

CO_2NTROL Sensors

Operating Instructions

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HAMILTON

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The liability of Hamilton Bonaduz AG is detailed in the *General Terms and Conditions of Sale* (GTS) document. Hamilton is expressly *not* liable for direct or indirect losses arising from the use of the sensors. It must in particular be insured in this conjunction that malfunctions can occur on account of the inherently limited useful life of sensors contingent upon their relevant applications.

The user is responsible for the calibration, maintenance, and regular replacement of the sensors. Hamilton recommends regular calibration of the sensor. In the case of critical sensor applications, Hamilton recommends using backup measuring points to avoid consequential damages. The user is responsible for taking suitable precautions in the event of a sensor failure.

Hamilton Warranty

To download the latest version of the GTS, visit the Hamilton Process Analytics website: https://www.hamiltoncompany.com/general-terms-and-conditions#purchase

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Document History

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Manual revision No.	Date of issue	Change summary
00	February 2021	The first release of the CO_2NTROL Sensor Operating Instructions
01	August 2021	All chapters and sections have been updated

Manual history for REF No. 111011046 [New]		
Manual revision No.	Date of issue	Change summary
00	March 2025	• Manual REF No. changed from 10102766 (obsolete) to **111011046** (new) • Manual contents have been migrated to SCHEMA ST4 Component Content Management System (CCMS) • New layout design: Improved look and feel • The content has been restructured and revised to improve comprehension and usability. • All chapters and sections have been updated

Preface

CO_2NTROL Sensor documentation suite

This manual is part of a documentation suite that includes the following documents:

Table 1. CO_2NTROL Sensor documentation suite

Document title	Description	Manual REF
CO_2NTROL *RS485 Sensors Operating Instructions (this manual)*	Provides detailed information about installing and setting up the sensor, as well as additional technical information.	10102766
CO_2NTROL *RS485 Sensors – Modbus RTU Programmer's Manual*	This manual is intended for software programmers. It provides detailed information about the CO_2NTROL RS485 Sensors Modbus RTU interface as well as general information about Modbus command structures and their implementation in the Hamilton Arc sensors family.	111003564
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.
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 numeric 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 directly 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 CO_2NTROL Sensor and the operating instructions.

Check the sensor 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 CO_2NTROL Sensor, it is essential that both operating and service personnel follow generally accepted safety procedures as well as the safety instructions given in this document, the CO_2NTROL 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 CO_2NTROL 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 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 has to be returned to Hamilton for investigation, as described in Section 7.3. Necessary precautions should be taken when transporting sensors. To return the sensor back to Hamilton for investigation, you must use the original reusable packaging for shipment. Every CO_2NTROL 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 of our manufacturer's warranties become void.

1.1 Intended use

⚠ WARNING

The CO_2NTROL Sensor is not intended for hazardous atmospheres.

The CO_2NTROL Sensors are intended for the measurement of dissolved carbon dioxide (dissolved CO_2) or carbon dioxide in gas phase.

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

NOTICE

- The measurement values transmitted over wireless communication are not intended to be used for process control.
- The CO_2NTROL Sensors are intended for use in an industrial electromagnetic environment and comply with IEC / EN 61326-1.

1.2 About these operating instructions

The CO_2NTROL Operating Instructions are intended to guide users to operate the CO_2NTROL Sensor in combination with the ArcAir application (version 3.7 or higher) correctly and safely. The operating instructions also describe the different components and functions of the CO_2NTROL Sensor and the ArcAir application.

These operating instructions provide an in-depth description of both the hardware and software of the CO_2NTROL 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 CO_2NTROL Sensor with the ArcAir application. After reading this manual, the user should be able to install and operate the CO_2NTROL Sensor with the ArcAir application.

To quickly resolve some of the most common problems, see Chapter 7.

1.3 General precautions

For safe and correct use of the CO_2NTROL Sensor, both operating and service personnel must follow the generally accepted safety procedures and the safety instructions given in the Operating Instructions of the CO_2NTROL Sensor. The specifications provided for temperature and pressure must not be exceeded. Inappropriate use or misuse can be dangerous.

Operating conditions, cleaning, assembly, and maintenance shall be performed by trained personnel. Before removing the sensor from the measuring setup, always make sure that no process medium can be accidentally spilled. The vessel shall have no over-pressure and be cooled down.

When removing and cleaning the sensor, it is recommended to wear safety goggles and protective gloves. 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 voids all the manufacturer's warranties.

2 Safety Precautions and Hazards

This chapter provides safety information and technical-related information about the CO_2NTROL Sensor.

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

⚠ CAUTION

- *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 impair 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) sensors

⚠ CAUTION

- *The CO_2NTROL Sensor has multiple built-in temperature sensors (NTC 22 kOhm) to compensate for the temperature effects on the optical elements caused by the environment and the light source. Thus, the temperature sensors are used to monitor the sensor condition, but are not intended for controlling the process temperature.*
- *The measurement values transmitted over wireless communication are not intended to be used for process control.*

Sensor handling

⚠ CAUTION

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

Sensor's material compliance

NOTICE

- The shaft of the CO_2NTROL Sensor is made of stainless steel, which complies with biopharma requirements, thus, **stainless steel 1.4435**. Different stainless steel heat numbers may be used due to minor variations in the manufacturing processes. The heat numbers are engraved on the stainless steel shaft of the sensor.
- For wetted steel surfaces > 1%, the corresponding Material Inspection Certificate EN 10204–3.1 can be downloaded from the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics).

2.1 Operating precautions CO2TROL Sensors

⚠ **CAUTION**

- *Only authorized/trained service personnel can install, operate, clean, calibrate, or maintain the sensor or do other service-related tasks.*
- *The CO_2NTROL Sensor and its accessories such as the Arc Wi 2G BT Adapter or Advanced/Basic Arc View Tablet must be used for the intended applications and in optimum safety and operational conditions. The customer has to validate the sensor to determine if it qualifies for the intended application.*
- *Make sure that the PG 13.5 thread process connections and the O-rings are not damaged when screwing a sensor into the process. The O-rings are consumable parts that must be exchanged regularly (at least once a year).*
- *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.*
- *Gases or liquids can escape unnoticed wherever seals or screws are installed. Always make sure that no process medium can be accidentally spilt before removing the sensor from the process setup.*
- *Even when all required safety measures have been complied with, potential risks still exist concerning leaks or mechanical damage. Wherever there are seals or screws, gases or liquids can leak out undetected. Do not put stress such as vibration, bending, or torsion on the system.*
- *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 procedures as the sensor can become very hot.*

⚠ CAUTION

To extend the service life for the sensor:

- *Prevent corrosive media contact with the sensor.*
- *Put the protective cap on the VP8 connector head of the sensor after you have disconnect 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 comes into contact with gaseous or liquid organic solvents, the accuracy of the resulting measurement must be checked separately in the application and validated by the customer.

Make sure that the following cross-sensitivities and resistance of the CO_2NTROL Sensor wetted parts are observed.

Cross-sensitivities and resistance

Cross-sensitivities and resistance of the CO_2NTROL Sensor wetted parts	
Wetted parts are resistant to	Lipophilic compounds
	Standard cleaning and disinfectant solutions (NaOH, Active Chlorine, Chlorine Dioxide)
	Organic solvents such as Ethanol, Isopropyl Alcohol, and Acetone

2.2 Electrical safety precautions

⚠ WARNING

- 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 altering the setup.

NOTICE

The PCS will show incorrect readings when the power supply (24 VDC) is tuned off or disconnected.

Minimize electromagnetic fields and static electricity

Keep the CO_2NTROL 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 all the instructions in Section Installing CO2NTROL in a Measuring Loop Section to prevent electrical damage to the 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 Chapter 10.2). 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 CO_2NTROL 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 Option A system setup:

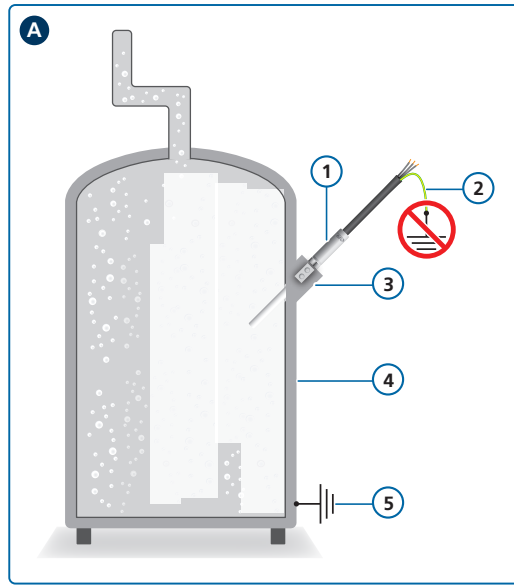
- *Do not double ground/earth the sensor and the metallic bioreactor at the same time. This can create a grounding loop in the system and can cause damage to the sensor.*
- *You must ground only the metallic bioreactor for the Option A system setup.*

NOTICE

- 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 B must be used if the glass or plastic tank bioreactor is not connected to earth.

Option A: Metal tank with earth/ground connection

Figure 2-1. Overview of the CO_2NTROL Sensor installed in a metallic bioreactor: Sensor is grounded via the bioreactor [Option A]



1. CO_2NTROL 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.*

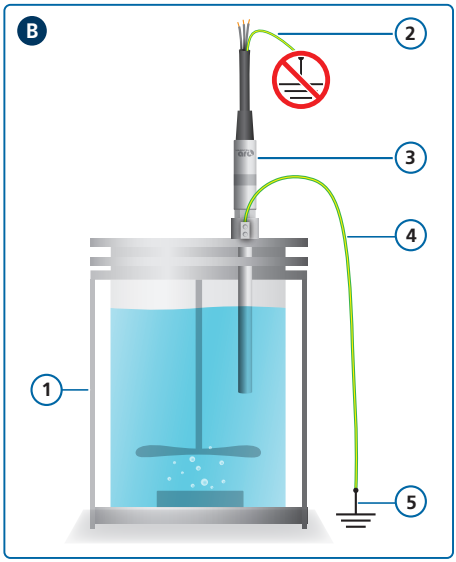
Option B: Glass, plastic tank, or bentchtop bioreactor without earth/ground connection

⚠ CAUTION

Ground/earth connection for Option B system setup:

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 VP8 earth/ground cable (yellow/green).

