

Incyte Arc Sensors

Operating Instructions

REF 10072078/04

2024-04-15

HAMILTON

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Liability

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

Manual revision No.	Date of issue	Change summary
00	April 2019	The first release of the Incyte Arc Sensor Operating Instructions.
01	July 2019	• Incyte Arc Sensor and features implemented into ArcAir software version 3.1.0. • Incyte Arc Sensor and features in ArcAir software version 3.1.0, including screenshots have been added.
02	June 2021	• Changes implemented for the ArcAir software version 3.6.0. • Incyte Arc Sensor and features in ArcAir software version 3.6.0, including screenshots have been added.
03	March 2022	• Changes implemented for the ArcAir software version 3.8.1. • All chapters and sections related to ArcAir software version 3.8.1, including the screenshots, have been updated.
04	April 2024	• Changes implemented for the ArcAir software version 3.9.2. • Manual contents have been migrated to SCHEMA ST4 Component Content Management System (CCMS) • New layout design: Improved look and feel • All chapters and sections have been updated • New chapter added: Quick Start Protocol for Incyte Arc Sensor Setup • The content has been restructured and revised to improve comprehension and usability.

Preface

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

Table 1. Incyte Arc Sensor documentation suite

Document title	Description	Manual REF
Incyte Arc Sensors Operating Instructions (this manual)	Provides detailed information about installing and setting up the sensor, as well as additional technical information.	10072078
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
Incyte Arc Sensors – Modbus RTU Programmer's Manual	This manual is intended for software programmers. It provides detailed information about the Incyte RS485 Modbus RTU interface as well as general information about Modbus command structures and their implementation in the Hamilton Arc sensors family.	695251

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 manual

Safety messages are displayed as follows:

⚠ WARNING

Alerts the user to the risk of injury, death, or other serious 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!

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 provide a description for 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.

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 to instantly access the corresponding information in another part of this document.

Incyte Arc Sensor operating instructions contain the following:

- The architecture and components of the Incyte Arc Sensor
- Information on hardware and software installation, operation, testing, troubleshooting, and maintenance procedures for the Incyte Arc sensor
- Glossary

Table 3. Incyte Arc Sensor operating instructions structure

Chapter/Section	Function	Your responsibility
Chapter 1 – *Introduction*	This chapter provides information on the intended use of the Incyte Arc Sensor and the operating instructions	Read the general information to understand the intended use of the Incyte Arc Sensor and the operating instructions.
Chapter 2 – *Safety Precautions and Hazards*	This chapter provides safety and technical information about the Incyte Arc Sensor.	Read the safety instructions carefully before installing, setting up, and operating the Incyte Arc Sensor.
Chapter 4 – *Product Description*	This chapter provides an overview of the Incyte Arc Sensor, measuring principle, and setup.	Read this chapter to familiarize yourself with the Incyte Arc Sensor.
Chapter 5 – *Hardware and Software Installation*	This chapter provides information, and instructions on how to install and set up the Incyte Arc Sensor and its hardware as well as the ArcAir software.	Read this chapter before you install and set up the Incyte Arc Sensor and its hardware as well as the ArcAir software.
Chapter 6 – *Operation: Integrating the Incyte Arc Sensor into an Experiment*	This chapter provides a detailed description of the recommended settings for integrating the Incyte Arc Sensor into an experiment.	Read this chapter before you set up the Incyte Arc Sensor and integrate the sensor into an experiment.
Chapter 7 – *Maintenance*	This chapter provides information on the sensor's maintenance procedures, including verification, calibration, cleaning, and firmware update instructions.	Read this chapter to familiarize yourself with the maintenance procedures and firmware updates for the Incyte Arc Sensor.

Chapter/Section	Function	Your responsibility
Chapter 8 – *Troubleshooting*	This chapter provides information on troubleshooting procedures.	Read this chapter to familiarize yourself with the troubleshooting procedures for the Incyte Arc Sensor.
Chapter 9 – *Disposal*	This chapter provides information on how to dispose of the Incyte Arc Sensor.	• You must dispose of the Incyte Arc Sensor according to the EU Directive 2012/19/EU or WEEE (Waste Electrical and Electronic Equipment). • Dispose of all parts removed from the sensor according to your institution's protocol. Follow all local, state, and federal/regulations concerning environmental protection, especially when disposing of the electronic device or parts of it.
Chapter 10 – *Services*	This chapter provides an overview of the services offered by Hamilton Process Analytics.	Read this chapter to familiarize yourself with the services offered by Hamilton Process Analytics.
Chapter 11 – *Ordering information*	This chapter provides an overview of the different types of Incyte Arc Sensors available to order.	Read this chapter to familiarize yourself with the different types of sensors offered by Hamilton Process Analytics.
Glossary	This chapter contains an alphabetical list of terms, words, or acronyms used in Incyte Arc Sensors Operating Instructions, with explanations.	Refer to the glossary for the definition of terms, words, or acronyms used in the Incyte Arc Sensors Operating Instructions.

1 Introduction

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

1.1 Intended use

⚠ CAUTION

The Incyte Arc Sensor does not have an Ex (explosion-proof) approval. This means that the Incyte Arc Sensor is not certified for use in potentially explosive atmospheres or hazardous locations where the presence of flammable gases, vapors, or dust could pose a risk.

The Hamilton Incyte Arc Sensor is designed to measure *permittivity* in a liquid medium. The permittivity measurement serves as a representation of the volume of all living cells. This measurement is valuable for monitoring cell growth and informing decision-making processes. The permittivity measurement can be used to correlate the Viable Cell Density (VCD). Besides the permittivity measurement, the Incyte Arc Sensor can measure conductivity and temperature.

1.2 About these operating instructions

The Incyte Arc Operating Instructions are intended to guide users to operate the Incyte Arc Sensor in combination with the ArcAir application (version 3.7 or higher) correctly and safely. The document also describes the different components and functions of the Incyte Arc Sensor and the ArcAir application.

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

To quickly resolve some of the most common problems, see Section 8.1.

1.3 General precautions

For safe and correct use of the Incyte Arc Sensor, both operating and service personnel must follow the generally accepted safety procedures and the safety instructions given in the Operating Instructions of the Incyte Arc 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 repaired by the operator, it must be sent back to Hamilton for inspection.

You must take necessary precautions when transporting the sensors. The sensor must be sent back in the original reusable packaging box for repair or shipment. Every sensor sent back for repair must be decontaminated. Failure to comply with Operating Instructions or inappropriate sensor usage voids all manufacturer's warranties.

2 Safety Precautions and Hazards

⚠ 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.*

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

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

2.1 Operating precautions for Incyte Arc Sensors

⚠ CAUTION

- *The Incyte Arc Sensor 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 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).*
- *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.*

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.

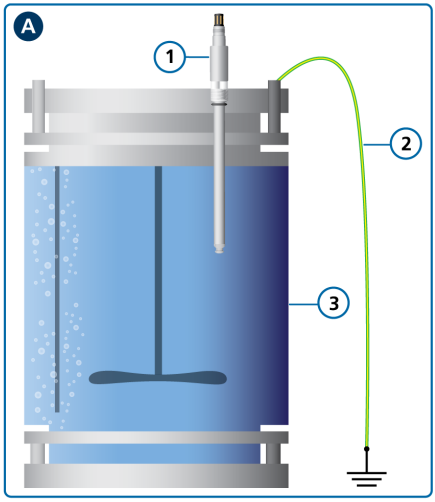
We recommend that you assign the sensor shaft and/or VP8 cable shield to ground or earth (potential equalization), especially in electromagnetically noisy environments. This significantly improves noise immunity and signal quality. The VP8 thread is connected to the metallic housing of the Incyte Arc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

Earth/ground the sensor, benchtop bioreactor, or large bioreactor

Option A: Recommended ground/eath connection for a benchtop bioreactor without ground

Connect the metallic cover plate of the benchtop bioreactor to the ground if it is not grounded. Note that the Incyte Arc Sensor will also be grounded via its stainless steel PG 13.5 thread (see Figure 2-1).

Figure 2-1. Overview of an Incyte Arc Sensor installed in a benchtop bioreactor: Sensor grounded/earthed via the benchtop bioreactor headplate [Optiond A]



1	Incyte Arc Sensor	3	Benchtop bioreactor or large bioreactor
2	Earth/ground cable (green/yellow)		

⚠ CAUTION

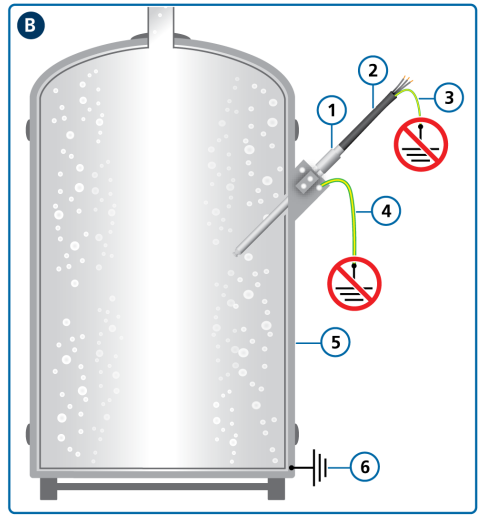
Ground/earth safety precaution for Option B system setup:

- *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 B system setup.*

Option B: Recommended ground/earth connection for a large metallic bioreactor with ground

If the large metallic bioreactor is already grounded, then it is not necessary to ground the Incyte Arc Sensor because the sensor will also be grounded via its stainless steel PG 13.5 thread (see Figure 2-2).

Figure 2-2. Overview of an Incyte Arc Sensor installed in a metallic bioreactor: Sensor grounded/earthed via the bioreactor [Option B]



1	Incyte Arc Sensor	4	Earth/ground cable (green/yellow) for sensor housing
2	VP8 sensor cable	5	Metallic bioreactor
3	Earth/ground cable (yellow/green) for the shaft of the sensor	6	Metallic bioreactor earth/ground

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

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 Incyte Arc 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 Incyte Arc Sensor is the sole responsibility of the user.

3 Quick Start Protocol: Incyte Arc Sensor Setup

NOTICE

- The *Quick Startup Protocol* does not replace the official Operating Instructions for the Incyte Arc Sensor. The protocol provides only a checklist for the software installation, bioreactor/fermented preparation, system setup, starting an experiment in the ArcAir application, and maintenance of the sensor. The protocol describes only the basic functions of the Incyte Arc Sensor.
- For the sensor specification details, refer to the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics).

Install the ArcAir application	
Task	**Status**
Download and install the latest software version of the Hamilton ArcAir from the Hamilton website.	☐

Setup the system	
Task	**Status**
NOTICE! You can rotate the sensor within the thread nut for the correct orientation during the setup. • Connect the sensor with the Arc USB Power Cable (REF 243490) to a PC. • Connect the USB Power Cable to an external power supply to make sure that there is sufficient power supply to the sensor.	☐
• Start the ArcAir application and wait until the sensor is displayed under the Sensor list. • Check if the **Filter** for the **Sensor type** is correct. You must select **Viable Cell Density** (VCD) under the **Sensors** list.	☐
Check if the status indicator color is green. **NOTICE!** The status indicator color will show red if there are no cells or media present.	☐

Setup the system	
Task	Status
• To connect the sensor, click on the sensor **Dashboard** in the ArcAir application. • Navigate to **Settings** tab > **Measurement Settings** subtab, then select the **Cell type mode:** `Bacteria, Yeast, Animal` or customized the settings according your application requirements.	☐
• Navigate to the **Sensor Data Logging** to make sure that the sensor is recording data on the internal memory. • Make sure that the Arc USB Power Cable (REF 243490) is connected to an external power supply.	☐

Starting an experiment	
Task	Status
Navigate to the **Experiment** pane in the ArcAir application, then select the sensor(s) that you would like combine in the experiment.	☐
Set an appropriate Sampling time. Note that only `5,000` data points can be displayed at a time. A `Sampling time` of `3 s` can show about 4 hrs of data recording, whereas a `Sampling time` of `2 min` can show about 166 hrs (approximately 7 days) of data recording in a batch process.	☐
Click the **Start** button to start the recording.	☐
Click the **Scan** button to activate the scan if required.	☐
Use **Mark Zero** (offset) to compensate for any media-based background noises before cell addition.	☐
Use **Inoculate** to mark the time-point when the cells enter the system and to start the counting of the *culture time* in a batch process.	☐
Add notes to mark the **Sampling Point** to create a correlation table afterwards.	☐

Starting an experiment	
Task	Status
Stop the **Experiment** and the recording once the run is finished and export the data via the `Export` button. **NOTICE!** The Export button can be used at any time during the Experiment to generate a temporary report.	

Maintenance of the sensor	
Task	Status
After cultivation, rinse the sensor with water and clean the bioreactor using one of the standard cleaning procedures (CIP, SIP, and/or Autoclaving).	☐
Depending on the user or company requirements, you can do a post-run to check the verification and performance of the sensor. For additional details, see Section 5.5.3 and Chapter 10 in the *Incyte Arc Sensors Operating Instructions* (REF 10072078).	☐

Prepare the bioreactor/fermenter	
Task	Status
Install the sensor into the bioreactor and autoclave the reactor with the sensor.	☐
or	
Install the sensor into the stainless steel fermenter, then clean (CIP) and/or sterilize (SIP) the equipment according to your working protocol/procedure.	☐

Remarks

4 Product Description

The Incyte Arc Sensor is designed to provide continuous real-time measurement of permittivity in a bioprocess. Permittivity is directly proportional to viable cell biovolume which correlates to viable cell density in many applications. The measurement is not influenced by media composition or the presence of microcarriers. This enables a robust measurement in both adherent and suspension-based bioprocesses.

In addition, dead cells and cellular debris do not contribute to the permittivity Permittivity measurement and thus provide an independent measurement of viable cell density within a culture. The Incyte Arc Sensor will perform in many mammalian, insect, bacterial, and fungal systems, depending on the cell concentration at inoculation. Table 4-1 provides an overview of the measurement ranges for *Permittivity*, *Animal*, and *Bacteria and Yeast*.

Table 4-1. Overview of the measurement ranges for permittivity, animal, bacteria, and yeast

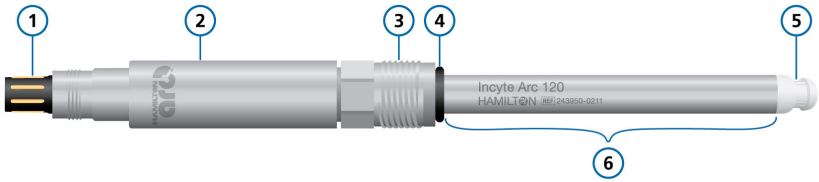
Measurement parameter	Measurement range
Permittivity:	0 - 700 pF/cm
Animal:	5 x 10^5 - 8 x 10^9 cells/mL
Bacteria and Yeast:	5 - 200 g/L

4.1 Hardware description

A schematic illustration of the Incyte Arc Sensor is shown in Figure 4-1. The Incyte Arc Sensor has a VP8 connector head for external connection, for example, to a PCS. The sensor receives its power via the VP8 connector cable. The sensor head has an integrated micro-transmitter and an internal memory for data logging (Sensor Data Logging). The internal memory of the sensor is big enough to record data for up to 28 days at a measurement interval of 5 minutes. For additional details about the Sensor Data Logging, see Section 5.5.5.5.

At the tip of the sensor are the sensitive platinum (Pt) electrodes that enable the measurement. The PG 13.5 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.

Figure 4-1. Overview of the Incyte Arc Sensor



1	VP8 connector	4	O-ring
2	Sensor head with integrated transmitter	5	Sensing part (Pt electrodes)
2	Process connection PG 13.5 thread, stainless steel	6	Sensor shaft with heat number, REF number, and serial number (SN)

Hardware compatibility

NOTICE

The Incyte Arc Sensor is not compatible with the Cell Density Monitoring System, and it cannot be connected to the Arc View Controller, ComBox, or PC Box.

4.2 Measuring principles

The Incyte Arc Sensor is designed based on the following measuring principles to provide continuous real-time measurement of permittivity in a bioprocess.

Measuring principles

- The dual-frequency measurement mode (see Section 4.2.1)
- Theory of the scan and Cole-Cole fitting (see Section 4.2.2)
- Theory of data modeling for offline/inline correlation (see Section 4.2.3)

4.2.1 The dual-frequency measurement mode

In the presence of an alternating electric field, viable cells act as small capacitors, storing a charge distribution within the cellular membrane (see Figure 4-2). The applied electrical field causes a charge division within the cellular membrane. The Incyte Arc Sensor measures the charge of these capacitors, which is reported as permittivity in pF/cm.

