered control options for managing and operating project-driven processes. The PCS is on level one of five of the control operations.

SIP

Sterilization in place of a bioreactor (SIP) is mainly used for bigger bioreactors that do not fit into an autoclave. This process of sterilization requires an external steam line.

Wi-Fi

Wi-Fi is a networking technology that uses radio waves to allow high-speed data transfer over short distances. Wi-Fi networks allow devices such as computers, mobile devices, and other equipment to interface with the Internet, and exchange information with each other.

More information and free software simulation:
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