Figure 2-2. Overview of the CO_2NTROL Sensor installed in a glass, plastic tank, or benchtop reactor setup without earth/ground connection [Option B]

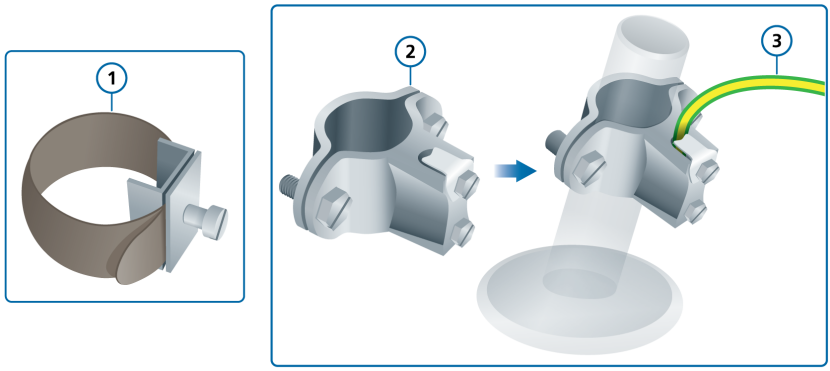


1. Glass, plastic tank, or benchtop reactor
2. VP8 earth/ground cable (yellow/green)
3. CO_2NTROL Sensor
4. Earth/ground cable (green/yellow) for the metallic parts (sensor shaft and clamp)
5. Metallic parts earth/ground

Examples of grounding clamps

Figure 2-3 show 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

⚠ WARNING

You must observe and follow the maintenance procedures. Pay attention to the cleaning and decontamination procedures if you work with hazardous liquids. Avoid any contact of the equipment with corrosive media.

⚠ CAUTION

- *You must clean the CO_2NTROL Sensor if it becomes contaminated with biohazardous, radioactive, or chemical material.*
- *Failure to observe and follow the maintenance procedures can decrease the reliability and the correct functionality of the system.*

The selection of the appropriate biological safety level and implementation of the required biosafety measures for working with CO_2NTROL Sensor is the sole responsibility of the user.

3 Product Description

The CO_2NTROL Sensor is an Optical Infrared (IR) dissolved carbon dioxide (CO_2) sensor for process measurement. With an integrated transmitter, the CO_2NTROL Sensor enables direct communication to the Process Control System (PCS) via digital Modbus and optionally via 4-20 mA interface using the Arc Wi Adapter 2G BT (REF 243470).

The Arc Wi adapter enables Bluetooth® wireless communication, which can be used for the sensor monitoring, configuration and calibration. This saves time without compromising the quality of the wired connection. A CO_2NTROL Sensor with Arc Wi adapter enables wireless communication with iOS/Android smart phones, or tablets, and computers (Windows®).

The CO_2NTROL Sensor Optical IR technology improves the measuring performance and simplifies maintenance. Improvements compared to conventional electrochemical (Severinghaus) sensors include:

- Higher accuracy
- Resistance up to 140 °C SIP temperatures
- Detection of CO_2 only, with no interference from other volatile molecules such as H_2S, NH_3, or SO_2
- Simplified maintenance (no need to replace parts or consumables through the service life of the CO_2NTROL Sensor)

With the integrated microtransmitter, the CO_2NTROL Sensor provides more reliable measurements directly to a PCS or via the Hamilton ArcAir application. The microtransmitter in the sensor head stores all the relevant sensor data, including calibration and diagnostic information. This simplifies calibration and maintenance procedures. The integrated quality indicators predicts the remaining sensor service life and measurement quality.

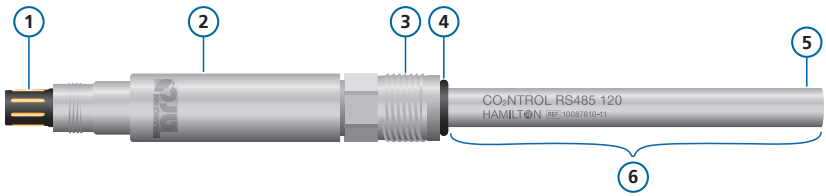
3.1 Hardware description

The CO_2NTROL Sensor consists of a sensor head with integrated electronics and a sensor shaft in contact with the measured medium. The shaft incorporates a sensing element which uses Hamilton's innovative solid-state design. This enables the accurate measurement of carbon dioxide molecules, due to its optimum hygienic design. All wetted parts comply with FDA and USP VI requirements. The CO_2NTROL Sensor is EHEDG certified.

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 Number** of the sensor can be found on the shaft of the sensor.

The measuring components of the sensor are located at the tip, comprising the light-source, IR detector, and solid state sensing element. (see Figures 3-1 and 3-3).

Figure 3-1. Overview of the CO_2NTROL Sensor



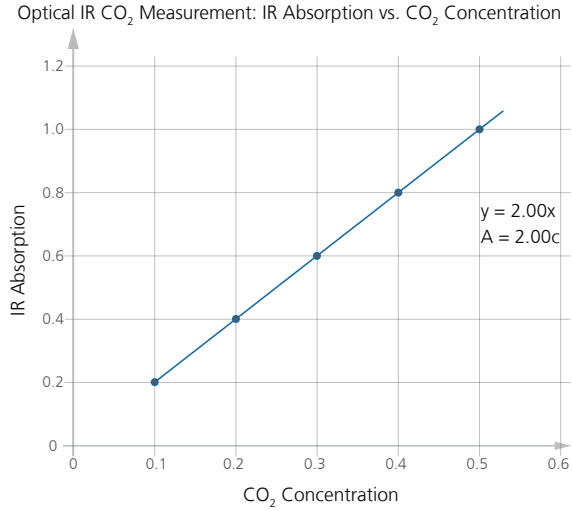
1.	VP8 connector	4.	O-ring
2.	Sensor head with integrated microtrans-mitter	5.	Sensing element (For details, see Figure 3-3)
3.	Process connection with PG 13.5 nut/ thread stainless steel	6.	Sensor shaft with Heat Number, REF Number, and Serial Number (SN)

3.2 Measuring principle: Optical IR CO2 measurement

The CO₂NTROL Sensor optical measurement principle is based on molecular infrared (IR) spectroscopy. Molecules such as CO_2 interact with very specific IR electromagnetic radiation by absorbing part of the radiation according to the Beer-Lamber law.

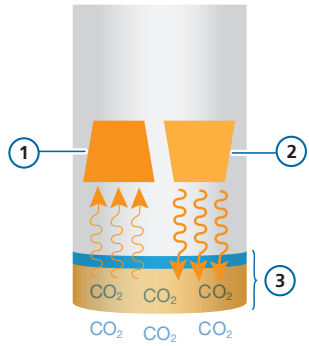
The higher the carbon dioxide content, the more IR radiation is absorbed. Measuring the CO_2 radiation absorption (the optical IR signal), allows the amount of CO_2 to be quantified as shown in Figure 3-2.

Figure 3-2. Example of CO_2 dependent absorbance measurement



The solid-state design of the CO₂NTROL sensing element, as shown in Figure 3-3, enables the accurate measurement of CO_2 partial pressure in both gas or liquid phase. The partial pressure above the liquid is proportional to CO_2 concentration in a liquid according to Henry's law. Therefore, it is possible to use the optical IR signal of the CO₂NTROL Sensor to measure dissolved CO_2 and partial pressure.

Figure 3-3. Overview of the CO_2NTROL sensing element



1. IR detector
2. Light source
3. Solid state sensing element

NOTICE

After the CO_2NTROL Sensor is turned on, it takes approximately 300 s to stabilize and adjust to the temperature due to the IR technology used.

3.3 CO2NTROL Sensor with an integrated microtransmitter

With the integrated microtransmitter, the CO_2NTROL Sensor offers fully compensated signal directly to the PCS. Communication protocols include digital Modbus and optional 4-20 mA, using the Arc Wi 2G Adapter BT (REF 243470).

The microtransmitter in the sensor head stores all relevant sensor data, including calibration and diagnostic information. This simplifies calibration and maintenance.

3.4 Using the CO2NTROL Sensor in a GMP environment

For additional information about using the CO_2NTROL 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 CO_2NTROL Sensor and its hardware as well as the ArcAir application.

4.1 Unpacking the sensor

⚠ CAUTION

- *Always handle the sensor with care.*
- *Verify the functionality of the sensor before use if the sensor is accidentally dropped when outside of the Hamilton original packaging. For details about troubleshooting (see Chapter 6).*
- *Contact Hamilton Technical Support if you experience warning and error messages with the sensor.*

NOTICE

- The Material Certificate 3.1 for the stainless steel can be accessed via a URL link or a QR code printed on the DoQ.
- The EU and UKCA Declaration of Conformity document (REF 111003489) for the CO_2NTROL Sensor can be downloaded from Hamilton website (https://www.hamiltoncompany.com/process-analytics).
- The Operating Instructions for the CO_2NTROL Sensor can be accessed by scanning the QR code on the card included in the product packaging.

1. Carefully unpack the CO_2NTROL Sensor. Inside the packaging, you will find the CO_2NTROL Sensor, Declaration of Quality (DoQ), and Operating Instruction Access Card.
2. Inspect the sensor for transport damage or missing parts.

Figure 4-1. Overview of the CO_2NTROL Sensor delivery package contents



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.