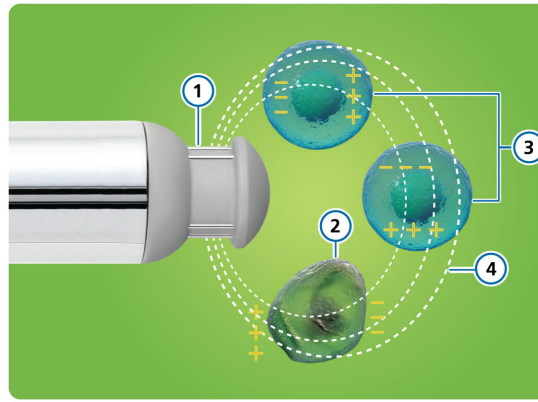
Permittivity is the variation in capacitance between the measuring frequency (1 MHz) and the background frequency (10 MHz). The sensor comes with default setting for mammalian cells. This settings only affects permitivity measurement. The frequency scan measurement will be performed in parallel independent of the settings. The sensor measurement is continuously and automatically corrected for the background permittivity measured at a high frequency typically at 10 MHz (background frequency). This measurement mode is referred to as the standard *Dual-frequency Measurement Mode*

The permittivity measured by the Incyte Arc Sensor can be correlated to the viable cell density (see Figure 4-3).

NOTICE

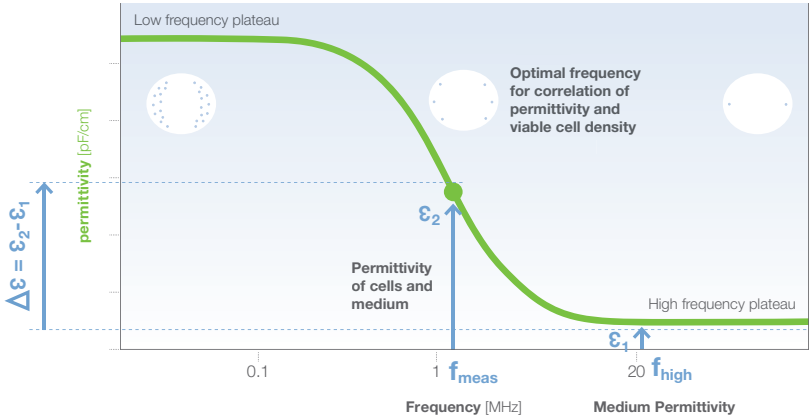
- In the Dual-frequency measurement mode, the permittivity of viable cells is measured at a frequency specific to the cell type and corrected by the background permittivity, which is measured at a high frequency.
- The Incyte Arc Sensor measures only viable cells but not dead cells, which exhibit a permittivity signal.

Figure 4-2. Overview of the Incyte Arc Sensor measurement principle: Sensing element measuring a cellular membrane



1	Pt electrodes	3	Polarized viable cells
2	Dead cells with a damaged membrane do not hold the ions across the cell membrane	4	Electric field

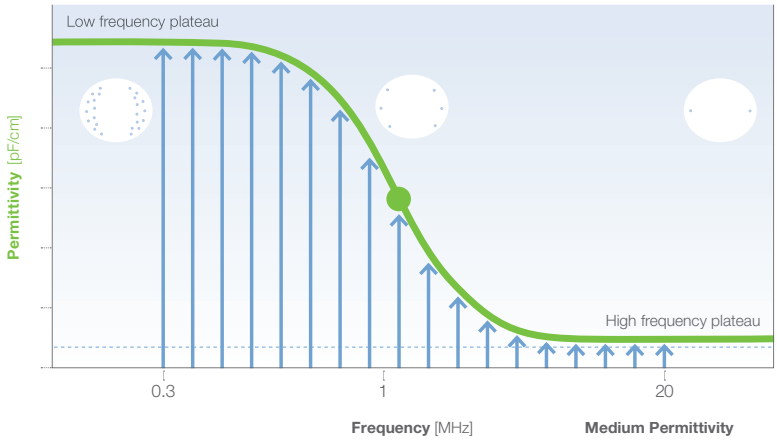
Figure 4-3. Graph illustrating the dual-frequency measurement mode: Combination of background signal subtraction and characteristic frequency



4.2.2 Theory of scan and Cole-Cole fitting

The polarization response of cells varies strongly at different frequencies as shown in Figure 4-3. The cells fully polarize and provide a measurable permittivity at lower frequencies, whereas cells that do not polarize fully provide a measurable permittivity at higher frequencies. This response can be described as the *Cole-Cole equation*. The Incyte Arc Sensor **`Frequency Scan`** measures the permittivity signal at 17 different frequencies between **0.3** and **10** MHz (see Figure 4-4).

Figure 4-4. Graph illustrating the ideal frequency spectrum of mammalian cells, which is referred to as beta-dispersion



The analysis of the Incyte Arc Sensor scan may provide additional information on the cell physiology response throughout the culture process. To better characterize the change in the curve shape of the scan taken by the Incyte Arc Sensor as well as the cell response within the dielectric field, the parameters are empirically calculated to fit the curve to the Cole-Cole equation.

The relevant parameters of the Cole-Cole equation, thus, the *difference between permittivity measurements* ($\Delta\varepsilon$), *characteristic frequency* (f_c), and *slope* (α) are automatically fitted and displayed in the ArcAir application. In general, qualitative observations of changing the Cole-Cole parameters can often be linked to process-specific changes in the culture parameters.

The characteristic frequency (f_c), may offer an indication of the average cell diameter. A decrease in f_c may indicate an increase in the diameter of the cell during the culture process. On the contrary, a shift in fc towards the higher frequency range may indicate a reduction in the cell size.

The height of the fitted low-frequency plateau ($\Delta\varepsilon$) can correlate to the viable cell density and is a theoretical calculation of the maximum permittivity able to be generated in the culture at that time.

The slope (α) of the beta-dispersion at the characteristic frequency (f_c) may indicate the distribution of the cell diameter. A steep slope, thus, a large α may correlate to a homogenous culture.

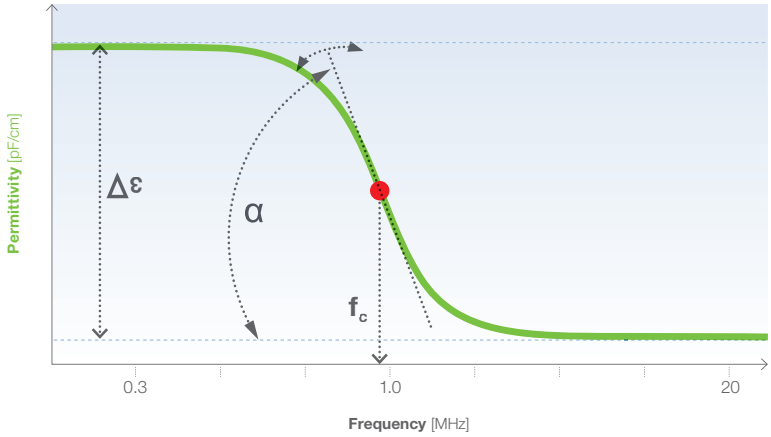
The Cole-Cole parameters are provided with a performance calculation estimation called fitting quality (`Cole fit R2`). Note that not all cultivation can support these parameters to yield a good calculation. The indicator shows a value between **100** and **0%**, where 100% refers to an ideal fit and 0% refers to a non-converging data set. In addition, the model error (`Cole fit RMSE`) is also provided as a secondary reference metric.

4.2.3 Theory of data modeling for offline/inline correlation

The Incyte Arc Sensor provides a measure of the viable cell density through the measurement of permittivity and viable cell biovolume. The measurement of permittivity is influenced by different parameters such as cell size, internal conductivity of the cells, and membrane permeability. As a result, the correlation strength between permittivity and an established offline metric may differ post-exponential phase as a culture undergoes metabolic stress, cell swelling, and the start of apoptosis.

To build a correlation model using the ArcAir Data Modeling software, you must use at least four batches including offline data for the same batch process. The offline data must include relevant variations that are necessary to build and validate in the ArcAir Data Modeling. For additional details on the ArcAir Data Modeling software, refer to the *ArcAir Data Modeling Operating Instructions* (REF 111003989).

Figure 4-5. Graph illustrating beta-dispersion of data acquired from the Incyte Arc Sensor scan



NOTICE

The design of the Incyte Arc Sensor optimizes the measurement values for α, f_c, and Δε for the Cole-Cole fit, whereas the Incyte Pre-Amp version may show different measurement values for α, f_c, and Δε.

4.3 Incyte Arc Sensor with an integrated microtransmitter

The Incyte Arc Sensor provides a fully compensated signal directly to the PCS through its integrated microtransmitter. Communication protocols include digital Modbus and an optional 4-20 mA, using the Arc Wi 2G BT Adapter (REF 243470).

The microtransmitter located in the sensor head stores all relevant sensor data. This includes factory calibration and diagnostic information which simplifies verification and maintenance.

4.4 Connecting the Arc sensors to the ArcAir application

Hamilton's Arc Sensor family of intelligent sensors enables operators to monitor and adjust process parameters in a bioprocess to their requirements. The Incyte Arc Sensor has an integrated microtransmitter that enables direct communication to 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).

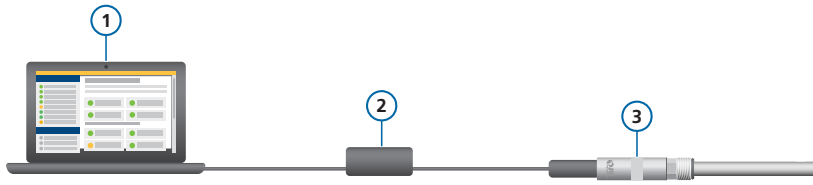
A wired connection can be established using an Arc USB Power Cable (REF 243490–XX) and a computer (see Figure 4-6). With the integrated microtransmitter, the Incyte Arc Sensor provides more reliable measurement directly to the process control system or the ArcAir application.

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 4-7). Wireless communication is available with smart phones, tablets, or computers.

Key benefits of connecting the Incyte Arc Sensor with the ArcAir application:

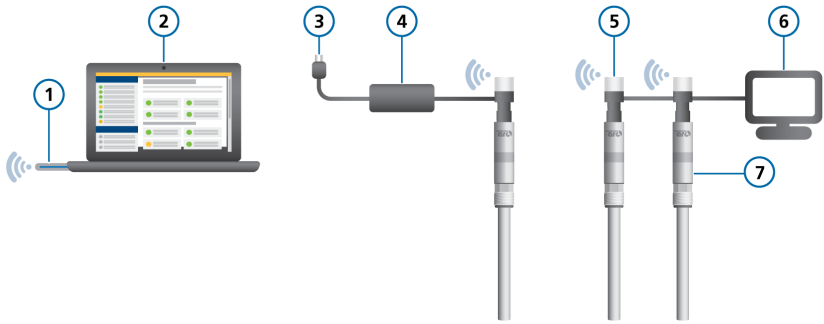
- A separate transmitter is not required
- Maintenance is simple
- Easy to install
- There is an option for a digital Modbus or analog communication via Arc Wi 2G BT Adapter (REF 243470)
- It offers a full online wireless option via Bluetooth® 4.0 for easy configuration
- It has a recording functionality (in ArcAir) with data export from the ArcAir experiment
- Reporting and central data management of user accounts, validation reports for verification, configuration, and communication within the GMP guidelines, including FDA CFR21 Part 11 and Eudralex Volume 4 Annex 11
- Advanced measurement correlation and multivariate data modeling via the ArcAir Data Modeling software (REF 111003989)

Figure 4-6. Arc system setup: Wired connection to ArcAir application on a PC



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

Figure 4-7. Arc sensor system setup: Wireless connection to ArcAir application



1	Arc wireless BT converter	5	Arc wireless BT adapter
2	ArcAir application installed on a PC/ Notebook	6	Process control system (PCS)
3	Power supply plug	7	Incyte Arc Sensor
4	Arc USB power cable		

NOTICE

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

4.4.1 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 making in-lab configurations and in-process adjustments by combining the reliability of Incyte Arc Sensors with external power and mobile devices. The offset compensation functions, thus, **Mark Zero** and **Clear Zero** can be used in the process environment and during sensor `Verification`.

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 Incyte Arc Sensor.

Different types of ArcAir application

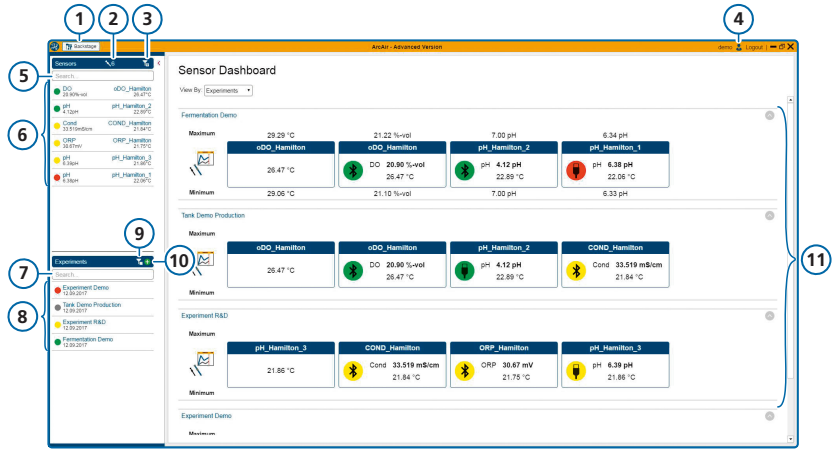
Table 4-2. Different types of ArcAir application: ArcAir Basic and ArcAir Advanced

AcrAir application type	Availability	Intended for...	Features
ArcAir Basic	Free download from the Hamilton website or App Store	PC/mobile	• Measurement information • Sensor status • Experiment function • Configuration • Firmware update

AcrAir application type	Availability	Intended for...	Features
ArcAir Advanced	• You can update the ArcAir Basic to ArcAir Advanced or acquire the ArcAir Advanced by purchasing the application via the App Store. • You can also order the Arc Wireless BT Converter (REF 242333) with ArcAir Advanced and install the application via a PC.	PC/mobile	• Full inoculation • Verification • Communication validation • User profile management • Audit trail • Report generation

Overview of the ArcAir application (PC version) main screen

Figure 4-8. ArcAir application (PC version): Overview of the ArcAir main screen



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

2 Number of sensors online

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

4 User profile name/account

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

8 Overview of the list of sensors used in an experiment

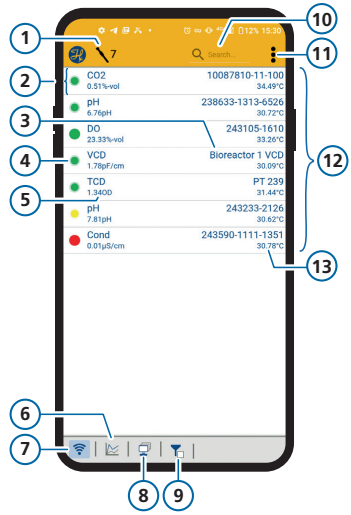
9 Filter icon: Use the filter to specify or refine your search for the sensor list under experiment

10 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 4-9. ArcAir application (mobile version): Overview of the ArcAir main screen



1	Number of sensors online	8	Computer connection
2	Primary sensor: Provides an overview of the sensor status, measurement parameter, and measured value with the corresponding units	9	Filter icon: Use the filter to specify and refine your search for the sensors connected to the ArcAir application
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 VCD.	10	Search field: Use the search field to search for sensors connected to the ArcAir application

4	Sensor status indicator: • **Green:** Indicates that there are not 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 For additional information about the Sensor Status Indicator, see Chapter 8.	11	ArcAir licenses and other information related to the sensor
5	Current measurement point	12	Sensor dashboard: Provides an overview of the sensors connected to the ArcAir application, including the sensor status, measurement parameters, and measured value with the corresponding units. It also serves as a reference to differentiate between the sensors.
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		

4.4.2 Accessories

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

All listed accessories for the Incyte Arc 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 Incyte Arc Sensor.

Accessories overview

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

NOTICE

We recommend you use the Arc Wi 1G BT Adapter (REF 243460) in combination with the Arc Modbus OPC Converter (REF 10089359). This will enable bi-directional communication.

- **Wired/external power**

  External Power supply with Arc USB Power Cable (REF 243490-01/-02)

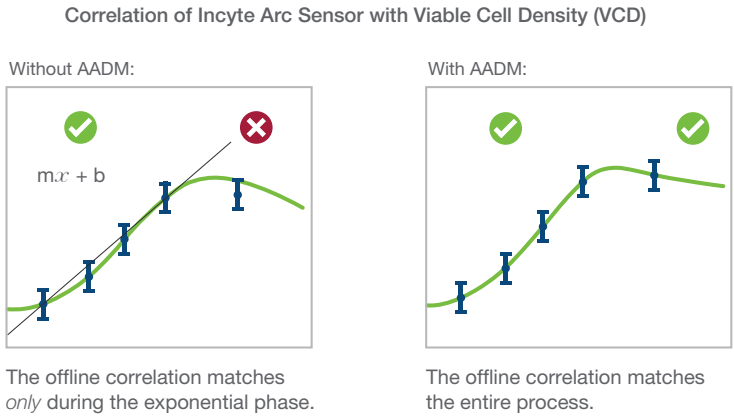
4.4.3 ArcAir data modeling

The measurement of permittivity by the Incyte Arc Sensor indicates the biovolume in a bioprocess. When the Incyte Arc Sensor uses Dual-frequency as the measuring mode (using selected frequencies), the sensor can generate a linear correlation of permittivity with the viable cell density. During exponential growth, the biovolume and the viable cell density are proportional (see Figure 4-10).

The permittivity measurement can be easily and reliably converted into the unit of cell density (VCD) via a linear correlation. This can change when the cells enter the stationary growth phase. The number of viable cells remains the same while the cells swell toward the end of their life cycle (initiation of apoptosis), which can be detected by the Incyte Arc Sensor probe. The end of the cell life cycle can cause an increase in permittivity.

An improvement in the correlation can be achieved by using multiple frequencies and multivariate data tools. The ArcAir Data Modeling software is Hamilton's tool to achieve exactly this improvement. For more information about using the Incyte Arc Sensor in a GMP environment, refer to the *ArcAir Data Modeling Operating Instructions* (REF 111003989). For additional information about the ArcAir Data Modeling software, contact Hamilton Technical Support (see Section 8.4).

Figure 4-10. Graph showing the correlation of Incyte Arc Sensor VCD measurements without AADM compared to VCD measurements with AADM.

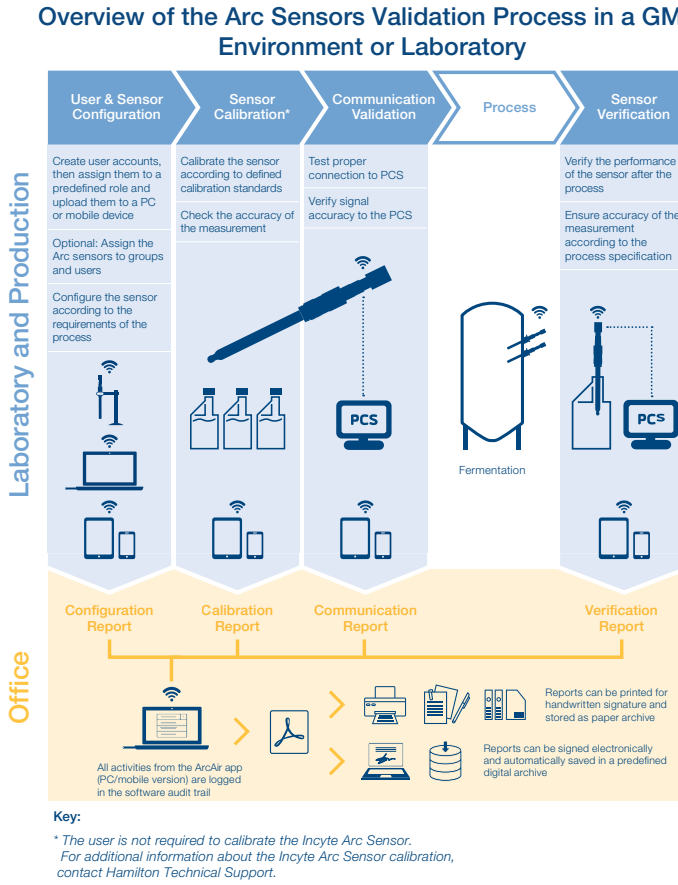


4.5 Incyte Arc Sensor in a GMP environment

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

Figure 4-11 provides an overview of the validation process for the Arc sensors in GMP environments or laboratories.

Figure 4-11. Overview of the Arc sensors validation process in a GMP environment or laboratory



Key:

** The user is not required to calibrate the Incyte Arc Sensor. For additional information about the Incyte Arc Sensor calibration, contact Hamilton Technical Support.*

5 Hardware and Software Installation

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

5.1 Hardware installation

⚠ 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 8.*
- *Contact Hamilton Technical Support if you experience warning and error messages with the sensor.*

1. Carefully unpack the Incyte Arc Sensor. Inside the packaging, you will find enclosed the Incyte Arc Sensor, the Declaration of Quality (DoQ), Material Certificate(s), and Operating Instructions (see Figure 5-1).
2. Inspect the sensor for damage or missing parts.

Figure 5-1. Overview of the Incyte Arc Sensor package contents: Incyte Arc Sensor, DoQ, Material Certificates, and Operating Instructions



5.2 Installing the Incyte Arc Sensors in a bioreactor

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

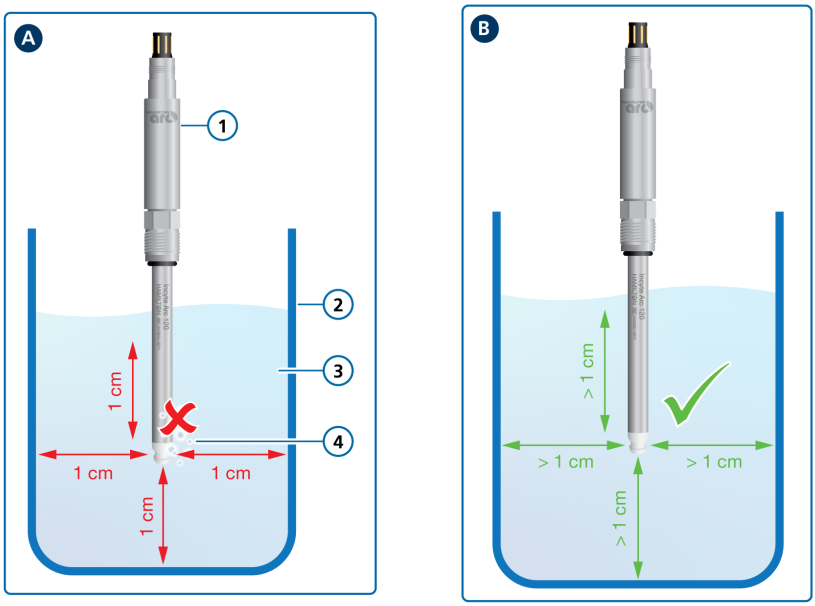
1. Remove the yellow protective caps from the VP8 sensor head and the sensor tip.
2. Inspect the Incyte Arc Sensor:
   - Check the O-ring on the sensor shaft.
   - Check if the sensing part (Pt electrode) is free of damage and dirt particles.

⚠ CAUTION

- *The gas bubbles from the media can interfere with the measurement while installing the Incyte Arc Sensor. We recommend that you evaluate 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.*
- *You must maintain a clearance of more than 1 cm around the sensor in relation to fixed parts in the bioreactor, such as reactor walls and stirrers.*
- *Do not use mechanical or power tools to tighten the Incyte Arc Sensor during the installation.*
- *Tighten the sensor by hand when you install it via the side wall port (stainless steel PG 13.5 thread) on the bioreactor. The torque must not exceed 2 Nm.*
- *Do not use the Arc Wi BT Adapter as a tool to install or unscrew the sensor from the reactor.*

3. Carefully install the sensor in the port on the bioreactor, then make adjustments if necessary (see Figure 5-2).
4. Tighten the sensor by hand. The torque must not exceed **2 Nm**.

Figure 5-2. Overview of the Incyte Arc Sensor setup for verification: Insufficient clearance around the sensor tip (A) and sufficient clearance around the sensor tip (B)



1	Incyte Arc Sensor	3	Medium
2	Beaker wall	4	Air bubbles

5.3 Connecting Incyte Arc Sensors 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 Incyte Arc Sensor integration options, see Sections 5.3.1, 5.3.2, and 5.3.3. For details on how to configure the different integration setups, refer to the Incyte Arc Sensor *Programmer's Manual* (REF 695251).

The mechanical design of the Incyte Arc Sensor makes it compatible with all Hamilton process housings. For additional information about the process housings offered by Hamilton Process Analytics, see Table 11-4.

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.

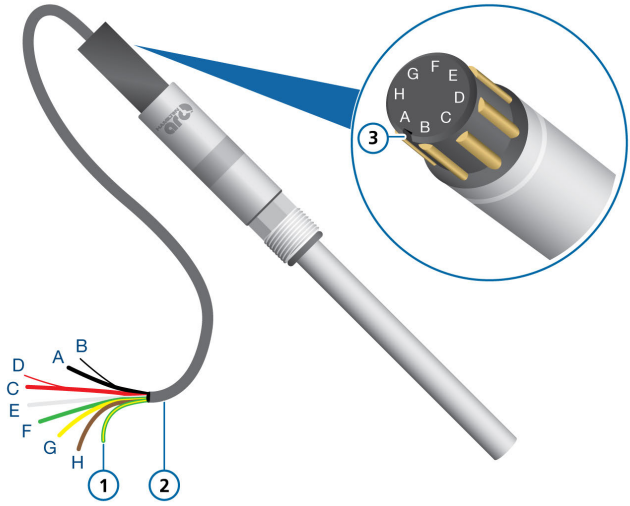
NOTICE

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

5.3.1 VP8 or M12 Pin assignment

Always use Hamilton VP8 sensor cables for safe connection and system operation. The sensor data cables are available in indifferent lengths to order (see Chapter 11). The Incyte Arc Sensor is fitted with a VP8 male connector by default.

Figure 5-3. Incyte Arc 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 alignment

Table 5-1 provides an overview of the VP8 connector Pin assignment for the Incyte Arc Sensor electrical connection.

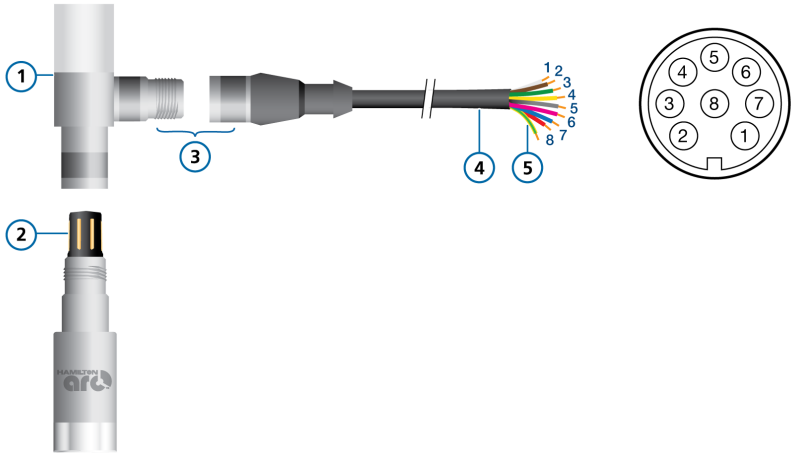
Table 5-1. Incyte Arc Sensor connector: VP8 connector Pin assignment

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: +24 V ±10 %	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

5.3.2 Connecting Incyte Arc Sensors via 4-20 mA analog interface

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

Figure 5-4. 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 5-2 provides an overview of the M12 (A coded) Pin assignment for the Hamilton M12-8 pole sensor cable connector.

Table 5-2. 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

M12 Pin	Function	Cable description	Description
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.

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

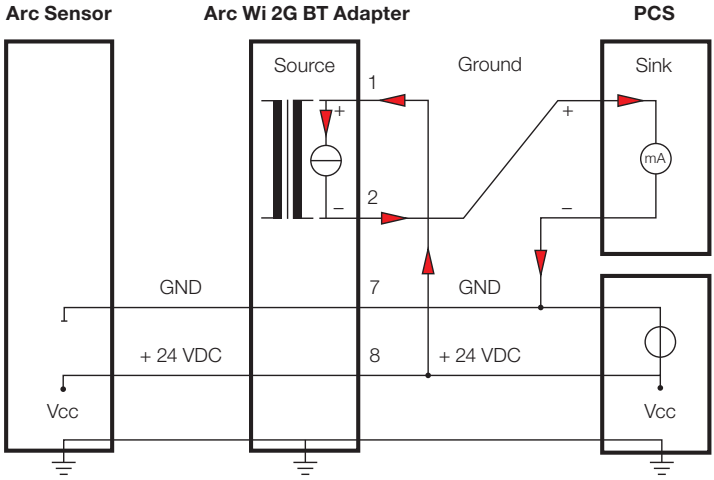
The 4–20 mA interface enables direct connection of the Incyte Arc Sensor to a data recorder, indicator, control unit, or PCS with an analog Input/Output (I/O). In this configuration, the Wi 2G BT Adapter works as a current sink in a passive state.

Connect the sensor according to the Pin assignments (see Sections 5.3.1 and 5.3.2).

The 4–20 mA interface setup consists of the Arc Wi Adapter and Incyte Arc Sensor which is pre-configured with default values for the 4–20 mA range, and the measurement unit. The same interface has to be configured according to the requirements of the user. For more details about the correct measurement in the ArcAir application, see Section 5.5.5.6.

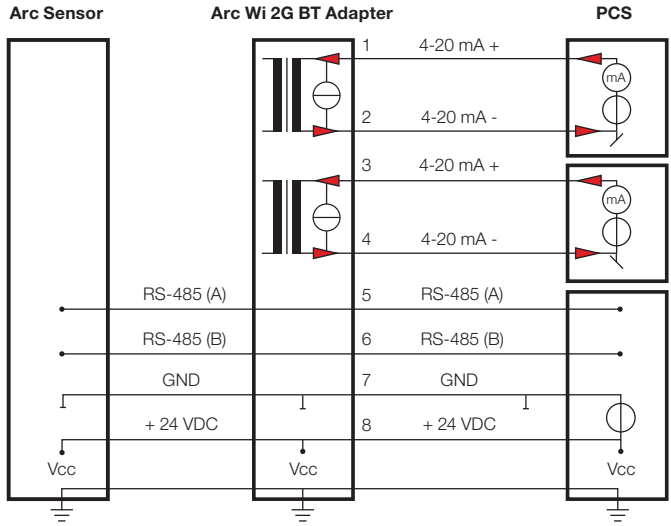
PCS configuration with a passive 4-20 mA input card: Sensor configured as the current sink

Figure 5-5. Typical PCS configuration with a passive 4-20 mA input card: Setup with an Arc Wi 2G BT Adapter (REF 243470) if there is no active 4-20 mA connection available



PCS configuration with an active 4-20 mA input card

Figure 5-6. Typical PCS configuration with an active 4-20 mA input card: Setup with an Arc Wi 2G BT Adapter (REF 243470)



NOTICE

- The Arc Wi 2G BT Adapter (REF 243470) provides internal galvanic isolation for improved analog signal quality.
- The Arc Wi 2G Adapter BT simplifies the connection to the process control system (PCS).

5.3.4 Connecting Incyte Arc Sensors 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 slave. The Arc sensors require a power supply via the VP8 Pins **C** and **D** to function correctly (see Figure 5-3}.

Additional information: Modbus RTU communication protocol

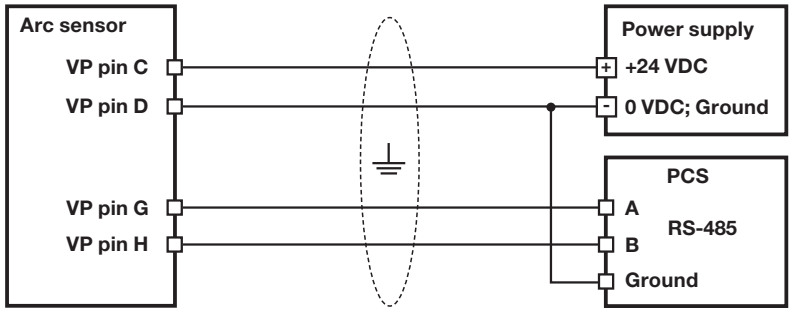
- The Modbus RTU communication protocol corresponds to the Modbus-IDA standard. For more information, refer to the Modbus organization website (https://modbus.org/). The Modbus physical layer is described in detail with requirements on cabling and line termination in the *Modbus Serial line Protocol 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.*
- The Incyte Arc Sensor connection via Modbus can be found in the Incyte Arc *Programmer's Manual* (REF 111004638).