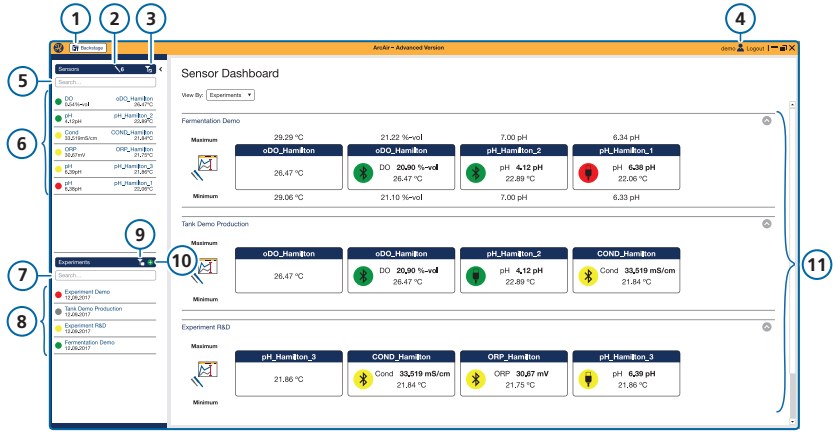
The ArcAir application can be installed on various devices, including computers, tablets, and mobile phones to provide users with an overview of all the Arc sensors in the operational environment. The ArcAir mobile version only supports the most important workflow. Note that data recording and display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

NOTICE

- For additional information about the ArcAir application and the general workflow of the ArcAir application, refer to the *Hamilton Arc Operating Instructions* (REF 10071115).
- We highly recommend that you use a screen/display with a minimum resolution of 1280 x 768 pixels.
- ArcAir v3.7 or higher is required to use the CO_2NTROL Sensor.

Overview of the ArcAir application (PC version) main screen

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

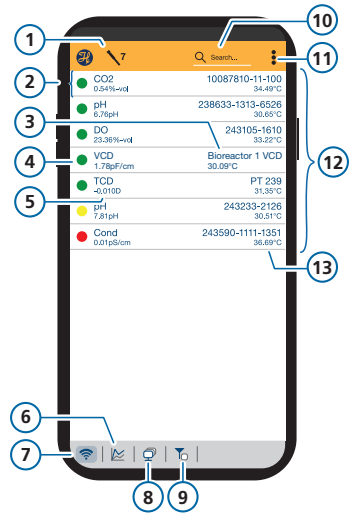


1	Backstage tab: You can access the user profile, manage passwords, sensor groups, mobile connection, Firmware update, audit trail, and electronic signatures	7	Experiment search field: Use the field to search for sensors used in an experiment
2	Number of sensors online	8	Overview of the list of sensors used in an experiment
3	Filter icon: Use the filter to specify or refine your search for the sensor list	9	Filter icon: Use the filter to specify or refine your search for the sensor list under experiment
4	User profile name/account	10	Create 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, Bioreactor 1 TCD/VCD.

4 Sensor status indicator:

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

11 ArcAir licenses and other information related to the sensor

	• **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		
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

For additional information about the Sensor Status Indicator, see Chapter 7.

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

- The initial operation of ArcAir will be in laboratory mode until a user account is created. Lab mode does not require a login password and allows all functions of the installed license version.
- The first user is the administrator and all user rights are assigned by default.

1. Start the ArcAir application on the computer.
2. Click the **Backstage** 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

Make sure that all configurations and experimental data are exported and saved before a new software version is installed.

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 CO_2NTROL Sensor can be combined with different hardware accessories from the Arc portfolio for specific applications.

All listed accessories for the CO_2NTROL 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 CO_2NTROL 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 senors.

- **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

- **Modbus connection**

  To get a better overview of what is required to connect your sensor to the existing control system, see Section 4.4.

4.3 Installing the CO2NTROL Sensor in a bioreactor

There are different ways of installing the CO_2NTROL Sensor into the reactor depending on the type of bioreactor. There are various housings available to custom-fit the sensor in every installation.

1. Remove the yellow protective caps from the VP8 head of the sensor .
2. Inspect the CO_2NTROL Sensor:
   - Check the O-ring on the sensor shaft.
   - Check if the sensing part (optical path) is free of damage and dirt particles.

⚠ CAUTION

- *The gas bubbles from the media can interfere with the measurement while installing the CO_2NTROL. We recommend that you revalidate the positioning regularly and make adjustments if necessary.*
- *Make sure the sensing part of the sensor is always submerged fully in the medium.*
- *Make sure the sensor does not rotate out of the defined position when you attach the power cable.*
- *Do not use mechanical or power tools to tighten the CO_2NTROL Sensor during the installation.*
- *Do not use the Arc Wi BT Adapter to unscrew the sensor from the reactor.*
- *Tighten the sensor by hand when it is installed via the side wall port (stainless steel PG 13.5 thread) on the bioreactor. The torque must not exceed 2 Nm.*

⚠ CAUTION

Insertion depth of the sensor when installed in Kleenpak™ Bellow Assembly or similar sub-probe bellow assembly:

Make sure that the insertion depth of the sensor in the bioreactor is sufficient to allow adequate fluid/media flow around the sensing element when installed in a Kleenpak™ Bellow Assembly or similar sub-probe bellow assembly similar connector or housing. The further the sensing element goes into the fluid/media, the better the temperature measurement.

3. Carefully install the sensor in the port on the bioreactor and make adjustments if necessary.
4. Tighten the sensor by hand. The torque must not exceed 2 Nm.

NOTICE

The notch on the VP8 head serves as an alignment guide for the sensor and the measuring gap (see Section 4.4.1).

CO_2NTROL Sensor configuration with the Arc Wi adapter

⚠ CAUTION

- *Do not use a manual or mechanical tool to install or remove the CO_2NTROL Sensor. Using a manual or mechanical tool to install or remove the sensor can cause damage to the sensor.*
- *Do not use the Arc Wi BT Adapter to unscrew the sensor from the reactor.*

The notch on the sensor head will determine the connection orientation of the two components if the CO_2NTROL Sensor is combined with the Arc Wi Adapter (see Figure 4-5). This orientation should be individually adapted to the process conditions. For example, signal quality and the distance between other reactor components.

4.4 Connecting the CO2NTROL Sensor to a process control system

Hamilton offers a wide range of options for integrating the sensors into a variety of process setups. For additional information about the CO_2NTROL Sensor integration options, see Sections 4.4.1, 4.4.2, and 4.4.3.

The mechanical design of the CO_2NTROL Sensor makes it compatible with Hamilton process housings, such as FlexiFits, FlowCells, Retractex retractable housings, and Hygienic Sockets. For information on the process housings offered by Hamilton Process Analytics (see Table 10-4).

NOTICE

Housings with cable protection, such as Retractofit, cannot be used for sensors with an Arc Wi 2G BT Adapter installed. In these cases, you must remove the cable protection from the housing.

Sensor installation tips

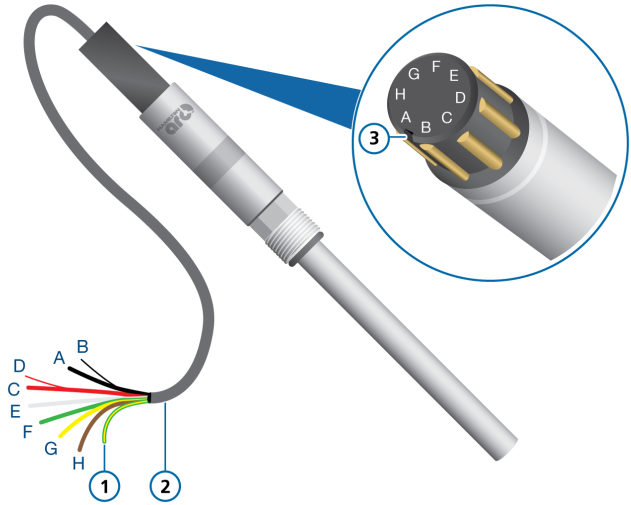
- Before you install the housing, you must test the seal for tightness and the functionality of the sensor parts.
- Make sure that there is no damage to the sensor or the housing.
- Make sure that each O-ring is in the appropriate groove and not damaged.
- To prevent mechanical damage to O-rings, apply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

4.4.1 VP8 or M12 Pin assignment

Always use Hamilton VP8 sensor cables for safe connection. The VP8 sensor cables are available in different lengths (see Chapter 10). The CO_2NTROL 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 4-4).

Figure 4-4. CO_2NTROL 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, as 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 CO_2NTROL Sensor electrical connection.

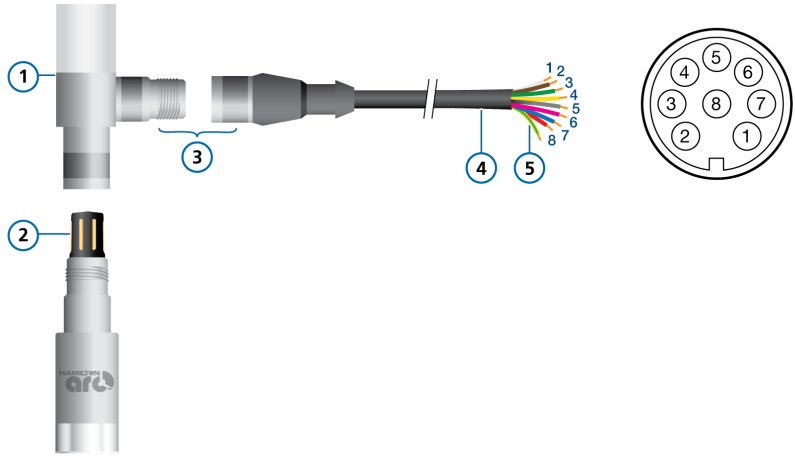
Table 4-1. Arc sensor head connector: VP8 connector Pin assignment

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 CO2NTROL Sensor via 4-20 mA analog interface

Connecting an Arc Wi 2G BT Adapter (REF 243470) to the CO_2NTROL 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 10).