⚠ 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 5).*
- *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

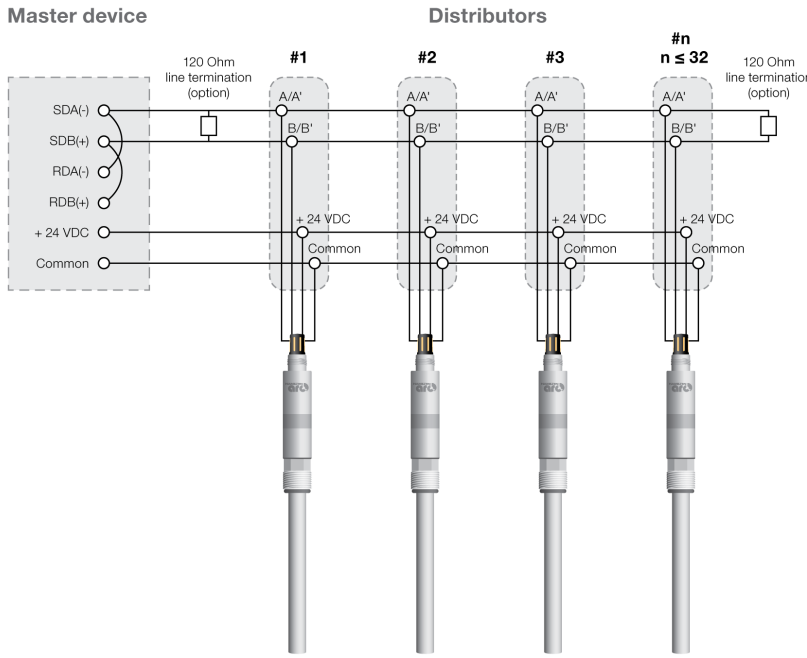
Figure 5-7. Wiring diagram for the RS-485 interface



⚠ CAUTION

You must assign a unique Modbus device address to each sensor for the correct communication in the wiring configuration shown in Figure 5-8.

Figure 5-8. Multi-drop bus wiring: Two-wire mode for the Modbus connection



NOTICE

- Each sensor functions as a Modbus slave.
- Only one sensor can communicate with the master 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 master and the corresponding interfaces of the sensors must comply with the EIA/TIA RS-485 standard.

5.4 ArcAir application

The ArcAir application provides secure and efficient communication for monitoring, validating, and managing Arc sensors and user accounts.

The application combines the cost savings and reliability of Arc sensors with the power, convenience, and portability of mobile devices.

The user benefits from the automated standard calibrations and configuration in the laboratory, along with product calibrations and validations in the process environment.

The additional reporting functionality offers management of validation reports for calibration, verification, configuration, communication, and user profiles within the GMP regulatory requirements for all Arc sensors.

ArcAir can be installed on a computer, mobile device, or tablet. ArcAir offers an overview of all the Arc sensors in your environment via a computer, tablet, and mobile phone.

NOTICE

- For details on 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 Incyte Arc Sensor.

5.4.1 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).

5.4.2 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).

5.4.3 Software 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.

5.5 Connecting Arc sensors to the ArcAir application

The Arc USB Power Cable (REF 243490-XX) is required to connect the Incyte Arc Sensor. Alternatively, a wireless connection is also possible with an Arc Wi BT Adapter (see Section 11.2).

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

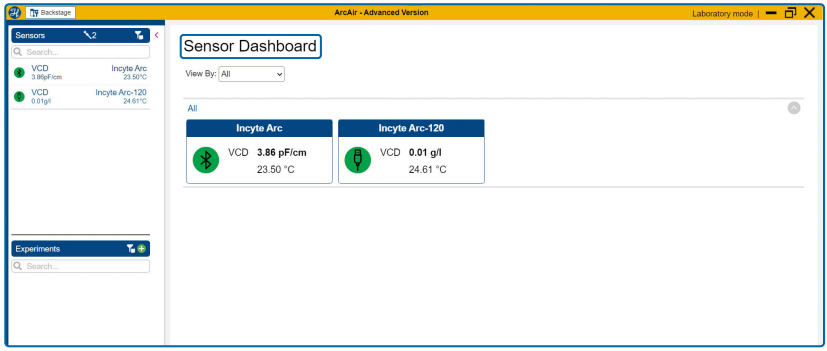
To connect the Arc sensors to the ArcAir application, follow these steps:

1. Connect one Incyte Arc Sensor with the power supply and the computer, by using the Arc USB Power Cable (REF 243490-XX) on a standard USB port.
2. he 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 5-9).
3. To connect to the Incyte Arc Sensor: Click the **VCD** sensor on either the **Sensor Dashboard** or select the applicable sensor from the list in the upper left corner of the display (see Figure 5-9). When the sensor is connected, the **Info** tab of the sensor will be shown on the display.
4. Verify the sensor functionality and status on the computer, mobile device, or PCS via the ArcAir application: **Sensor Quick View** screen or **Info** tab.

⚠ CAUTION

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

Figure 5-9. Overview of the ArcAir application: Dashboard showing the different types of sensors connected



5.5.1 Info tab

The **Info** tab is divided into the following categories:

- Sensor quick view
- Status
- Measurement value
- Measurement point
- Information
- Userspace

Sensor Quick View

The following information is under the **Sensor Quick View** page: `Current Measurement` and `Sensor Health`.

- **Current Measurement**

  Shows the currently measured Viable Cell Density (VCD) and Temperature (see Figure 5-11).

- **Sensor Health**

  Displays information about the life cycle and the quality of the sensor. In addition to the operating hours and the number of sterilization (SIP) and cleaning cycles (CIP), the Quality Indicator is also displayed under `Sensor Health`.

NOTICE

The Quality Indicator increases in value after the sensor conditioning process (see Sections 5.5.2.1 and 5.5.2.2).

- **Warnings and Errors**

  This part shows a detailed list of existing warnings and errors.

Status

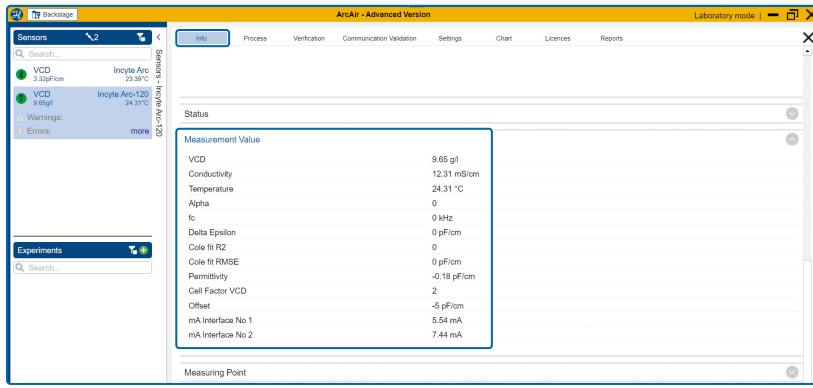
Shows the current status of the sensor and information about the life cycle and the quality of the sensor. In addition to the operating hours, the number of sterilization (SIP) and cleaning cycles (CIP), the Quality Indicator is also displayed here. Note that the status is not automatically updated.

Measurement Value

Provides detailed information about the current measurement. The displayed information includes the measured Viable Cell Density (VCD), conductivity, and temperature. The current values for α, `fc`, `Delta Epsilon`, `Cell Factor`, and `Offset` (Mark Zero) are also shown.

Note that the measurement value is not automatically updated. To update the values, click the drop-down arrow to refresh and view the updated values.

Figure 5-10. Overview of the measurement value screen



Measuring Point

You can assign a name to the sensor to help you identify the specific sensor when multiple sensors are connected.

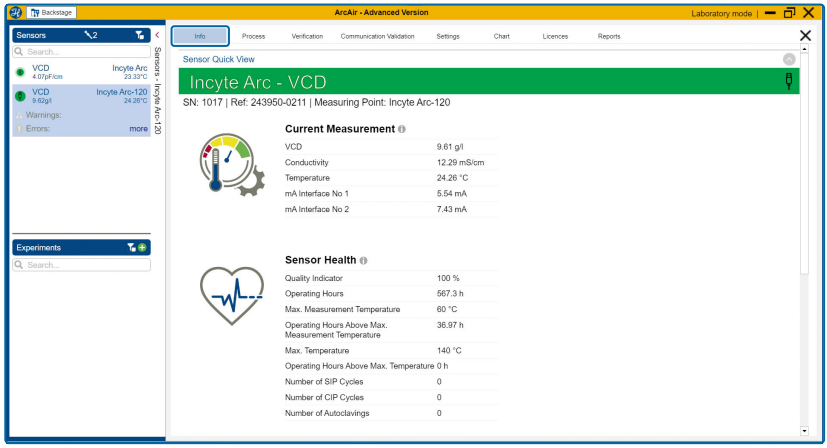
Information

Shows information about the sensor. For example, the sensor `Name`, `Ref No.`, `Serial Number (SN)`, `Sensor ID`, `Sensor Length`, `Lot`, `Lot Date`, `Firmware Version`, `Firmware Date`, and `Sensing Material`.

Userspace

Offers users the choice to include extra comments or descriptions. For example, bioreactor ID.

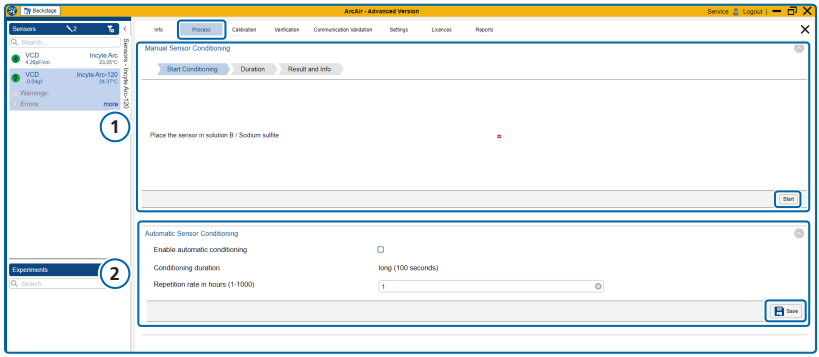
Figure 5-11. Sensor quick view screen: Information about the connected Incyte Arc Sensor



5.5.2 Process tab

The **Process** tab holds settings designed for sensor use during operations. This includes both manual and automatic conditioning for the Incyte Arc Sensor.

Figure 5-12. Overview of the process screen



1	Manual sensor conditioning settings	2	Automatic sensor conditioning settings

5.5.2.1 Manual conditioning

⚠ CAUTION

- *Use the* ***Manual Conditioning*** *function with caution.*
- *Prolonged cleaning cycles can cause sensor signal instability up to two hours after the conditioning process.*

The **Manual conditioning** option is intended to remove cells from the electrodes when cells attach to parts of the sensor tip, which is known as Fouling. In this process, a high current is applied to the electrodes to create bubbles that dislodge the cells. For a detailed procedure description, see Section 7.2.1.

5.5.2.2 Automatic conditioning

⚠ CAUTION

- *Only use the* ***Automatic Conditioning*** *function if the sensor has been in the process media for more than four weeks and you can visibly observe cell aggregation/agglomeration on the sensing part of the sensor*
- *Prolonged cleaning cycles can cause sensor signal instability up to two hours after the conditioning process.*

The **Automated Conditioning** option is intended for processes where cell attachment to the sensor is known to be frequent. You can use this function to set different cleaning cycles at regular intervals during the process. In this process, a high current is applied to the electrodes to create bubbles that dislodge the cells. For a detailed procedure description of the Automatic Conditioning, see Section 7.2.2.

5.5.3 Verification tab

The **Verification** process provides the possibility to check the *repeatability* of the sensor to exclude drift. The verification process for Incyte Arc Sensors used in a GMP environment is described in Section 7.1. The verification process in a GMP environment must be validated with the process requirements of the customer. This function is only available in the ArcAir Advanced version.

NOTICE

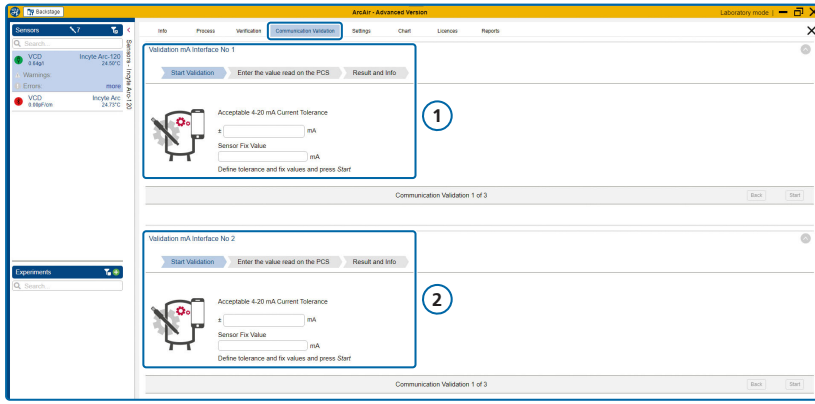
- The condition of the sensor electrodes is checked independently of the verification results for conditioning, regardless of the result of the verification. The 12880 µS/cm conductivity standard (REF 238988) is required for verification
- The solution required for the electrode conditioning is Solution B (REF 243742).

5.5.4 Communication validation tab

Under the **Communication Validation** tab, it is possible to validate the 4-20 mA communication and custom tolerances (see Figure 5-13). In addition, it is possible to set up the 4-20 mA or the Modbus communication.

The **Settings mA Interface No. 1 and 2**, and **Settings Modbus** options can also be found under the **Settings** tab. For additional information, see Sections 5.5.5.6 and 5.5.5.7.

Figure 5-13. Communication validation screen: Example of communication validation in ArcAir application



1	Settings for mA Interface No. 1	2	Settings for mA Interface No. 2

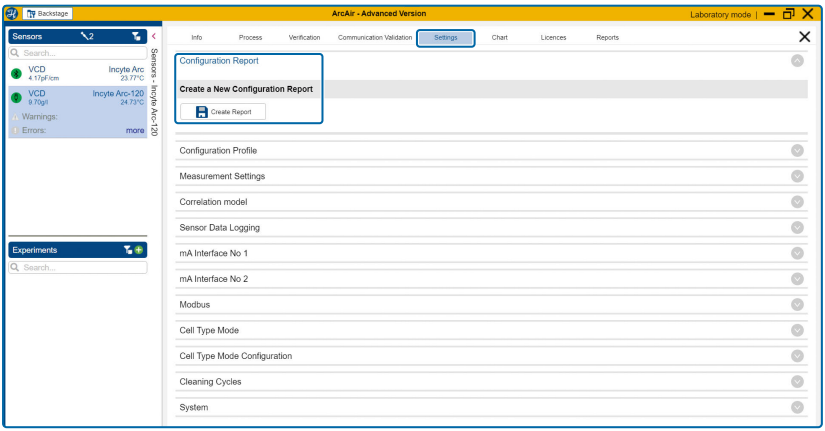
5.5.5 Settings tab

This **Settings** tab contains settings related to the sensor and signal processing. The submenu of the **Settings** tab is described below.

5.5.5.1 Create a new configuration report

The **Configuration Report** compiles the properties, for example, the temperature range of the sensor and adjustments/settings made by the user, such as `Offline Correlation Models` and `Offset` in a tabular format. The reports can be viewed under the **Report** tab and exported as a PDF.

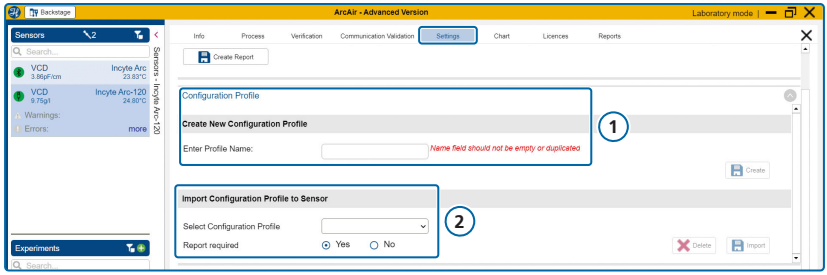
Figure 5-14. Settings screen: Create a new configuration report



5.5.5.2 Configuration report/profile

The **Configuration Report/Profile** can be exported, as described in the *Hamilton Arc Operating Instructions* (REF 10071115).

Figure 5-15. Settings screen: Create a configuration profile for the sensor



1	Create a new configuration profile	2	Import the configuration profile to the sensor

5.5.5.3 Measurement settings

All important settings that are based on the measurement of the Incyte Arc Sensor can be found in this section. To activate the changes, click the **Save** button. Figure 5-16 shows an example of the `Measurement Settings` parameters for the Incyte Arc Sensor.

Figure 5-16. Settings screen: Measurement settings for the Incyte Arc Sensor

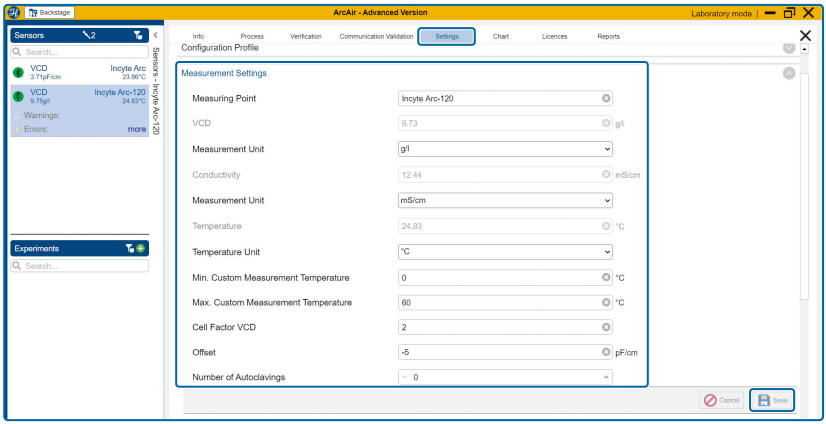


Table 5-3. Measurement settings overview

Parameter	Description
Measuring Point	Name of the `Measuring Point`
VCD	The Viable Cell Density (VCD) is determined based on the selected `Measurement Unit`.
Measurement Unit	pF/cm (standard unit) and user-defined correlated for the offline measurement. **NOTICE!** You have the option to choose a different measurement unit from the available units when using an offline correlation with a correlation model.
Conductivity	Measurement of the conductivity in mS/cm
Measurement Unit	Set to mS/cm
Temperature	Temperature of the medium
Measurement Unit	°C (standard). The user can change the measurement unit to K or °F.
Min. Custom Measurement Temperature	Minimum temperature value defined by the user. **NOTICE!** This is the minimum temperature required to turn on the electronics of the sensor.
Max. Custom Measurement Temperature	Minimum temperature value defined by the user.
Cell Factor VCD	Cell factor value range: 0.01 to 1 000 000. **NOTICE!** The standard value is 1.
Offset	The user can enter an `Offset` value to change the VCD measurement output value. **NOTICE!** You can also use Mark Zero in the Experiment to set an Offset or Clear Zero to delete an Offset.

Parameter	Description
Number of Autoclaving	The user has the option to set the number of autoclaving cycles used for cleaning the sensor. **NOTICE!** The autoclaving cycle does not update automatically due to the sensor being disconnected from the power supply during autoclaving. Therefore, you must manually adjust the autoclaving counter to match the number of autoclave cycles the sensor has undergone.

Measuring Point

You can assign a name or description to the sensor in the **Measuring Point** field. By default, the measuring point reference is based on the `Serial Number` of the connected sensor. The **Sensor List**, **Dashboard**, or **Experiment** provides a better overview of the connected sensors. The name or description of the sensor can also be changed in the **Sensor Quick View** (see Section 5.5.1).

Measurement Unit

You can set the measurement units for `Temperature`, `Conductivity`, and `Permittivity` here. The units are displayed with the measured value.

The Incyte Arc Sensor is designed to measure permittivity. The permittivity measurement unit can be converted into another unit via Offset and Cell Factor using an Offline Correlation. The user can select the unit required. Note that the default measurement unit is `pF/cm` (see Table 5-4). Figure 5-17 shows the formula used in the design of the Incyte Arc Sensor to calculate the permittivity. For example, if you use a Correlation Factor of 3 and an Offset (Mark Zero) of `0.5` on a permittivity value of 2 `pF/cm` will produce a Viable Cell Density (VCD) value of `4.5 g/L`.

⚠ CAUTION

You cannot change the measurement unit if the AADM model is set to active.

Figure 5-17. Permittivity formula

$$(Permittivity - Offset)\left[\frac{pF}{cm}\right] \times Correlation\ Factor\left[\frac{unit}{{}^{pF}/_{cm}}\right] = \textbf{\textit{Cell Density}}\ \textbf{[unit]}$$

$$(2 - 0.5)\left[\frac{pF}{cm}\right] \times 3\left[\frac{{}^{g}/_{L}}{{}^{pF}/_{cm}}\right] = 4.5\left[\frac{g}{L}\right]$$

Table 5-4. Permittivity units available in the ArcAir application

Permittivity units	
Measurement parameter	Unit
Packed cell volume	PCV
Gram per liter	g/L
10^6 cells per milliliter	E6
Picofarad per centimeter	pF/cm
Optical density	OD

Table 5-5. Conductivity units available in the ArcAir application

Conductivity units	
Measurement parameter	Unit
Millisiemens per centimeter	mS/cm

Table 5-6. Temperature units available in the ArcAir application

Temperature units	
Measurement parameter	Unit
Degree Celsius	°C
Kelvin	K
Degree Fahrenheit	°F

Min. / Max. Custom Measurement Temperature

NOTICE

Permittivity and conductivity measurements cannot be performed if the temperature of the sensor is higher than 60 °C and the temperature of the medium. This is a safety feature built into the sensor to protect the sensing part and extend the service life.

Use the **Min. / Max. Custom Measurement Temperature** settings to customize the `Min.` and `Max.` of the measurement temperature settings for the sensor. By default, the `Min.` temperature is set to 0 °C and the `Max.` temperature is set to 60 °C.

Cell Factor VCD

Enter the Cell Factor to correlate the permittivity signal to the viable cell density. The cell factor can be changed during an `Experiment`. A change of cell factor is tracked in the experiment documentation. Make sure the measurement unit is adapted to the cell factor.

Offset

The user can enter a manual Offset. In addition, the **Mark Zero** button can be used in the `Experiment`. To reset the offset value, set the value to zero or click **Clear Zero** in the `Experiment`.

Number of Autoclaving

The user has the option to set the number of autoclaving cycles used for cleaning the sensor. The autoclaving cycle does not update automatically due to the sensor being disconnected from the power supply during autoclaving. Therefore, you must manually adjust the autoclaving counter to match the number of autoclave cycles the sensor has undergone. For additional information about the Cleaning Cycles, see Section 5.5.5.10.

5.5.5.4 Correlation model

By using the frequency scan of the Incyte Arc Sensor, you can enhance the correlation between Offline and Online measurement for reproducible processes, such as production or pilot plant operations, throughout the entire process. This enhancement is particularly beneficial during the plateau and death phases of a bioprocess.

The ArcAir Data Modeling generates the model by using previously recorded process datasets. You can then transfer and execute this model on the sensor to obtain real-time predictions of viable cell density. For additional details on the ArcAir Data Modeling software, refer to the *ArcAir Data Modeling Operating Instructions* (REF 111003989).

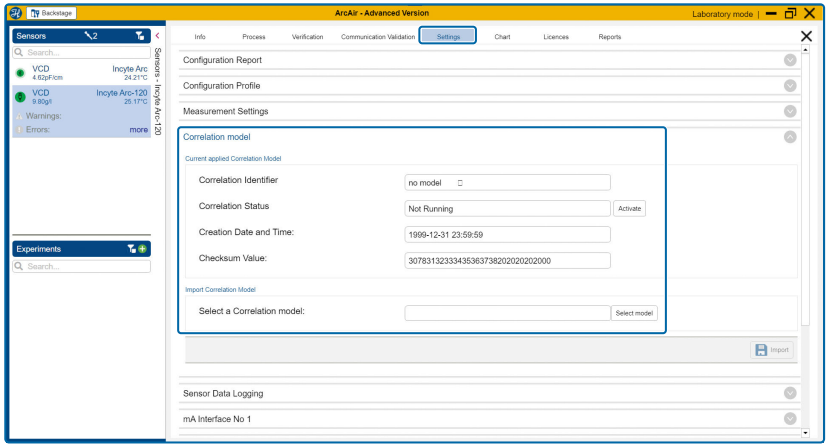
NOTICE

The model is identified by a checksum, creation date, and time to ensure the integrity of data between model construction and its import into the ArcAir application. This information cannot be edited by the user.

Creating a correlation model

1. Navigate to the **Import Correlation Model** screen, then select the correlation file exported from the ArcAir Data Modeling.
2. Click the **Import** button.
3. Navigate to the **Current applied Correlation Model** screen.
4. Verify the **Creation Date and Time** and **Checksum Value** are the same as the selected model.
5. Click the **Activate** button (see Figure 5-18).

Figure 5-18. Settings screen: Example of creating a new correlation model



5.5.5.5 Sensor data logging

If you use the `Experiment` function in the ArcAir application to record attachment data, the information will also be stored separately on the sensor head independently of the ArcAir application (see Section 6.1). This feature is accessible through the Sensor Data Logging (see Figure 5-19).

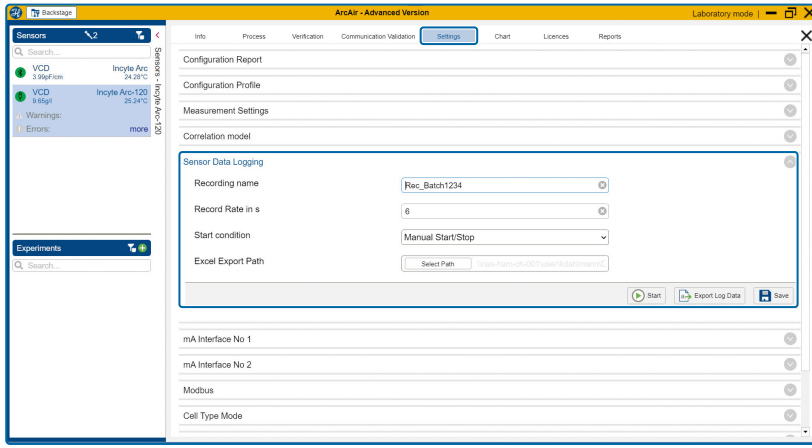
The internal memory of the sensor can accommodate `8191` measurements. The Record Rate setting determines the time frame for data storage. For example, a Record Rate of 5 minutes (equivalent to 300 seconds), it is possible to record data over 28 days (see Table 5-7).

If you restart the `Sensor Data Logging`, the previous data will be overwritten. Make sure you download the download the existing file before you start a new recording. When the storage reaches full capacity, a warning will alert you, and the recording will stop until the memory space is cleared. To free the memory space, you must start a new recording. Always make sure you save the old data before deletion. To activate the changes, click the **Save** button located at the bottom right corner of the screen.

NOTICE

We recommend you use the Arc USB Power Cable (REF 243490-XX) to power the sensor rather than relying solely on the USB power supply from the PC/Notebook.

Figure 5-19. Settings screen: Sensor data logging overview



Start sensor data logging

⚠ CAUTION

When you start a new recording, the previous file is automatically overwritten. Make sure you download the download the existing file before you start a new recording.

1. Enter a `Recording Name`. Note that the Recording Name entered will appear in the header of the CSV (comma-separated values) file as the `Batch Name`.
2. Define the recording rate in seconds. Refer to Table 5-7 for examples of different recording rates along with estimated maximum recording times.
3. Define the start condition for the recording:
   - **Manual Start/Stop:** This feature is available in the ArcAir application for PC/Notebook, mobile, or tablet. Note that a popup window will appear on the display asking you to reset the inoculation: `Do you want to reset the inoculation?` Select `Yes` if there is no previous inoculation has been conducted for the process run (see Figure 5-21). If you select `NO` the **Inoculation** button in the Experiment window will be disabled. The Sensor Data Logging will either start or stop depending on the configuration setting (see Figures 5-22 and 5-23).
   - **Start recording the inoculation:** Once the culture has been inoculated, click the **Inoculate** button to start the recording (see Figure 5-20). The inoculation feature is available in the ArcAir application for PC/Notebook, mobile, or tablet. For details on how to use the inoculate feature via the ArcAir mobile/tablet application, see Section 6.5.3.
   - **Start recording at the next power up:** When the sensor is turned on, the recording will start automatically.

NOTICE

Start recording at the next power up configuration is valid for a single power up cycle. If you want the sensor to start recording automatically during the next power-on, you must activate the automatic recording configuration each time.

4. Click the **Save** button to save the configuration. Note that a popup window will appear on the display, showing the message "`Sensor Data Logging is active`" (see Figure 5-22).

NOTICE

After you have started the sensor data logging, you will notice the text "`LOG`" will appear in red above the sensor(s) in the **Sensors** pane (see Figure 5-22).

Figure 5-20. Overview of the Sensor data logging screen of the ArcAir mobile application

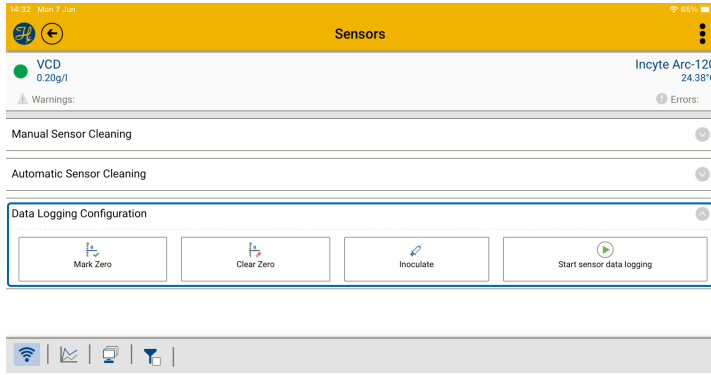


Table 5-7. Examples of recording rates with estimated maximum recording times

Planned recording rate	Recording rate for ArcAir (S)	Estimated maximum recording time
6 seconds	6	13.65 hours
10 seconds	10	22.75 hours
15 seconds	15	34.13 hours
30 seconds	30	68.25 hours
1 minute	60	5.69 days
5 minutes	300	28.44 days
10 minutes	600	56.88 days
12 minutes	720	68.25 days
15 minutes	900	85.21 days
30 minutes	1800	170.63 days

To save a Sensor Data Logging file to a computer, follow these steps:

1. Remove the Arc Wi Adapter BT from the sensor head.
2. Establish a direct connection between the sensor and the computer using the Arc USB Power Cable (REF 243490).

To export the logged data, follow these steps:

1. Choose a path to **Export** the Excel file.
2. Click the **Export Log Data** button.
3. Locate the exported data at the designated storage path. Note that the filename will include the export date, time, and Log Data.