Figure 4-5. 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 CO_2NTROL 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 CO_2NTROL Sensor. The interface has to be configured according to the requirements of the user. The CO_2NTROL Sensor is pre-configured with default values for the 4-20 mA and measurement unit.

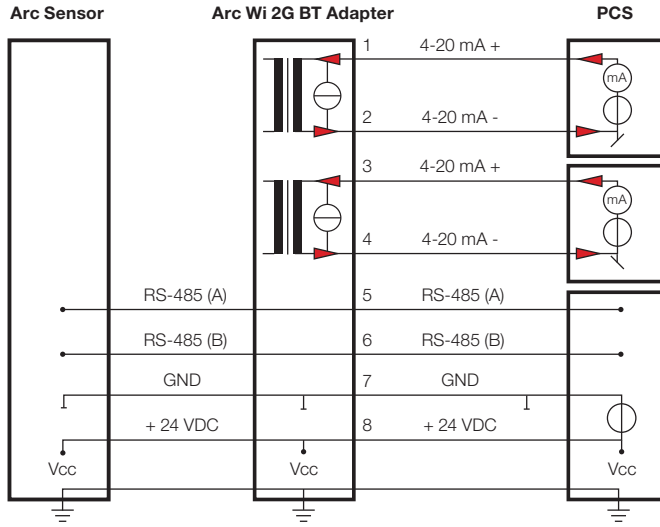
Connect the sensor according to the Pin assignments (see Sections 4.4.1 and 4.4.2).

⚠ CAUTION

- *The PCS connection with an active 4-20 mA input card setup is the safest form of wiring an Arc sensor.*
- *The Arc Wi 2G BT Adapter (REF 243470) provides internal galvanic isolators for enhanced analog signal quality as well as simplified connection to the PCS.*
- *The PCS requires an active 4-20 mA input card.*

PCS configuration with an active 4-20 mA input card

Figure 4-6. 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 CO2NTROL 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.

The 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 Figure 4-4).

Additional information: Modbus RTU communication protocol

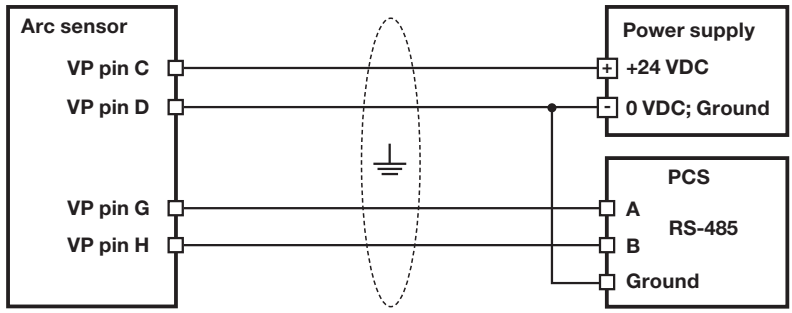
- The Modbus RTU communication protocol corresponds to the Modbus-IDA standard. For more information, refer to the Modbus organization website (https://modbus.org/). The Modbus physical layer is described in detail with requirements on cabling and line termination in the *Modbus Serial line Protocol 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 CO_2NTROL Sensor via Modbus, refer to the CO_2NTROL RS485 Sensors *Programmer's Manual* (REF 111003564).

⚠ CAUTION

- *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, we recommend that you connect the VP cable shield to the earth (see Section 2.2). This significantly reduces noise interference and improves the signal quality.*

Example of the circuit arrangement

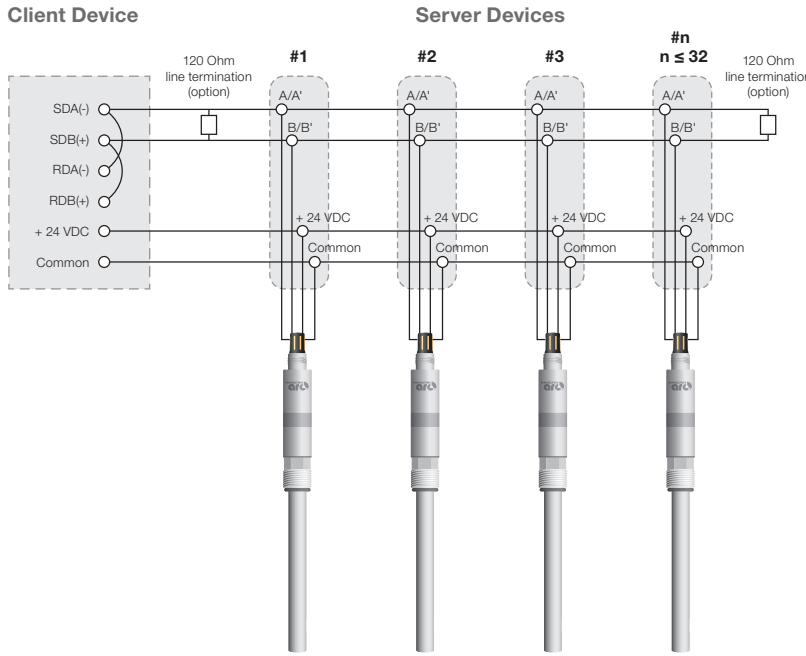
Figure 4-7. Wiring diagram for the RS-485 interface



⚠ CAUTION

You must assign a unique Modbus device address to each sensor for the correct communication in the wiring configuration shown in Figure 4-8.

Figure 4-8. Multi-drop bus wiring: Two-wire mode for the Modbus connection



NOTICE

- 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, we recommend that you use a line termination resistor of 120 Ω on each line.
- The effect of signal reflections becomes noticeable with long cable and/or high baud rates.
- The serial Modbus connection between the RS-485 port of the client and the corresponding interfaces of the sensors must comply with the EIA/TIA RS-485 standard.

4.4.5 Mechanical process connection

The CO_2NTROL Sensor has been certified to EHEDG Type EL Class I in combination with Hamilton Hygenic Socket REF 242535. An EHEDG EL Class I certificate is valid for the CO_2NTROL Sensor for this combination.

To achieve the same test performances, install the sensor according to the requirements given in the EHEDG Guidelines 8, 10, and 37. That is, you must install the sensor in a self-draining orientation.

⚠ 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

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 devices as a Modbus server. The Arc sensor requires a power supply (VP 8 Pins C and D), see Section 4.4.1 to function. For additional information about the operating the sensor via digital mode, see Section 4.6.

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 a bioprocess to their requirements. The CO_2NTROL 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

The Arc USB Power Cable (REF 243490-XX) is required to supply power to the CO_2NTROL Sensor.

A wired connection can be established using an Arc USB Power Cable (REF 243490-XX) and a computer (see Figure 4-9). With the integrated microtransmitter, the CO_2NTROL 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 4-9). Wireless communication is available via a smart phone, tablet, or computer.

NOTICE

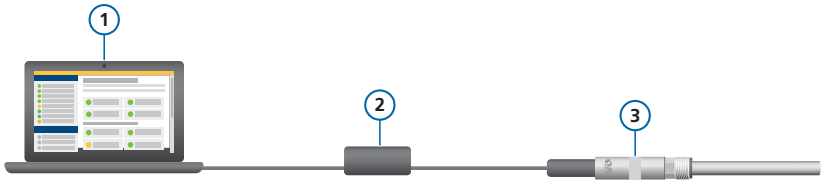
ArcAir User Password Setting: Global Operator Level S Password

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 connection the CO_2NTROL Sensor to the ArcAir application

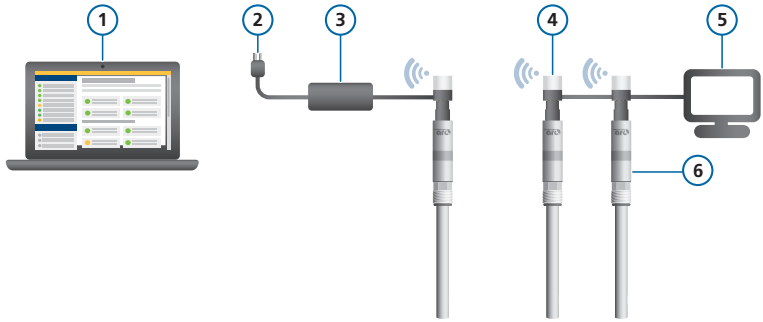
- Direct Optical IR measurement of CO_2 without any interference by other volatile molecules
- Easy to install
- A separate transmitter is not needed
- Direct digital Modbus or analog 4-20 mA communication via Arc Wi 2G Adapter
- Full online wireless option via Bluetooth® 4.0 for diagnostic and easy configuration via Arc Wi 2G Adapter
- User-friendly maintenance with robust industrial design
- High resistance against high temperature (SIP / autoclaving)
- No need to replace parts
- Reporting and centralized data management of users and validation reports for the sensor calibration, verification, configuration and communication, making the sensor ready for compliance with GMP regulations such as FDA CFR21, Part 11, and Eudralex Volume 4 Annex 11 (requires the ArcAir Advanced App)

Figure 4-9. Arc system setup: Wired connection to ArcAir application on a PC



1	ArcAir application installed on PC/ Notebook	3	CO_2NTROL Sensor
2	Arc USB power cable (REF 243490-XX)		

Figure 4-10. 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	CO_2NTROL Sensor

NOTICE

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

You must generate a Communication Validation Report from the ArcAir application if the CO_2NTROL 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 CO_2NTROL Sensor and the USB connector to the USB port on the computer.

NOTICE

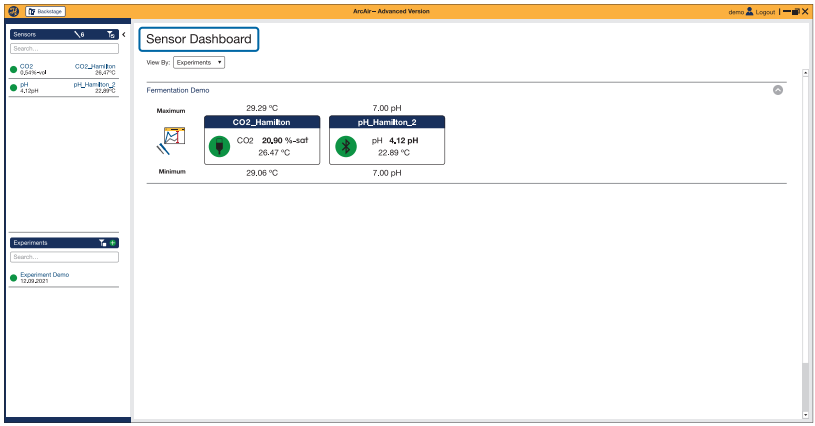
The ArcAir application recognizes and displays the connected sensor automatically on the Sensor Dashboard. The available connection type used to connect the sensor is indicated next to the sensor in the dashboard. For example, via Bluetooth® or the USB power cable (see Figure 4-11).

2. To connect to the CO_2NTROL Sensor: select the **CO2** Sensor on either the **Sensor Dashboard** or select the applicable sensor from the **Sensor** list on the left pane of the display (see Figure 4-11). When the sensor is connected, the **Info** tab of the sensor will be shown on the display. Figure
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

For details on how to resolve connection issues, refer to Chapter 7.

Figure 4-11. Overview of the ArcAir application dashboard: View of the Arc sensors connected



4.6 Configuring the CO2NTROL Sensor with ArcAir

CO_2NTROL Sensor requires application specific configuration. To configure and set up the CO_2NTROL 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

ArcAir version	ArcAir application functionality				
	Read	Calibrate	Configure	Documentation	Remark
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

4.6.1 Configuring the CO2NTROL 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, see Section 4.6.1.1.

4.6.1.1 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	Location
Measurement Unit: CO_2	Measurement physical units	• %-vol. • %-sat. • µg/L ppb • mg/L ppm • mbar • mmHg • hPa	Required	Settings ► Measurement Settings
Temperature Unit	Temperature physical units	• K • °F • °C	Required	Settings ► Measurement Settings
Pressure	The partial pressure of carbon dioxide is proportional to the atmospheric or pressure during the process	1013 mbar (Default)	Required (application dependent)	Settings ► Measurement Settings
Humidity	The partial pressure of carbon dioxide in gas phase is dependent on the relative humidity	100% (Default)	Required (application dependent)	Settings ► Measurement Settings

Parameter	Description	Option / Default Value	Configuration	Location
Min. / Max. Custom Measurement Temperature	It is possible to set a minimum and maximum measurement temperature	-10 °C to 60 °C	Default parameter	Settings ► Measurement Settings
Moving Average	The sensor uses a moving average 1-150 over the measuring points	50 (Default)	Default parameter recom-mended	Settings ► Measurement Settings ► Moving Average

Units of measurement for partial pressure

Common units of measurement for partial pressure are **mbar**, **kPa**, **mmHg**, or **% saturation**. The unit of measurement for CO2 literature usually varies depending on the subject area: For example, in biology-related literature, the CO2 measurement unit of “mmHg” and “% saturation” are commonly used. Table 4-5 provides an overview of the CO2 measurement units and the conversion value of the corresponding unit.

Table 4-5. Overview of the units of measurement for partial pressure with the corresponding value

pCO_2 units	mbar	kPa	mmHg	%Vol*
mbar	1	0.1	0.750	0.1
kPa	10	1	7.50	1
mmHg	1.33	0.133	1	0.13
%Vol*	10	1	7.5	1

Where:

** Atmospheric temperature = 25 °C | Atmospheric Pressure = 1,013 mbar*

4.6.1.2 Configuring the calibration settings

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

Table 4-6. Overview of the calibration settings

Parameter	Description	Default value	Configuration	Location
Maximum Measurement Drift	High drift will interrupt the calibration process. **NOTICE!** The Warning message "Drift measurement" will be shown on the display.	2 mbar/min	Default parameter recommended	Settings ▸ Calibration
Maximum Temperature Drift	High drift will interrupt the calibration process. **NOTICE!** The Warning message "Drift temperature" will be shown on the display.	0.5 K/min	Default parameter recommended	Settings ▸ Calibration

4.6.1.3 Configuring the temperature settings of SIP/CIP processes

Table 4-7 provides an overview of the *Temperature Settings* in ArcAir application.

Table 4-7. 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

4.6.1.4 Configuring the analog interface for a PCS

⚠ CAUTION

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

Table 4-8 provides an overview of the analog interface parameters and configuration settings in ArcAir application for a PCS.

Table 4-8. 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 linear or with a fix 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 CO2 or Temperature	CO2 / Temperature	Required	mA Interface No. 1 and / or No. 2

Parameter	Description	Default value	Configuration	Location
Value at 4 mA	Defined measurement value for 4 mA output	0 %-Vol / 0 °C	Required	mA Interface No. 1 and / or No. 2
Value at 20 mA	Defined measurement value for 20 mA output	100 %-Vol / 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
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 temperature out of limit	3.5 mA	Default parameter recommended	mA Interface No. 1 and / or No. 2

4.6.2 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 4-9. Measuring point settings

Parameter	Description	Default value	Configuration	Location
Measuring point	The user can define a sensor name to identify the measuring point.	10087213-XXYYYY	Optional	Info ▸ Measuring Point

5 Operation: Integrating the CO2NTROL Sensor via a PCS

This chapter provides a detailed description of the recommended setup and integration of the CO_2NTROL 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.

Setting up and integrating the CO_2NTROL Sensor via a PCS

⚠ CAUTION

- *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 carbon dioxide at a temperature higher than 60 °C. This is to protect the optoelectronics and enhance the sensor service life.*
- *You must set the Humidity in ArcAir application before you set up the CO_2NTROL Sensor via the PCS.*

1. Remove the protective caps from the CO_2NTROL Sensor tip and the VP8 sensor head.
2. Check that the O-ring on the sensor shaft is seated correctly and that the sensor elements/parts are not damaged (see Section 3.2).
3. Verify the functionality of the sensor (see Section 6.1).
4. Calibrate the sensor (see Section 6.2).
5. Verify the measurement in air before you install it in the control system.
6. Install the sensor in the housing or process connection (see Section 4.4).
7. Connect the sensor to the Process Control System (PCS) (see Section 4.4).

6 Maintenance

⚠ CAUTION

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

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

All of the procedures in this chapter must be performed by the operator. For additional maintenance requirements, contact Hamilton Technical Support (see Section 7.3).

6.1 Verification

The purpose of verification is to identify measurement drifts, and mechanical issues and to assess whether corrective action is necessary. Verification is an important procedure used to determine the Quality Indicator (QI) and, thus, the performance and accuracy of the sensor.

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

1. Power the sensor: Connect the CO_2NTROL 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 CO_2NTROL Sensor to ArcAir.
3. Navigate to the **Info** tab > **Sensor Quick View** > **Sensor Health** in ArcAir application to check status of the sensor (see Figure 7-1)..
4. Follow through the troubleshooting procedures to resolve the error if the sensor status indicator is not green (see Chapter 7).
5. Check the quality of the sensor or measurement in ArcAir under the **Info** tab > **Status** or **Sensor Health**.
6. Calibrate the CO_2NTROL Sensor if required (see Section 6.2).

NOTICE

Sensor service life and Quality Indicator (QI)

- The service life of the CO_2NTROL 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 remains active as long as the sensor quality is below 40%. The measurement quality status takes into account warnings and errors associated with the sensor.
- Avoid corrosive media contact with the senor.

6.2 Calibration

There are two calibration methods to calibrate the CO_2NTROL Sensor via the ArcAir application. The calibration methods are as follows:

1. Automatic standard calibration
2. Product calibration

⚠ **CAUTION**

Calibration environment and humidity setting in ArcAir application

- *To achieve accurate calibration results for the two calibration points (Zero Point and CO2 point), you must do the calibration in a laboratory and set the Humidity in the ArcAir application.*
- *To achieve accurate calibration results, make sure that the temperature difference between the calibration and the process environment is minimal.*
- *Make sure that the humidity and pressure are compensated during calibration by setting the humidity and pressure both calibration points in the ArcAir application ▸ Settings. For example, set the humidity and pressure for Zero Point and for CO2 Point in ArcAir.*

NOTICE

Hamilton offers a Calibration Station (REF 243575 / REF 10141853) that is suitable for calibrating the sensor. You can also use a conventional FlowCell to calibrate the sensor.

To calibrate the CO_2NTROL Sensor via ArcAir application, follow the procedure described in Section 4.6.

6.2.1 Automatic standard calibration with ArcAir

⚠ CAUTION

Sensor calibration precautions:

Before do a new calibration, the CO₂NTROL Sensor temperature must be stabilized at ambient conditions. If a sensor is installed in a housing, this can act as a heat sink, which can influence the temperature measurement of the sensor. Due to the heat sink effect, we recommend that you observe the following times before you calibrate the CO₂NTROL Sensor:

- *The sensor has been removed from the process housing: wait 20 minutes until the sensor has cooled down.*
- *The sensor is no longer immersed in the medium, but is still in the process housing: wait 30 minutes until the sensor has cooled down.*

⚠ CAUTION

- *Both "Zero Point" and "CO_2 Point" calibration must be done sequentially to complete the CO₂NTROL Sensor calibration.*
- *If only one calibration is done, ArcAir will show the message "`Calibration incomplete`" and the sensor will continue to operate with the previous successful Two-point calibration. Only when the missing calibration point has been successfully completed will the new calibration be activated.*
- *Only use certified gas mixtures for accurate measurements.*

⚠ CAUTION

CO_2NTROL Sensor calibration in air or with certified gas mixtures

You must calibrate the CO₂NTROL Sensor in air or with certified gas mixtures. The unit of measurement for the sensor calibration / verification is always % volume to comply with gas standards, which are usually specified as % volume.