Figure 5-21. Settings screen: Sensor data logging using the manual start option

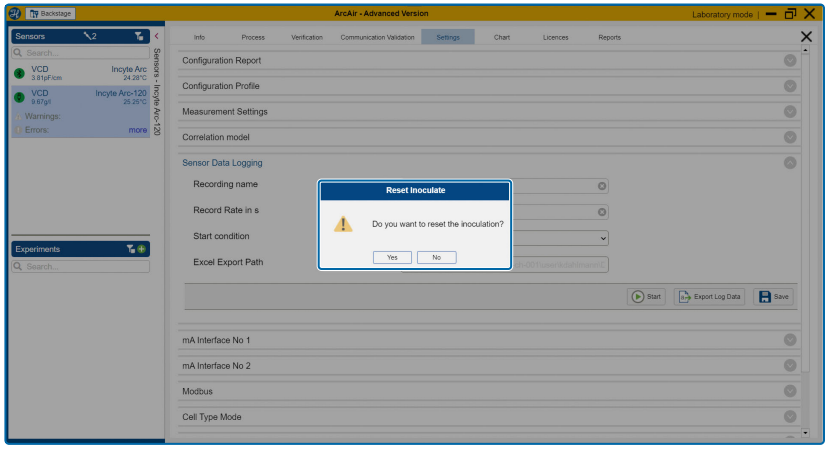


Figure 5-22. Settings screen: Sensor data logging activated

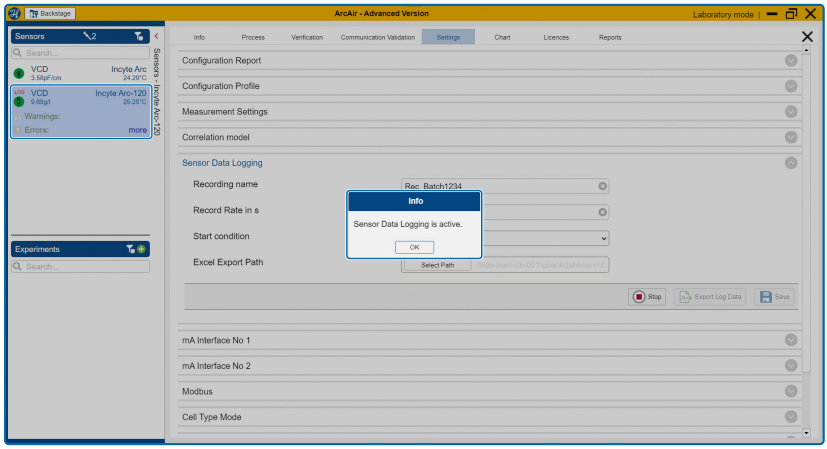
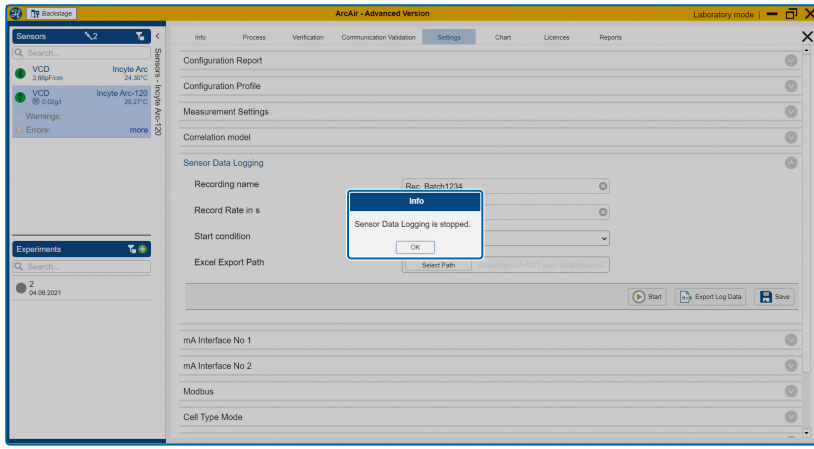


Figure 5-23. Settings screen: Sensor data logging stopped



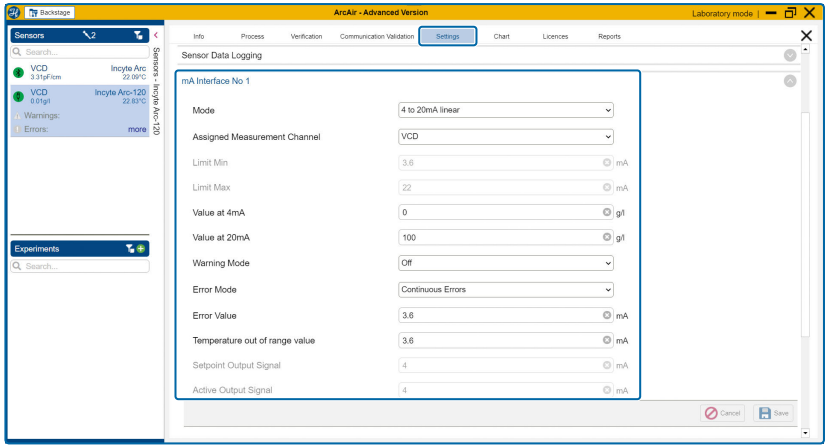
5.5.5.6 mA Interface No. 1 / No. 2

NOTICE

The Arc Wi 2G BT Adapter (REF 243470) is required to receive a 4–20 mA signal.

The **mA Interface No. 1** feature provides users with the option to configure the 4–20 mA communication interface. To apply these modifications, click the **Save** button located at the bottom right of the screen.

Figure 5-24. Settings screen: Overview of the mA interface No. 1 or mA interface No. 2 parameters



Mode

The 4-20 mA interface can be operated with one of the following **Modes**:

- `4-20 mA linear`
- `4-20 mA fixed`
- `Off`

Table 5-8 provides an overview of the different Modes for the 4-20 mA interface.

Table 5-8. Overview of the different modes for the 4-20 mA interface

4-20 mA interface mode	Description
4 to 20 mA linear	Linear correlation of 4-20 mA and permittivity, or cell density and conductivity
4 to 20 mA fixed	Can be used for testing the 4-20 mA signal transmission
Off	Disables the current on the 4-20 mA lines

Assigned measurement channel

Each interface can only be assigned one of the three available variables: `VCD`/ `Permittivity`, `Conductivity`, or `Temperature`. The value transmitted through VCD/Permittivity relies on the configurations specified in the **Measurement Settings**. The transfer of permittivity depends on the settings, which consider whether to include or exclude the Cell Factor and the Offset (Mark Zero).

Limit Min.

The `Limit Min.` describes the minimum possible analog current. The unit of measurement is milliampere (mA).

Limit Max.

The `Limit Max.` describes the maximum possible analog current. The unit of measurement is milliampere (mA).

Value at 4 mA / Value at 20 mA

Define the `Limit Min.` and `Limit Max.` range for the **Assigned Measurement Channel** and assign the limits to a `Value at 4 mA` or `Value at 20 mA`. For example, for the **Assigned Measurement Channel**, select VCD, then enter the mA value range:

- `Value at 4 mA := 0 g/L`
- `Value at 20 mA := 100 g/L`

Warning mode

Table 5-9 provides an overview of the different Warning Modes.

Table 5-9. Warning modes description

Warning Mode	Description
Off	No warnings output
Continuous warnings	All warnings will be transferred on the 4-20 mA signal

Error mode

Table 5-10 provides an overview of the different Error Modes.

Table 5-10. Error modes description

Error Mode	Description
Off	No errors output
Continuous Errors	All errors will be transferred on the 4-20 mA signal

Error Value

Define a current value to be output when an error occurs.

Warning Value

Define a current value to be output when a warning occurs.

Temperature out-of-range value

Define a current value to be output when the temperature is out of a specified range.

NOTICE

The parameter settings for mA Interface No. 1 are also valid for mA Interface No. 2.

5.5.5.7 Modbus

You can establish a Modbus connection using an Arc Wi BT Adapter. An overview of the available setting options is provided in Table 5-11. To apply the changes, click the **Save** button at the bottom right of the screen (see Figure 5-25).

⚠ CAUTION

Apply the following standard settings to the Modbus:

- *Device Address: 1*
- *Baud rate: 19200*
- *Parity: None*
- *Stop bit: 2*

Table 5-11. Overview of the Modbus setting options

Setting	Value range	Description
Device Address	1–32	The device address is a unique address that allows communication with up to 31 sensors on one bus.
Baud rate	Available baud rate options: • 4800 • 9600 • 19200 • 38400 • 57600 • 115200	The baud rate is used to specify the transmission speed. It is defined in baud/second.
Parity	Parity options: • None • Even • Odd	Parity is used to control the transmission of individual data bytes. This check refers to the sum of all bits in a data byte.
Stop bits	1, 2	The sum of the data byte must be 11 bits. If no parity is set, then you must set 2 stop bits.

Changing the baudrate of the Incyte Arc Sensor with Firmware version 001

⚠ CAUTION

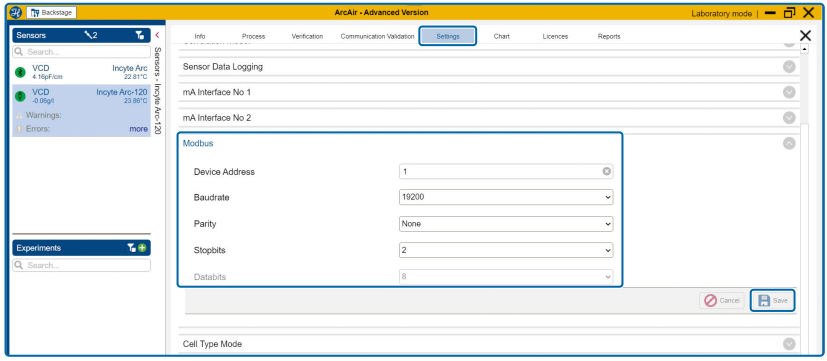
The Baudrate change will not be registered if the Incyte Arc Sensor is not disconnected from the power source and reconnected after the change in Baudrate.

NOTICE

Incyte Arc Sensor firmware version higher than 001 will automatically save the Baudrate change and it is not necessary to disconnect the sensor from the power supply and reconnect.

1. Change the `Baudrate` to the required value.
2. Disconnect the sensor from the power supply
3. Reconnect the sensor to the power supply so that the sensor can register the change in `Baudrate` .

Figure 5-25. Settings screen: Overview of the Modbus standard parameters



5.5.5.8 Cell type mode

You can filter signals and set the Dual-frequency mode with three predefined settings based on experience with different organism types. To implement these adjustments, click the **Save** button at the bottom right of the screen (see Figure 5-26). For personalized cell type mode configurations, see Section 5.5.5.9.

Select the frequencies that best suit your application. The Moving Average calculates the mean value of the list of values provided in Table 5-13. The Moving Average enhances the signal-to-noise ratio.

NOTICE

The moving average is applied to the scan data and the conductivity data at any time.

Figure 5-26. Settings screen: Overview of the cell type mode parameters

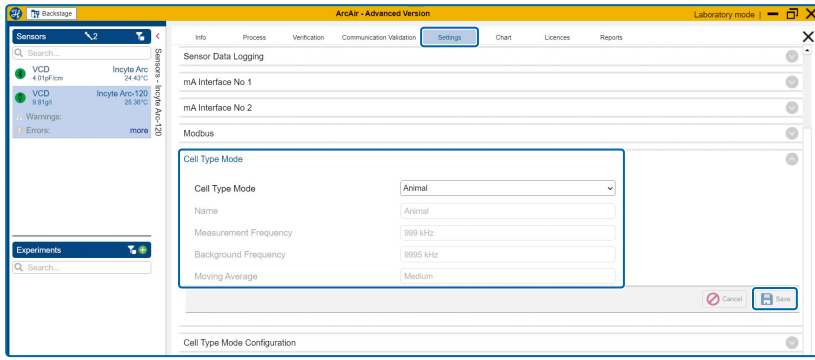


Table 5-12 provides an overview of the Cell Type Mode parameters.

Table 5-12. Cell type mode: Overview of the measurement frequency, background frequency, and moving average/signal integration

Cell type mode	Measurement frequency	Background frequency	Moving average / Signal integration
Animal	1,000 kHz	10 MHz	Middle
Yeast	2,000 kHz	10 MHz	High
Bacteria	1,000 kHz	10 MHz	High
User 1	User-defined	User-defined	User-defined
User 2	User-defined	User-defined	User-defined
User 3	User-defined	User-defined	User-defined

Table 5-13 provides an overview of the Moving Average/Signal Integration parameters.

Table 5-13. Overview of the moving average/signal integration parameters.

Moving average / Signal integration	Count of Measurements	Time required to hit counter in Dual Scan Mode	Time required to hit counter in Scan Mode
Low	32	32 s	96 s
Middle	64	64 s	192 s
High	128	128 s	384 s

5.5.5.9 Cell type mode configuration

The filter options under the `Cell Type Mode` can be customized using this menu. You can personalize the frequencies for dual measurements and set averaging values. These configurations can be saved in three different locations, with the assigned unique names (User 1-3).

NOTICE

We recommend that you use a longer moving average time when you do data analysis with Cole-Cole fittings.

Configuration set up for cell type mode

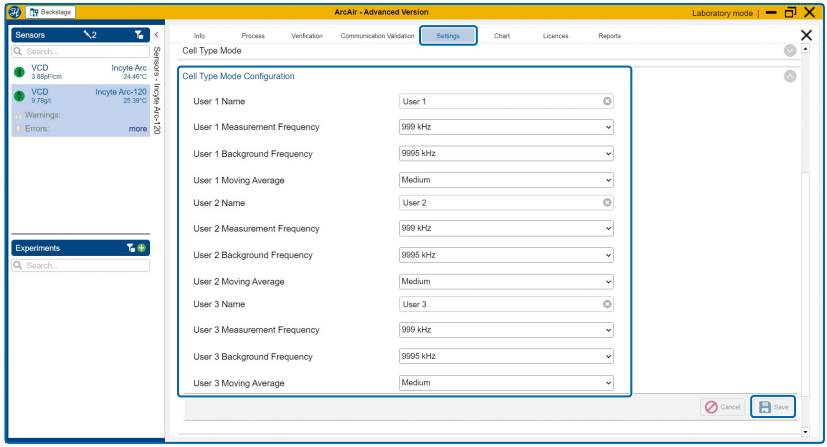
1. Select **User 1, 2,** or **3**. This is where the settings would be saved.
2. Assign a unique name if required:
   - Select the **Measurement Frequency** from the drop-down list.
   - Click the **Save** button.
   - Select the **Background Frequency** from the drop-down list
   - Click the **Save** button.
   - Select a moving average: **Low**, **Middle**, or **High**.

NOTICE

The moving average is the mean value over a certain number of measurements (see Table 5-13).

3. Click the **Save** button.

Figure 5-27. Settings screen: Setting up cell type mode configuration



5.5.5.10 Cleaning cycles

Settings for Cleaning-in-Place (CIP) or Sterilization-in-Place (SIP) can be made under this menu item. In addition, the counters for autoclaving can be increased here, as these cannot be counted automatically by the system.

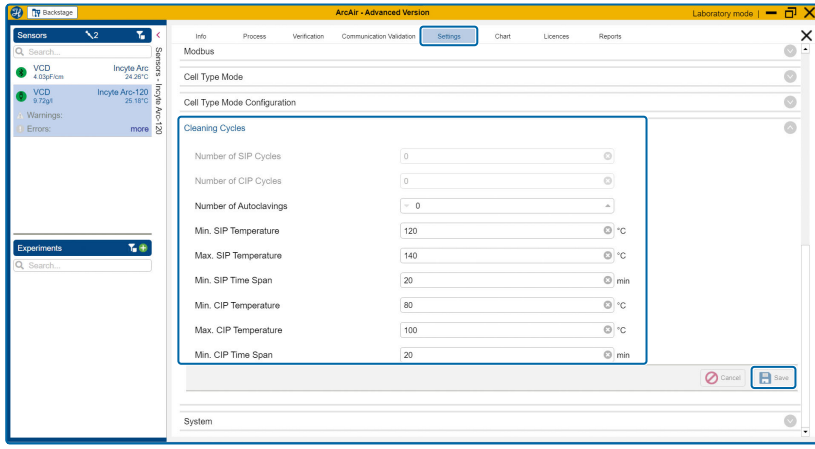
Define the cleaning (sterilization) cycle conditions

Define the conditions to automatically count the SIP and CIP cycles. Note that the `Number of SIP/CIP Cycles` is set at zero (0) as the default, but can be customized (see Figure 5-28). The cycles can be changed manually with the pointers on the left and right side of the text field.

The standard temperature settings for SIP are between 120 and 140 °C for 20 minutes and CIP between 80 and 100 °C for more than 20 minutes. To activate the changes, click the **Save** button at the bottom right of the screen.

The standard temperature settings for SIP are between 120 and 140 °C for 20 minutes and CIP is between 80 and 100 °C for more than 20 minutes. To activate the changes, click the **Save** button located at the bottom right of the screen.

Figure 5-28. Settings screen: Define the cleaning cycle conditions



Increase the number of autoclaving cycles

Since it is not possible to increase the autoclaving cycles automatically, the cycles must change the cycle counter manually with the pointers on the left and right side of the text field (see Figure 5-28).

5.5.5.11 System

To delete all user settings and configuration: select **System** > check ☑ the **Restore Factory Settings** checkbox > click the **Save** button.

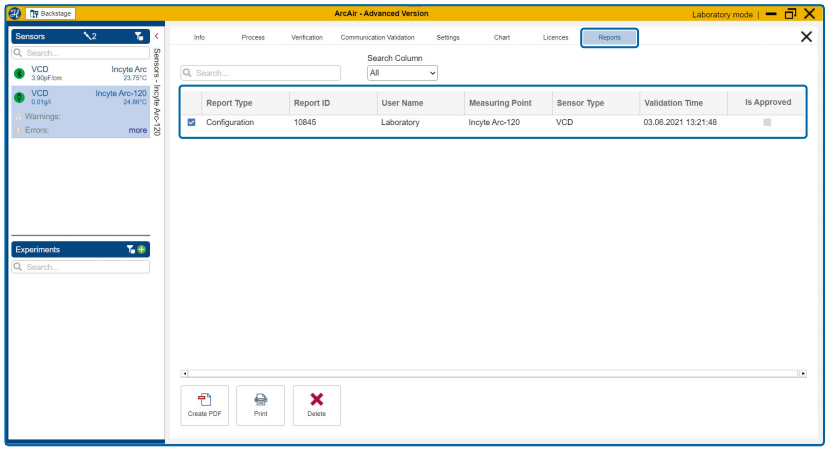
5.6 Licenses tab

The **Licenses** menu offers a summary of licenses and their respective functional capabilities.

5.7 Reports tab

All reports created via the ArcAir application are saved under the **Reports** tab (see Figure 5-29). You can manage the saved reports here and export the reports as a PDF for analysis.

Figure 5-29. Reports screen: Overview of the available reports to download



6 Operation: Integrating the Incyte Arc Sensor into an Experiment

This chapter provides a detailed description of the recommended settings for integrating the Incyte Arc Sensor into an experiment. This chapter is brief because it contains cross-references to previous chapters/sections where the detailed settings and procedures are described.

6.1 Experiment functionality

In ArcAir version 3.6 or higher, you can combine up to six sensors within a single `Experiment`.

To understand wireless (Bluetooth®) functionality better, it is important to differentiate between a *Peer-to-Peer* connection and the use of *Advertiser* data. There are two modes for connecting Arc sensors to the ArcAir application:

Peer-to-Peer Connection

In this mode, an Arc sensor establishes an active Bluetooth® or wired connection with the ArcAir application. This allows access to all functions and information specific to that particular Arc sensor. No additional connections to other Arc sensors are possible in this mode.

Advertiser Mode

Advertiser mode functions as a wireless broadcast mode where multiple sensors transmit data wirelessly to a PC or mobile device. Every three seconds, the PC or mobile device can receive the following information from the Arc sensors without requiring an active peer-to-peer connection:

- Measured value and unit
- Temperature value and unit
- Sensor status

NOTICE

The experiments use `Advertiser Mode` to record data from multiple sensors via Bluetooth®.

For a detailed overview of the Experiment functionality, refer to the *Hamilton Arc Operating Instructions* (REF 10071115).

6.2 Starting an experiment

To start an Experiment, follow these steps:

1. Click the **+** icon located under `Experiment` within the **Sensors** list.
2. Select all the sensors that you want to include in a single `Experiment`.
3. Assign a **Batch name** in the field and an experiment name under the **Name** field. Note that the Batch name will appear in the header of the Excel sheet and the experiment Name will be used for the Excel filename.
4. Specify the Sampling Time by choosing an interval between `3 seconds` and `1 hour`, or set a custom time interval (see Table 6-1).
5. Specify the temperature sensor under the **Temperature Sensor** field to be shown on the graph if required.

NOTICE

All Hamilton Arc sensors have a temperature sensor. For the Experiment, it is adequate to display the temperature data from just one of the sensors on the graph.

Table 6-1 provides an overview of the Sampling Time Range.

Table 6-1. Sampling time range

Sampling time range							
Second			Minute				Hour
3 s	6 s	30 s	1 min	5 min	12 min	30 min	1 hr

NOTICE! We recommend a Sampling Time greater than 6 s for the Incyte Arc Sensor.

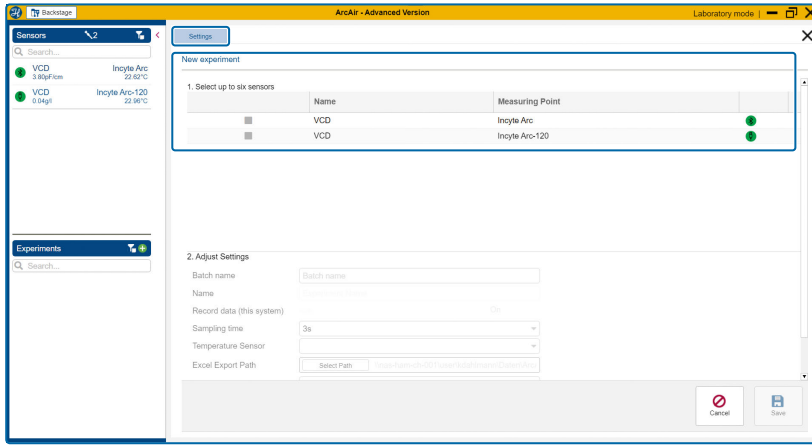
⚠ CAUTION

Make sure that all sensors intended for the Experiment are configured with the correct units before starting the Experiment. Once the experiment starts, you cannot change the units.

6. Choose the storage path where the Experiment data will be saved.

7. Click the **Save** button to store the adjusted settings and initiate the recording of the Experiment.

Figure 6-1. Settings screen: Overview of new experiment setup



6.3 Introduction to experiment functionality

The **Experiment** functionality is a feature in the ArcAir application that allows you to create and manage experiments involving multiple sensors. It provides a systematic way to collect and analyze data from these sensors collectively. Figure 6-2 provides an overview of multiple sensor data selected for experiment in the ArcAir application.

NOTICE

The Experiment function is not available in the ArcAir application for mobile devices.

Figure 6-2. Graph screen: Overview of an experiment data and graphical information for multiple Arc sensors



1	Graph tab	8	Temperature information for the selected Arc sensors
2	Measurement parameters for experiment set for the Incyte Arc Sensor	9	Export button
3	Arc sensors measurement scale with units	10	Delete data button
4	Active Arc sensors selected for experiment	11	Stop button
5	Mark zero button	12	Inoculate button
6	Clear zero button	13	Auto scale button
7	Scan On/Off button	14	Restore axes button

Functionality and features related to the graphical display in ArcAir application

Overview of the functionality and features related to the graphical display and the interaction buttons with sensors in an Experiment:

- **Buttons below the graph:**

  Actions like **Start/Stop**, **Inoculate**, **AutoScale**, and **Restore axes** apply to all sensors in the Experiment. These actions affect all sensors collectively.

- **Buttons on the right side:**
  - These buttons are specific to the sensor selected in the `Sensor` list above, indicated by a blue background. Functions like **Mark Zero**, **Clear Zero**, and **Scan On/Off** are highlighted with the same color as the selected sensor. For example, if the select the Incyte Arc Sensor, it will be highlighted with the color orange. Note these functions also apply to other sensors in the Experiment.
  - The displayed `Conductivity`, `Permittivity`, `Offset`, `Cell Factor` and `Cell Density` corresponds to the selected sensor.

- **Sliders on the sides of the axes:**

  These sliders allow you to zoom in on a specific interval range but do not set the overall range of values on the scale.

- **Y-axes range:**

  You can configure the value range of the y-axes under **Configure Y-Axes**.

- **Export data:**
  - Experiment results can be exported not only at the end of the Experiment but also at any time during the experiment by using the **Export** button.
  - Events such as `Inoculation`, `Mark Zero/Clear Zero` actions, and comments are tracked and can be accessed later through an Excel file.

- **Graph management:**

  When an Experiment contains more than 5000 data points, a new graph is created. You can use the **Previous** and **Next** buttons to switch between graphs to view both old and new data.

- **Restore axes:**

  Use the **Restore axes** button to reset the configuration of the y-axes to the setting stored in the sensor.

- **Reset zoom:**

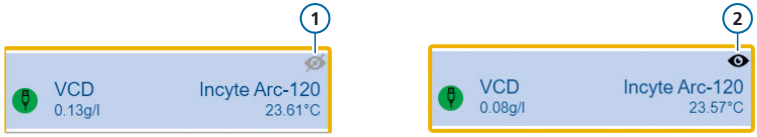
  The **Reset Zoom** button allows you to reset all zoom settings made with the slider on the axes.

When using Incyte Arc Sensor with other Arc sensors in an Experiment, there are several important factors to consider:

- **Bluetooth:** Incyte Arc Sensor connected via Bluetooth can only be used individually within an Experiment. This limitation arises from the peer-to-peer connection feature, which enables functions like **Mark Zero** and **Clear Zero**. In a peer-to-peer connection, other Bluetooth sensors are disregarded.
- **Multi-sensor connection:** To use the Incyte Arc Sensor alongside other Arc sensors without limitations, connect them using an Arc USB Power Cable (REF 243490).
- **Graphical display:** The `Experiment` function offers the capability to graphically visualize the trends of up to six sensors side by side (see Figure 6-2). Each sensor is represented with a distinct color, which is evident by the frame surrounding the sensor name.
- **Sensor visibility:** You can manage the visibility (hide or show) of individual sensors in the graphical display by using the eye icon located above (top right) the name of the sensor (see Figure 6-3). This feature allows you to focus on specific sensors or data points as needed.

These considerations ensure efficient and flexible data collection and analysis when using the Incyte Arc Sensor alongside other Arc sensors in an Experiment.

Figure 6-3. Sensor visibility status in an experiment: Hide or show the sensor date in the experiment



1	Sensor measuring data hidden in the experiment	2	Sensor measuring data shown in the experiment

6.4 Setting up the Incyte Arc Sensor for an experiment

Configuring Incyte Arc Sensor settings for an Experiment involves several steps to ensure that data collection aligns with your experimental requirements. Use the checklist provided in Table 6-2 when preparing the Incyte Arc Sensor for use in an Experiment:

Table 6-2. ArcAir configuration checklist for preparing the Incyte Arc Sensor for an experiment

Configuration parameter	Description	Incyte Arc Sensor manual reference	Status
Offline Correlation	To transfer the permittivity signal of the Incyte Arc Sensor to viable cell number, you need a correlation model. Whether a cell factor or an AADM (Advanced Adaptive Data Modeling) model is required depends on the specific conditions of your bioprocess and the accuracy you want to achieve.	• For additional information on the *Cell Factor*, see Section 5.5.5.3. • For additional information on the *AADM Model*, see Section 5.5.5.4.	☐
Cell Type Mode	Set a filter and adapt the sensor to Experiment conditions.	• For additional information on the default *Type Mode*, see Section 5.5.5.8. • For additional information on the custom *Cell Type Mode Configuration*, see Section 5.5.5.9.	☐
Sensor Data Logging	To store Experiment data directly on the sensor and independently from the ArcAir application, you must enable the Sensor Data Logging feature. This feature allows the sensor to record and store data internally. Configure the Sensor Data Logging for your Experiment if required.	For additional information on the *Sensor Data Logging*, see Section 5.5.5.5.	☐

6.5 Starting an experiment

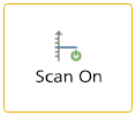
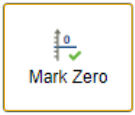
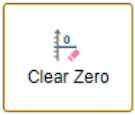
This chapter provides information about the `Experiment` workflow that we recommend you follow to run a successful experiment via the ArcAir application.

NOTICE

Inoculation is an important event when using ArcAir Data Modeling because it initiates the calculation of the model in the sensor. It is important that you accurately mark the Inoculation event to ensure that the modeling process aligns with the actual experiment conditions and data. This accuracy is important to obtain reliable and precise modeling results.

Follow the recommended workflow below after you have initiated an experiment:

Table 6-3. AcrAir experiment workflow for the Incyte Arc sensor

Task	Description	ArcAir GUI: Button/Icon to click	Incyte Arc Sensor manual reference	Status
Scan function	Use the **Scan** button to switch On or Off the scan function if required for the experiment.	 *or* 	For additional information about the Scan function, see Section 6.5.2.	☐
Set an offset	**NOTICE!** Starting an Experiment at point (0 | 0) is a standard procedure. • To start the readings at `0 pF/cm` or `0 g/l`, use the **Mark Zero** button. • To deactivate the offset, use the **Clear Zero** button. These actions will be visibly shown on the graph.	 *or* 	For additional information about the Mark Zero or Clear Scan function, see Section 6.5.1.	☐

Task	Description	ArcAir GUI: Button/Icon to click	Incyte Arc Sensor manual reference	Status
Inoculate	**NOTICE!** The Inoculation action can be done only once in an experiment. Click the **Inoculate** button after the cells have entered the bioreactor. This action will be visibly shown on the graph.		For additional information about the Inoculate function, see Section 6.5.3.	☐
Add a comment	Click on a measurement point to add a comment if required.	–	–	–
Set the y-axes scale	Setting the y-axes scale: 1. Navigate to **Configure Y-Axes** in the upper section of the Experiment screen. 2. Set the required Minimum (Min.) and Maximum (Max.) values. For example, set the Min. value to −10 and the Max. to 100 The measured units for the y-axes scale are pF/cm, E6/mL, or g/L. 3. Click the **Save** button to save the configuration settings.	–	–	–

6.5.1 Mark Zero and Clear Zero functions

While the Dual Frequency Measurement Mode helps minimize the impact of medium changes on measurements, it is common practice to do an in-process adjustment, specifically a zero adjustment, before inoculation. To adjust the process measurement, click the **Mark Zero** button to apply both *permittivity* and *scan* measurements in the experiment.

You have the option to apply the signal offset during an Experiment using one of the following two methods:

- Measurement settings
- Mark Zero / Clear Zero

For additional information about how to apply the signal offset during an Experiment, see Section 5.5.5.3.

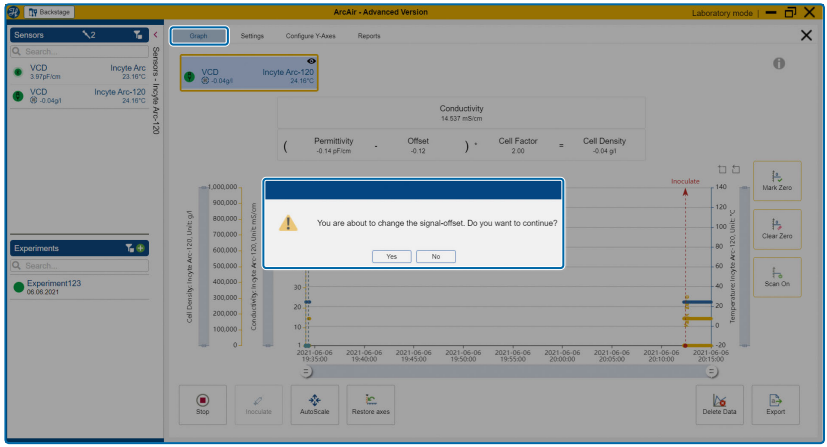
Once the Experiment is initiated, a popup window with the message "`You are about to change the signal offset. Do you want to continue?`" will be shown on the display. Select **Yes** to confirm the adjustment or select **No** to cancel the adjustment (see Figure 6-4).

Note that if you select **Yes** to proceed, the status message "`Mark zero was successful`" will be shown in a pop-up window before the experiment starts. Click the **OK** button to confirm and exit the window.

NOTICE

After the Inoculation event, the ArcAir application will always prompt you to confirm whether a Mark Zero or Clear Zero action is required.

Figure 6-4. Example of Mark Zero function activated after inoculation

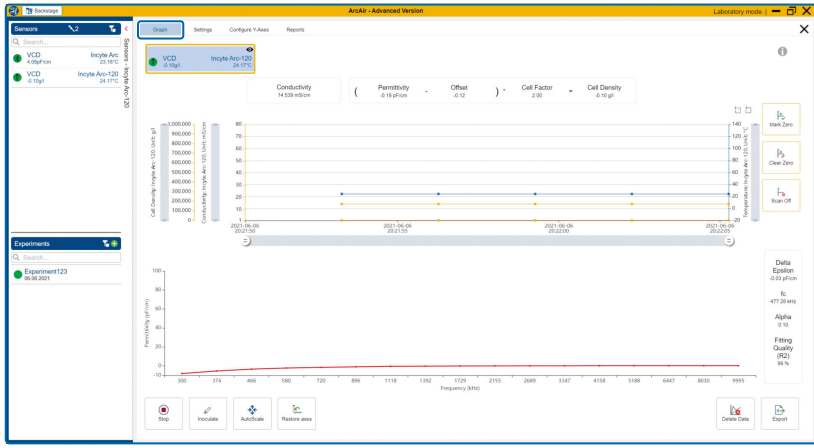


6.5.2 Scan function

You must enable the `Scan On` function before you start the Inoculation event. If the experiment relies on ArcAir Data Modelling, then you must also enable the `Scan On` function.

To use all frequencies of the Incyte Arc Sensor, you must enable the `Scan On` function during an Experiment (see Section 4.2.2).

Figure 6-5. Scan function overview: Example of the scan function switched on during an experiment



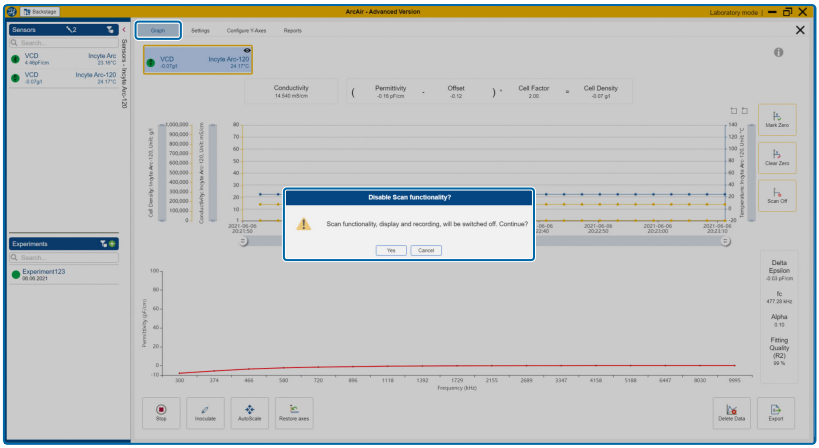
The `Fitting Quality R2` is an indicator in the ArcAir application that assesses how well the scan data can be fitted to the Cole-Cole equation. It provides information/insight about the quality of the data fitting process.