The CO₂NTROL Sensor calibration must be done at two different points: **Zero Point** and **CO_2 point**.

The first is the "**Zero Point**" calibration, The CO₂NTROL Sensor is calibrated in air or CO_2-free environment, for example, nitrogen.

The second is the **"CO_2 point"** calibration. The CO₂NTROL Sensor is calibrated in a certified gas mixture CO_2/ N_2. The recommended gas mixture is 20% CO_2 and 80% N_2. During calibration, the sensor automatically controls the stability of the CO_2 and the temperature signals.

6.2.2 Zero point calibration (in Air or CO2-free environment)

To do a Zero Point calibration (in Air or CO2-free environment), follow these steps:

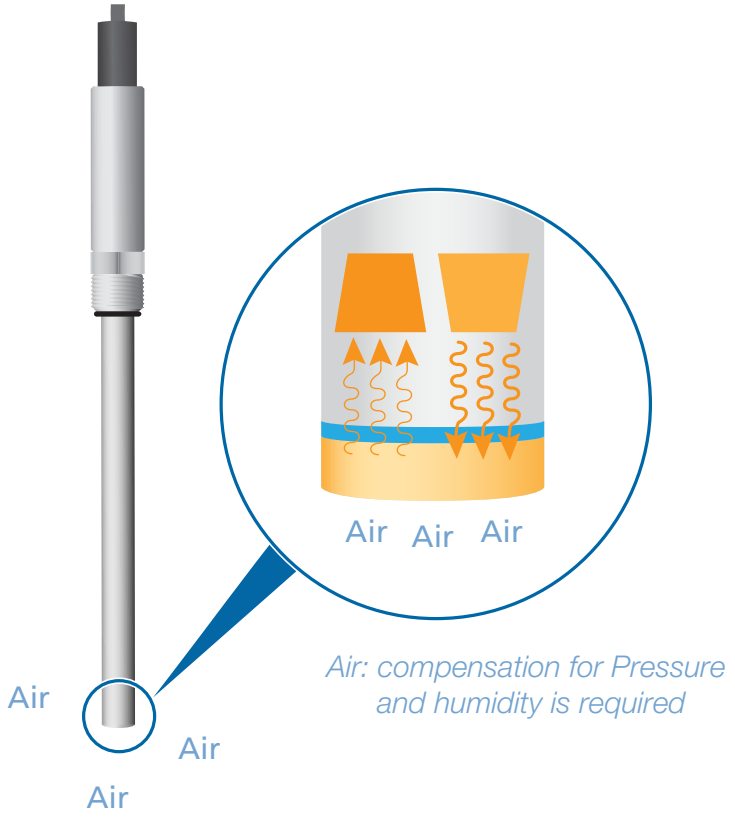
⚠ CAUTION

Humidity setting for gas and/or liquid phase in the ArcAir application:

Make sure that you set the Humidity for measuring in gas and/or liquid phase in the ArcAir application.

1. Place the sensor in Air or CO_2-free atmosphere.
2. Make sure that the temperature remains constant.
3. Power the sensor: Connect the CO_2NTROL 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.
4. Launch the ArcAir application to connect the CO_2NTROL Sensor to ArcAir.
5. Select the applicable sensor under the **Sensor** list.
6. Open the **Calibration** tab.
7. Select the **Zero Point** calibration.
8. Click the **Start** button to start the calibration wizard.
9. Follow the on-screen instructions in the ArcAir application to complete the Zero Point Calibration.

Figure 6-1. Overview of the Zero Point calibration setup in Air or CO2-free environment



NOTICE

Alternatively, you can immerse the CO₂NTROL Sensor in a CO_2-free environment, for example, nitrogen with a setup similar to the one shown in Figure 6-1.

6.2.3 CO2 point calibration (in gas mixture CO2 / N2)

⚠ CAUTION

Precaution for gas mixture CO2 / N2 and gas flow rate

- *To achieve accurate calibration result, you must prevent the CO₂NTROL Sensor from becoming overpressurized. Make sure that the gas mixture flow rate does not exceed 0.5 L/min.*
- *The CO_2 gas flow for the entire calibration must be approximately 4 L of the CO_2 gas standard. Do not use a gas bottle that is almost empty.*

⚠ CAUTION

Significance of carbon dioxide concentration for CO2 measurement:

The value of the carbon dioxide concentration at different temperatures, pressures and air humidity plays an important role in CO_2 measurement accuracy. Make sure you set the the values for atmospheric pressure and humidity in the ArcAir application before the sensor calibration, product calibration, and verification.

NOTICE

You can verify the CO_2 Point after the sensor calibration with ArcAir verification.

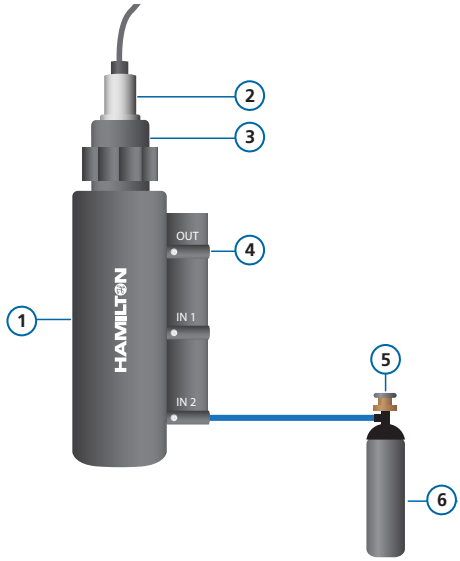
To do CO2 point calibration (in gas mixture CO_2 / N_2), follow these steps:

1. Install the sensor into the Hamilton calibration station (REF 243575) and connect the calibration mixture of gas CO_2/ N_2 (see Figure 6-2).
2. Power the sensor: Connect the CO₂NTROL 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.
3. Launch the ArcAir application to connect the CO₂NTROL Sensor to ArcAir.
4. Select the applicable sensor under the **Sensor** list.
5. Open the **Calibration** tab.
6. Select the **CO_2 Point** Calibration.
7. Verify that the gas mixture flow rate in the calibration station does not exceed 0.5 L/min to prevent overpressure.
8. Click the **Start** button to start the calibration wizard.
9. Follow the on-screen instructions in the ArcAir application to complete the CO_2 Point Calibration.

NOTICE

- The calibration certified gas mixture should be selected according to the intended application. For example, the gas mixture that we recommend to use with CO_2NTROL Sensor in bioprocess applications is 20% CO_2 and 80% N_2.
- The CO_2 point calibration is possible for CO_2 values in the range of 8 to 100%-vol (80 – 1000 mbar pCO_2). When the ambient pressure is higher than 1000 mbar, the calibration range falls below 100 %-vol. For example, when the ambient pressure is set to 1013 mbar, the calibration upper limit is 98.7 %-vol.

Figure 6-2. CO2 point calibration setup



1. Calibration Station (REF 243575)
2. Sensor for calibration in 20% CO_2
3. Sensor connection PG 13.5 for sensor shaft with 12 mm diameter
4. Gas outlet
5. Valve for setting the flow: 0.5 L/min
6. 20% CO_2 / 80% N_2 certified gas bottle

6.3 Product calibration

The product calibration is an in-process calibration procedure used to adjust the measurement to specific process conditions. Product calibration is an additional calibration procedure to a standard calibration. It is accessible from the "**Process**" tab in ArcAir.

If product calibration is activated, the CO_2NTROL Sensor calibration curve is calculated from the last two-points calibration (see Section 6.2) and corrected with the data of the product calibration. This is clarified graphically in Figure 6-3.

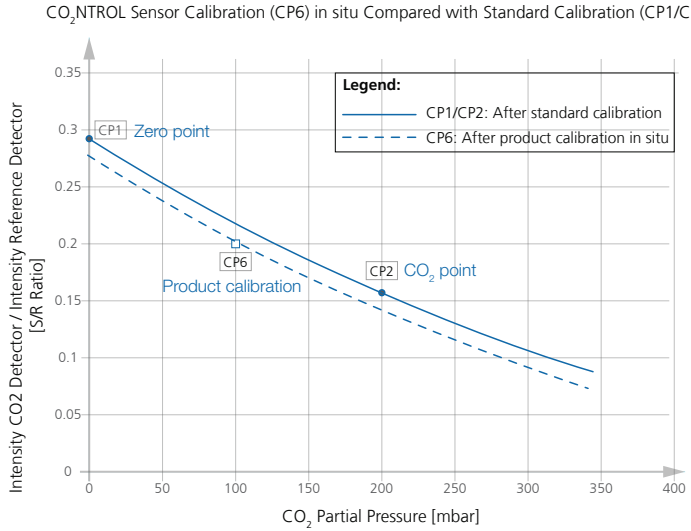
To restore the original standard calibration curve, the product calibration can be deleted at any time by selecting in the ArcAir Process **Discard Existing Product Calibration**.

⚠ CAUTION

Verification precaution:

Before yo do a sensor verification (see Section 6.4) with the wizard, the original calibration curve must be restored by selecting "`Discard existing product calibration`" from the "Process" panel.

Figure 6-3. Effect of a product calibration (CP6) on an existing standard calibration function based on the Zero Point Calibration (CP1) and the CO2 Point Calibration (CP2)



To do a Product Calibration with ArcAir, follow these steps:

⚠ CAUTION

Product calibration precautions:

- *The product calibration is only possible for CO_2 values in the range of 0 - 1000 mbar.*
- *To achieve the best results for the Product Calibration, you mus set the correct Humidity in the ArcAir application > Measurement Setting before you start the Product Calibration. For additional about the humidity setting, see Section 4.6.1*
- *Before you do a new Product Calibration, you must delete the previous calibration by following the on-screen instructions in the ArcAir application.*

1. Power the sensor: Connect the CO_2NTROL 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 CO_2NTROL Sensor to ArcAir.
3. Select the applicable sensor under the **Sensor** list.
4. Navigate to the **Process Settings**, then click the **Start** button to start the product calibration wizard.
5. Follow the on-screen instructions in the ArcAir application to complete the Product Calibration.

NOTICE

Alternatively, you can also do the Product Calibration with a field mobile device on-site to the measuring point. For such cases, the Hamilton IP 67 tablets, Arc View Mobile Basic (REF 10071111) or Arc View Mobile Advanced (REF 10071113) can be used.

6.4 Verification

The CO_2NTROL Sensor provide the possibility to verify the sensor and generate a verification report, which can be used for GMP purposes. The verification can be done for a single point or for two points. We recommend that you do the verification with the same setup and gas mixtures, and follow the Calibration Procedures described in Section 6.2.

⚠ CAUTION

Sensor calibration precautions:

Before do a new calibration, the CO_2NTROL Sensor temperature must be stabilized at ambient conditions. If a sensor is installed in a housing, this can act as a heat sink, which can influence the temperature measurement of the sensor. Due to the heat sink effect, we recommend that you observe the following times before you calibrate the CO_2NTROL Sensor:

- *The sensor has been removed from the process housing: wait 20 minutes until the sensor has cooled down.*
- *The sensor is no longer immersed in the medium, but is still in the process housing: wait 30 minutes until the sensor has cooled down.*

To a sensor verification via the Hamilton Calibration Station, follow these steps:

⚠ CAUTION

You must set the humidity in ArcAir application before you start the sensor Verification procedure.

1. Install the sensor in the Hamilton Calibration Station (REF 243575) or an alternative device and connect the calibration gas mixture of CO_2/N_2 (see Figure 6-2). Note that for “Zero Point” verification, you must place the sensor in Air or CO_2-free atmosphere.
2. Power the sensor: Connect the CO_2NTROL 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.
3. Launch the ArcAir application to connect the CO_2NTROL Sensor to ArcAir.
4. Select the applicable sensor under the **Sensor** list.
5. Open the **Verification** tab.
6. Specify the `Verification value`, `Tolerance` (suggested ± 1% vol), `Ambient pressure`, and `Humidity`.

7. For gas mixture verification, you must verify the gas mixture flow rate in the calibration station does not exceed 0.5 L/min to prevent overpressure.
8. Click the **Start** button to start the product calibration wizard.
9. Follow the on-screen instructions in the ArcAir application to complete the Verification procedure.

6.5 Cleaning

⚠ CAUTION

- *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 acetone and strong acid solutions to clean the sensor.*
- *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

***Cleaning solution composition and specification**:*

- ***CIP cleaning**: 3% NaOH, at 90 °C for a cleaning cycle of 30 minutes.*
- ***SIP cleaning**: At 140 °C for a sterilization cycle of 30 minutes.*

This section outlines the manual cleaning procedures or the care and maintenance of CO_2NTROL Sensor, including a procedure for the cleaning sensors with solid state sensing element.

The sensor can be autoclaved and then cleaned manually instead of going through an SIP process before use in the process and a CIP after use in the process.

The sensor can be cleaned of cells and sterilized using CIP and/or SIP procedures. Also, you must make sure that the optical window is clean and free from interfering particles or scratches.

6.5.1 Cleaning in accordance with EHEDG EL Class I certificate

The CO_2NTROL Sensor was developed in accordance with EHEDG guidelines in combination with Hamilton Hygienic Socket (REF 242535).

For tanks/bioreactors, it is important that you position the cleaning device so that the sensor is directly accessible and can be wetted for cleaning. The sensor must be installed flush with the process area. When mounting in a T-piece, the ratio between the depth of the upstand (L) and the diameter (D) of the upstand must be L/(D-d) < 1 [d = 12 mm diameter of the sensor].

If welded adapters are used, the food contact surface must be smooth. The welding must be done according to EHEDG Guideline 9 and 35 (Ra < 0.8 µm). Suitable pipe couplings and process connections must be used in accordance with the EHEDG Position Paper (refer to https://www.ehedg.org/). The CO_2NTROL Sensor was developed for Cleaning in Place (CIP) applications and must not be removed from the process setup during cleaning.

6.5.2 Cleaning not in accordance with EHEDG EL Class I certificate

To do the cleaning procedure, follow these steps:

1. Remove the sensor from the process setup.

⚠ CAUTION

Cleaning sensors contaminated with oil, grease or other organic matter:

If the sensing element of the sensor is contaminated with oil, grease or other organic matter, soak a clean, lint-free cloth with isopropyl alcohol and use it to wipe the sensor clean. Immediately rinse the remaining isopropyl alcohol off the membrane with deionized water and carefully wipe over the membrane.

2. Soak a lint-free cloth or tissue paper with deionized water and wipe the wetted parts of the sensor and thoroughly rinse the wetted parts and the solid state sensing element of the sensor with deionized water.
3. Dry the wetted parts with a clean lint-free cloth or tissue and store the sensor in dry conditions.
4. Always do a new calibration after cleaning and before installing the sensor in the process setup for measurements (see Section 6.3).

7 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 a 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 7-1).

Table 7-1. 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 CO_2NTROL 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.

7.1 Sensor self-diagnostic

⚠ CAUTION

- *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 4.6.1.3). Use the ArcAir application to monitor the status of the sensor and troubleshoot.

7.2 Sensor status

An overview of the condition of the sensor is indicated by the `Sensor Status` described in Sections 7.2.1, 7.2.2, and 7.2.3.

NOTICE

For additional information about the sensor status and the diagnostics features refer to the Troubleshooting chapter of the *CO2NTROL RS485 Sensors Programmer`s Manual* (REF 111003564).

7.2.1 Warnings associated with sensor calibration and product calibration

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

Table 7-2. Overview of the warnings associated with sensor calibration and product calibration

Sensor calibration and product calibration troubleshooting		
Warning description	Possible cause	Corrective action
Below calibration range	The value entered by the user for the Zero Point (Calibration Point 1) and CO_2 Point (Calibration Point 2) is below the acceptable calibration limits	Make sure the value entered for the Zero Point (Calibration Point 1) and CO_2 Point (Calibration Point 2) is with the acceptable calibration limits (see Section 6.2.3).
Above calibration range	The value entered by the user for the Zero Point (Calibration Point 1) and CO_2 Point (Calibration Point 2) is above the acceptable calibration limits.	Make sure the value entered for the Zero Point (Calibration Point 1) and CO_2 Point (Calibration Point 2) is with the acceptable calibration limits (see Section 6.2.3).
Temperature was too low	Temperature during the calibration is below 15 °C.	Adjust the temperature and repeat the calibration process.
Temperature was too high	Temperature during the calibration is above 45 °C.	Adjust the temperature and repeat the calibration process.
Reading too low	• Applied calibration standard is not consistent with the required calibration range. • The S/R value measured is too low. Check the calibration standard and repeat the calibration process.	Check and repeat the Calibration Standard process (see Section 6.2.3).
Reading too high	• Applied calibration standard is not consistent with the required calibration range. • The S/R value measured is too high.	Check and repeat the Calibration Standard process (see Section 6.2.3).

Sensor calibration and product calibration troubleshooting		
Warning description	Possible cause	Corrective action
Drift temperature	Temperature during the calibration is not stable.	Stabilize the temperature and repeat the calibration process.
Drift measurement	The CO_2 value during the calibration is not stable.	Stabilize the CO_2 gas-flow and repeat the calibration process.
Assigned value was out of calibration range	The value entered by the user for Calibration is outside the acceptable calibration limits.	Make sure the value entered for the Calibration is within the acceptable calibration limit (see Section 6.3).
Calibration is not complete, Calibration Point 2 required	The sensor requires a Two-point calibration.	Do the CO_2 point calibration (Calibration Point 2), see Section 6.2.3.
Calibration is not complete, Calibration Point 1 required	The sensor requires a Two-point calibration.	Do the Zero point calibration (Calibration Point 1), see Section 6.2.2.
Calibration coefficients were out of range	• The applied product calibration value is not consistent with the required product calibration range. • The S/R value measured is out of range.	Check and repeat the Product Calibration process and (see Section6.2.3).

7.2.2 Warnings associated with sensor use and routine measurements

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

Table 7-3. Overview of the warnings associated with sensor use and routine measurements

Sensor use and routine measurements troubleshooting		
Warning description	Possible cause	Corrective action
CO_2 reading is below lower limit	CO_2 reading too low (CO_2 < 0 mbar).	Recalibrate the sensor.
CO_2 reading is above upper limit	CO_2 reading too high (CO_2 > 1000 mbar).	Recalibrate the sensor.
CO_2 calibration recommended	CO_2 reading is too low (CO_2 < 0 mbar) or high CO_2 reading (CO_2 > 1000 mbar).	Repeat the sensor calibration (see Section 6.2).
Temperature reading is below lower limit	The temperature is below the user-defined lower limit temperature range. If the process temperature is outside this range, the sensor will not perform CO_2 readings.	Adjust the user-defined temperature so that it is within the lower limit temperature range.
Temperature reading is above upper limit	The temperature is above the user-defined upper limit temperature range. If the process temperature is outside this range, the sensor will not perform CO_2 readings.	Adjust the user-defined temperature so that it is within the upper limit temperature range.
Measurement is not running	Applied voltage is too high or too low. **NOTICE!** The sensor operating voltage range is between 10 - 27 VDC or the temperature measurement is outside user defined temperature range.	Make sure the sensor operating voltage range is between 10 - 27 VDC.

Sensor use and routine measurements troubleshooting		
Warning description	Possible cause	Corrective action
Sensor supply voltage too low	Applied voltage is too low. **NOTICE!** The sensor operating voltage range is between 10 - 27 VDC or the temperature measurement is outside user defined temperature range.	Make sure the sensor operating voltage range is between 10 - 27 VDC.
Sensor supply voltage too high	Applied voltage is too high. **NOTICE!** The sensor operating voltage range is between 10 - 27 VDC or the temperature measurement is outside user defined temperature range.	Make sure the sensor operating voltage range is between 10 - 27 VDC.
IR power limit reached	Light source consumes too much power.	Contact Hamilton Technical Support for assistance (see Section 7.3).
Replace sensor	The sensor is defective or the sensor Quality Indicator (QI) is below10%. The quality of the sensor is not sufficient for reliable measurement.	Replace the sensor. Contact Hamilton Technical Support for assistance (see Section 7.3

7.2.3 Errors associated with sensor calibration or use for routine measurements

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

Table 7-4. Overview of the errors associated with the sensor calibration or use for routine measurements

Sensor calibration or use for routine measurements troubleshooting		
Error description	Possible cause	Corrective action
CO_2 reading failure	CO_2 measurement failure.	Contact Hamilton Technical Support for assistance (see Section 7.3).
CO_2 exceeds air pressure	The sensor measurement value for CO_2 partial pressure is higher than the value set for total air pressure in settings of the sensor.	Check and correct the total air pressure set value, if required or recalibrate the sensor. If the error persists, contact Hamilton Technical Support. • Check and correct the total air pressure set value, if required or recalibrate the sensor. • If the error persists, contact Hamilton Technical Support (see Section 7.3).
Sensor defective	The sensor is defective or the sensor Quality Indicator (QI) is below10%. The quality of the sensor is not sufficient for reliable measurement.	Replace the sensor. Contact Hamilton Technical Support for assistance (see Section 7.3).
Temperature sensor is defective	Temperature sensor is defective.	Replace the sensor. Contact Hamilton Technical Support for assistance (see Section 7.3).
Temperature reading is far below the lower limit	Temperature is far below -10 °C. Contact Hamilton Technical Support.	Contact Hamilton Technical Support for assistance (see Section 7.3).
Temperature reading is far above the upper limit	Temperature is far above 140 °C.	Contact Hamilton Technical Support for assistance (see Section).

Sensor calibration or use for routine measurements troubleshooting		
Error description	Possible cause	Corrective action
Internal communication error.	Internal communication error,	Contact Hamilton Technical Support for assistance (see Section 7.3).
Internal communication failure front-end.	Internal communication failure front-end.	Contact Hamilton Technical Support for assistance (see Section 7.3).
Internal communication error.	Internal communication error.	Contact Hamilton Technical Support for assistance (see Section 7.3).
Internal memory failure. Restart the sensor.	Internal memory failure.	If the sensor restart does not resolve the issue, contact Hamilton Technical Support for assistance (see Section 7.3).

7.3 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).

7.4 Returning the sensor for investigation

⚠ WARNING

- Make sure you decontaminate the CO_2NTROL Sensors and remove health hazards such as radiation, hazardous chemicals, or infectious agents before returning the sensor to Hamilton.
- Provide a complete description of any hazardous materials that have been in contact with the sensor.

⚠ CAUTION

- *Do not return an the sensor to Hamilton without an RMA number. The RMA number ensures that your sensor can be tracked, so your request can be handled by the correct department.*
- *CO_2NTROL Sensors that are returned without an RMA number will be sent back to the customer without an investigation being done.*

Before returning a sensor to Hamilton for investigation, you must contact our Customer Service (see Section 7.3) and request: a Returned Material Authorization (RMA) number.

8 Disposal

⚠ CAUTION

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

NOTICE

You can also send the sensor to Hamilton for disposal.

The design of the Hamilton sensors optimally considers environmental compatibility and regulations compliance (see Table 8-1).

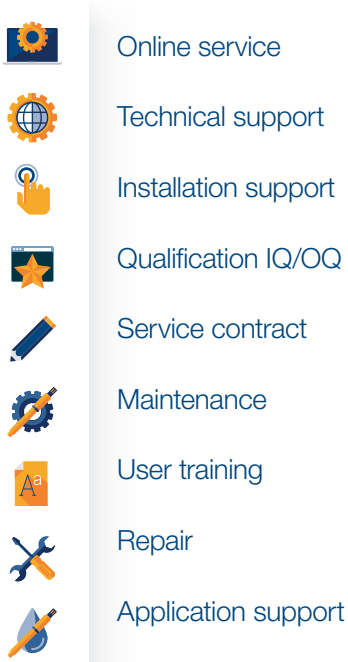
Table 8-1. Symbols used on the sensor labels and packaging

Symbol	Definition
	Dispose of in accordance with the EU Directive 2012/19/EU or WEEE (Waste Electrical and Electronic Equipment)
	有害物質表，請參閱, 章節過程分析， 符合性聲明 (For additional information, see the Hamilton website: www.hamiltoncompany.com)

9 Services

This chapter provides an overview of the services offered by Hamilton Process Analytics (see Figure 9-1).

Figure 9-1. 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 9-2. 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.

10 Ordering Information

This chapter provides an overview of the different types of VisiFerm DO Sensors available to order (see Table 10-2).

10.1 CO2NTROL Sensors

CO_2NTROL Sensors

Figure 10-1. CO2NTROL Sensors

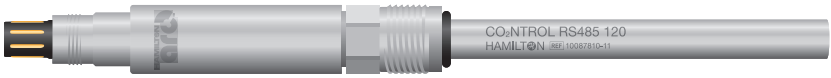


Figure 10-2. CO_2NTROL Sensors family: Ordering information

Ordering Information			
10087810	CO_2NTROL RS485		
	Code	Interface	
	1	Arc (Modbus RS-485)	
		Code	Sensor length (mm)
		1	120
		2	160
		3	225*
		4	325
		5	425
REF 10087810-			(REF No. - Code No.)

** The CO_2NTROL Sensor 225 has an actual shaft length of 215 mm. This allows optimal rinsing in a retractable housing such as the Retractex.*

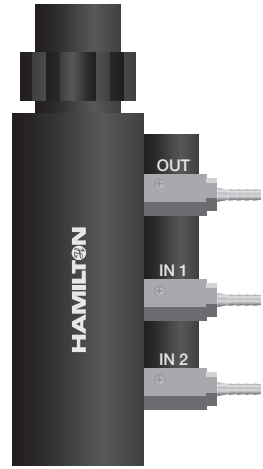
10.2 Parts, accessories, and software

The parts below may only be replaced by original spare parts.

Calibration station

The calibration station is specifically designed for two-point calibration with two test gas connections, for example, 20% CO2 and 80% N2 with 5.0 purity.

Figure 10-3. Overview of the calibration station

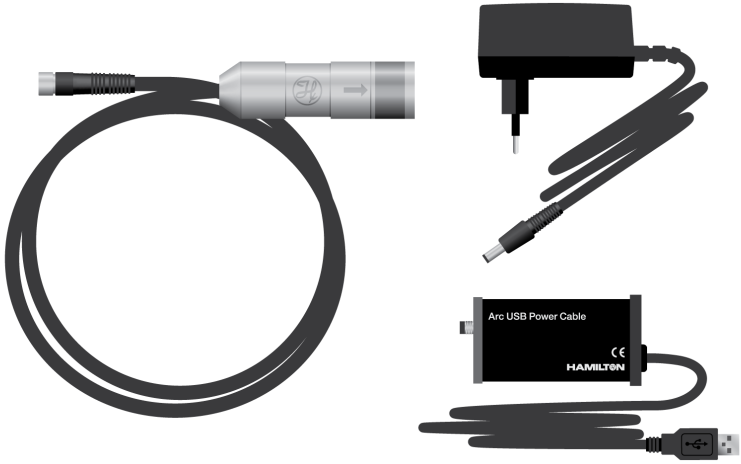


REF	Product description
243575	Calibration station | Material: Black POM, Material (body): Black POM Inlet and outlet ports: Steel 1.4435

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 10-4. 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, and ORP.

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, and ORP.

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 10-5. Basic Arc view tablet for non-Ex environments



Table 10-1. 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 10-6. Arc Wi 2G BT adapter



REF	Product description
243470	Arc Wi 2G BT adapter

Phased out (discontinued) products: Arc Wireless BT Converter and Arc Wireless BT Converter Advanced

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 functionality of 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®:

- ArcAir versions 3.8.2 and higher support the use of the internal Bluetooth® chip in a PC/Notebook or a third-party USB Bluetooth® device.
- The internal Bluetooth® of the PC can be used.

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 10-7. Arc sensor data cable: VP8 double coaxial / open-end wiring

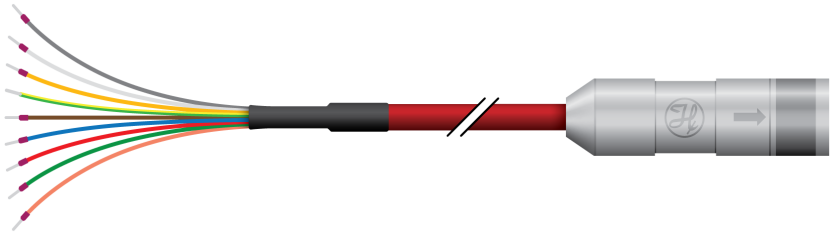


Table 10-2. VP8 double coaxial / open-end data cable

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 10-3. 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-Pole Sensor Cable with open-end wires is designed to enable interface connection between the sensor and a data recorder, indicator, control unit, or PCS with analog I/O.

Figure 10-8. 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

Process housings

Table 10-4. Overview of the process housings offered by Hamilton Process Analytics

FlexiFit REF	Retractex REF	RetractoFit REF	Hygienic Sockets REF
237331-OP	243200-XXXXXX	237240	242535
237341	243255-XXXXXX	237490	242545
237344		237440	242548
237345		237480	242550
237380-OP			

⚠ CAUTION

Housings with cable protections such as RetractoFit are not compatible with the Arc Wi 2G Adapter and the power cable. If the adapter is required, the cable protection can be removed.

ArcAir application download

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

Figure 10-9. ArcAir application download from the App Store or Google Play



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.

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:
www.hamiltoncompany.com/process-analytics

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