Overview of the Fitting Quality R2

- An indicator between 90% and 100% suggests a good fit.
- An indicator between 70% and 90% is an average fit.
- An indicator below 70% is considered unreliable.

In the Experiment file, these values are recorded between `0` and `1`. If the scan function is switched off during an Experiment, only the Dual-frequency measurements will be available. To prevent accidental deactivation, a pop-up window with the message "`Scan functionality, display, and recording will be switched off. Continue?`" will be shown on the screen to confirm or cancel the change (see Figure 6-6).

Figure 6-6. Scan function overview: Example of the scan function switched off during an experiment



6.5.3 Inoculation function

The **Inoculate** button enables you to mark a time point in the experiments when the cells enter the cultivation system. Inoculation is available in the `Experiment` function in the ArcAir application. This event is unique and occurs once in a process cycle. Figure 6-7 shows an example of an inoculation graph with a marked time point in an experiment.

The status message "Inoculation was successful!" will be displayed in a popup window after clicking the **Inoculate** button. Click the **OK** button to acknowledge the Inoculation status and exit the window (see Figure 6-8).

Figure 6-7. Inoculation function overview: Example of inoculation graph with a marked time point in an experiment

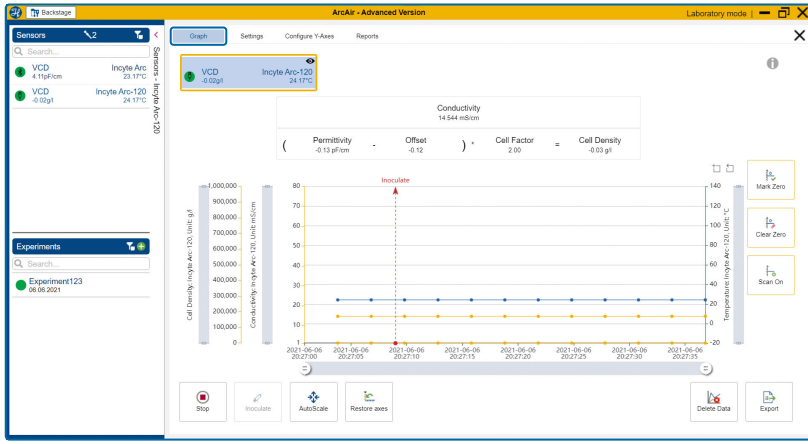
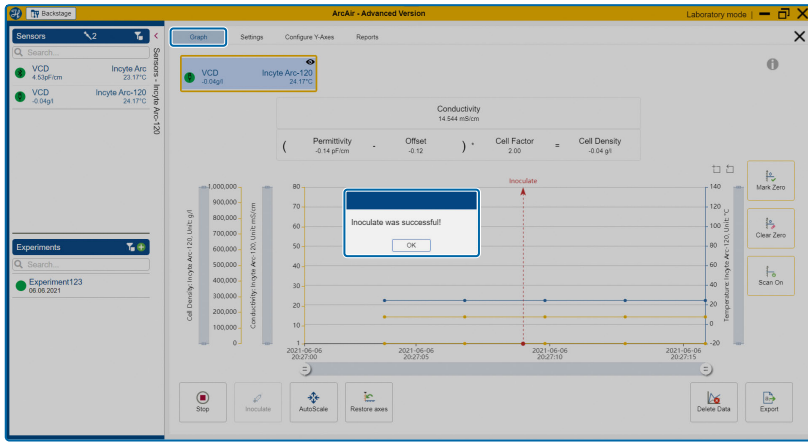


Figure 6-8. Inoculation function overview: Example of successful inoculation in an experiment



6.5.4 Add a comment

You can add comments to the export file of the Experiment at any stage during the experiment (see Figure 6-9). This feature can be used to track offline samples and allows you to annotate your experiment data with relevant comments for better tracking and documentation.

To add a comment, follow these steps:

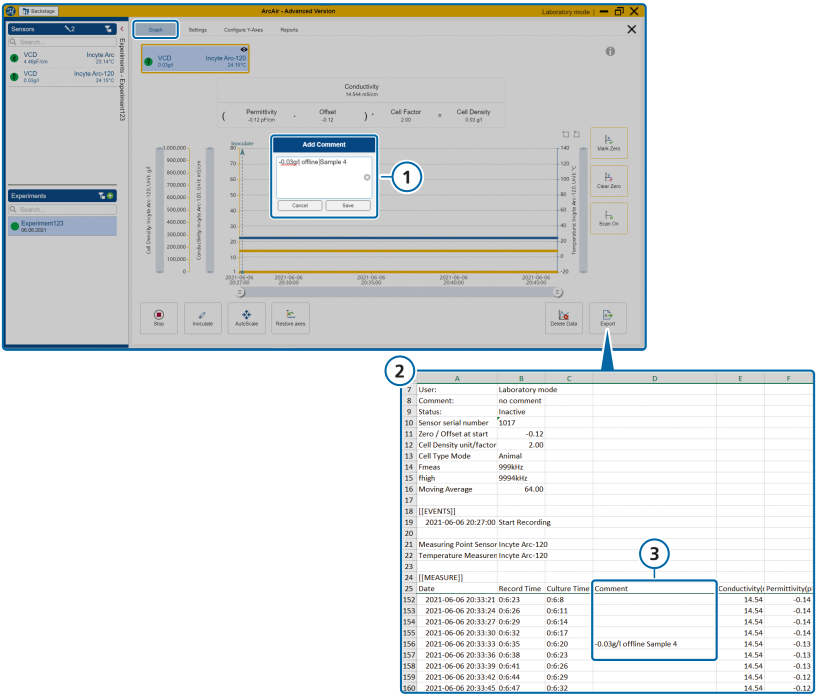
1. Click on a sample point on the graph. Note that the `Add Comment` window with an entry field for your comments will appear on the screen.
2. Enter your comments in the entry field provided.
3. Click the **Save** button to save your comments. Note that the data point on the graph will be highlighted to indicate that a comment is associated with it.

NOTICE

- When you export the experiment data to Excel, the comment will appear alongside the corresponding sample point with additional context and information for that data point.
- Comments on the Temperature values can be found in the Excel file under the header `Temperature Note`.

4. Click the **Export** button in the experiment data file for analysis.

Figure 6-9. Overview of the experiment graph and exported Excel file for the experiment data



1 Add a comment dialog box

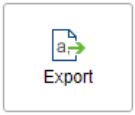
2 Example of exported file (Excel format) for the experiment data

3 Exported Excel file with a comment

6.5.5 Stopping an experiment

Table 6-4 provides an overview of the `Experiment` screen buttons: Stop, Delete, and Export.

Table 6-4. ArcAir GUI: Experiment screen buttons (Stop, Delete, and Export)

ArcAir GUI: Experiment screen buttons	Functional description
Stop 	Once the `Experiment` is over, click the **Stop** button to end the recording. To restart the recording, click the **Start** button. **NOTICE!** In the Excel file, you will notice a gap (an interval) between the recordings to indicate the stop and restart of the experiment recording.
Delete Data 	**NOTICE!** All the experiment data stored in the ArcAir application will be deleted, including the current data. The data cannot be retrieved once deleted. To delete the `Experiment` data and the graph, click the **Delete Data** button.
Export 	Export the `Experiment` data and save it as an Excel file. **NOTICE!** The experiment data is not saved automatically.

7 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, 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 8.4).

7.1 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 parts of the Quality Indicator (QI) and, thus, the performance and accuracy of the sensor. To maintain an accurate QI, we recommend that you do verification on the sensor regularly. The acceptance criteria for a successful verification are as follows:

- Δε (difference in permittivity) must be equal to **0 pF/cm** ± 5 pF/cm.
- Use Hamilton's 12880 µS/cm Conductivity Standard (REF 238988) at Dual Frequency, with the frequency measurement (f_{meas}) set at 1 MHz for the verification.

To realize the improvement in the performance of the Incyte Arc Sensor, you must do the verification process. You can view the QI value under the **Info** tab > **Sensor Quick View** > **Sensor Health**.

If the Incyte Arc Sensor does not pass the verification check, we recommend that you do the conditioning process. Navigate to the **Process** tab > `Manual Conditioning` and follow the on-screen instructions in the ArcAir application (see Section 5.5.2.1).

During the verification process, both the Dual Frequency Measurement and the Scan are analyzed to assess the condition of the electrodes. Follow the on-screen instructions provided in the ArcAir application during the verification procedure.

NOTICE

- ArcAir Advanced application is required for the sensor verification.
- Manual conditioning can help improve the performance and accuracy of the sensor, which can lead to a better QI.

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

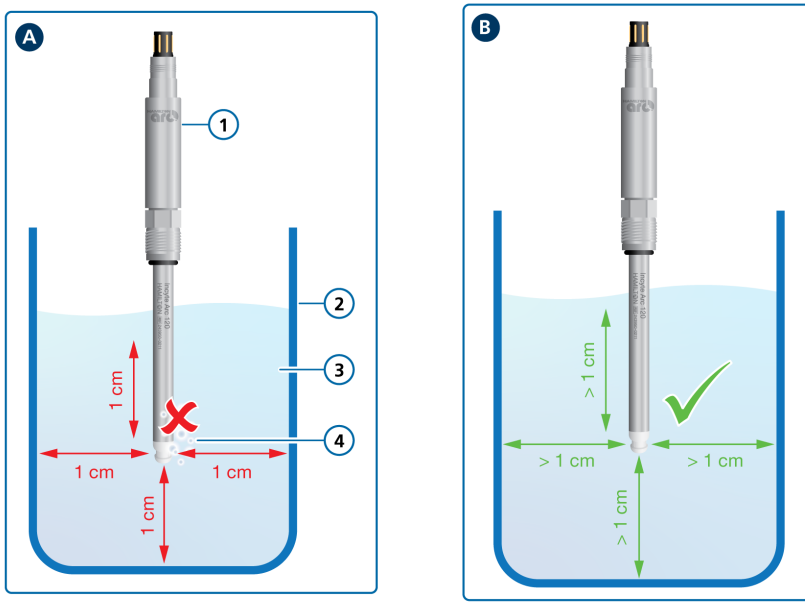
1. Place the Incyte Arc Sensor in the Beaker containing Hamilton's 12880 µS/cm Conductivity Standard (REF 238988). Make sure there is sufficient clearance around the sensor tip, at least the clearance has to be > 1 cm between the sensor and the Beaker wall (see Figure 7-1).
2. Check for the presence of bubbles around the sensor tip. Gently shake the sensor to remove any bubbles.

⚠ CAUTION

Make sure that the Offset and/or Cell Factor is not set before you generate the verification report.

3. Launch the ArcAir application and navigate to the **Verification** tab (see Figure 7-2).
4. Enter the `Lot Number` of the conductivity standard to track it in the **Verification Report**.
5. Click the **Start** button to start the stabilization process. Allow 180 seconds to 3 minutes for this process.
6. Click the **Save** button to save the report if the Verification was successful.
7. Navigate to the **Report** tab to generate and download the report.

Figure 7-1. Overview of the Incyte Arc Sensor setup for verification: Insufficient clearance around the sensor tip (A) and sufficient clearance around the sensor tip (B)



1	Incyte Arc Sensor	3	Medium
2	Beaker wall	4	Air bubbles

Figure 7-2. Overview of the verification screen: Start the verification process

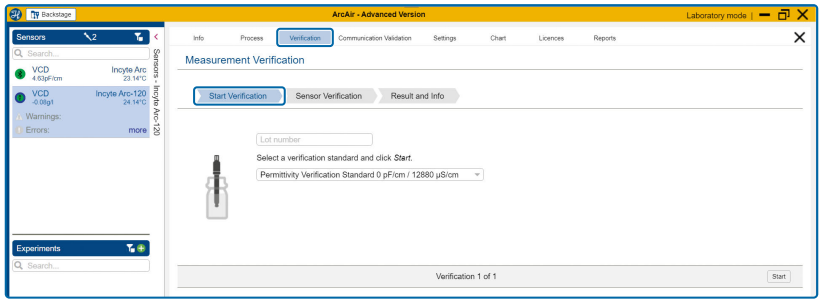


Figure 7-3. Verification screen: Sensor stabilization before the verification process

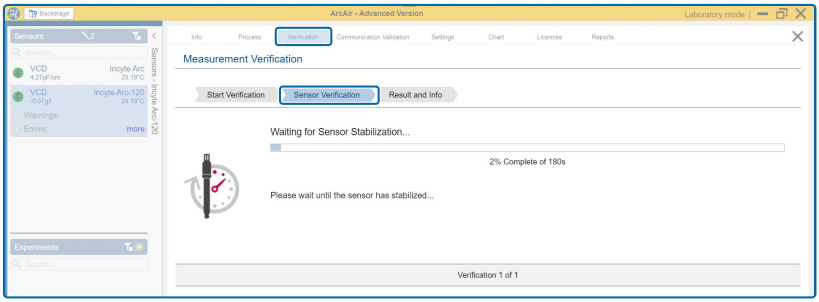
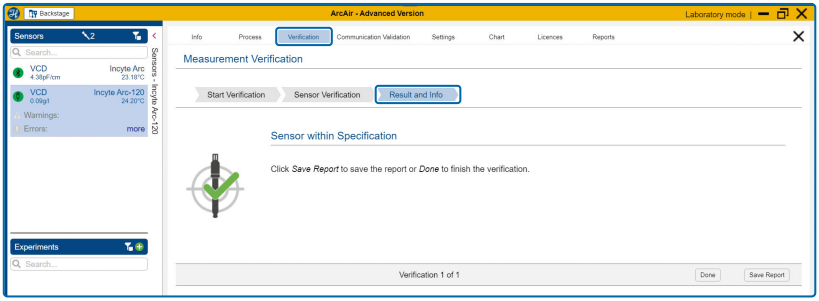


Figure 7-4. Verification screen: Sensor verification passed



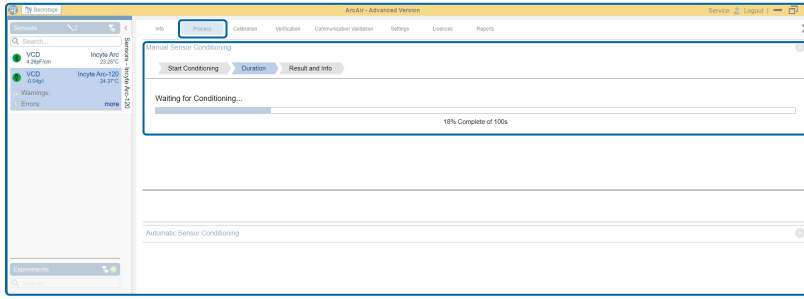
7.2 Conditioning

This section covers information only on the conditioning process. The conditioning process functionality can be utilized for cleaning the Pt electrodes on the sensor tip or for conditioning the sensor in Solution B (REF (REF 243742) during the process. For detailed information on the cleaning process, see Section 7.4.

7.2.1 Manual sensor conditioning

If `Manual Sensor Conditioning` is required, you must follow the steps in the ArcAir application to recondition the electrodes of the sensor. This will restore the electrodes as closely as possible to their factory condition. For the reconditioning process, you will require Hamilton's Saturated Sodium Sulfite Solution, also known as Solution B (REF 243742).

Figure 7-5. Process screen: Overview of the manual sensor conditioning process



Manual sensor conditioning procedure via ArcAir application

⚠ CAUTION

Make sure you clean the Polyetheretherketone (PEEK) part of the sensor tip and decontaminate the sensor with the CIP process before you start the Manual Sensor Conditioning.

NOTICE

- Manual Sensor Conditioning can be used to clean the sensor tip during the process or as a cleaning procedure by using a saturated Sodium Sulfite (Na_2SO_3) solution. This cleaning process ensures that the electrodes of the sensor remain clean before you start the next cultivation.
- The conditioning process does not shorten the service life of the sensor.
- We recommend that you allow the sensor to rest for 4 hours after conditioning.

1. Use the CIP process to clean and decontaminate the sensor via the ArcAir application.
2. Immerse the PEEK part of the sensor tip in Sodium Sulfite Solution with a concentration of 15 g/mL (Na_2SO_3) or use Solution B (REF 243742)
3. Connect the Incyte Arc Sensor to a power supply via the Arc USB Power Cable (REF 243490) on a standard USB Port on a PC/Notebook.
4. Navigate to the **Process** tab in the ArcAir application.
5. Select the `Manual Sensor Conditioning` option.
6. Press the **Start** button to start the cleaning process.
7. Wait until the set cleaning time elapses.

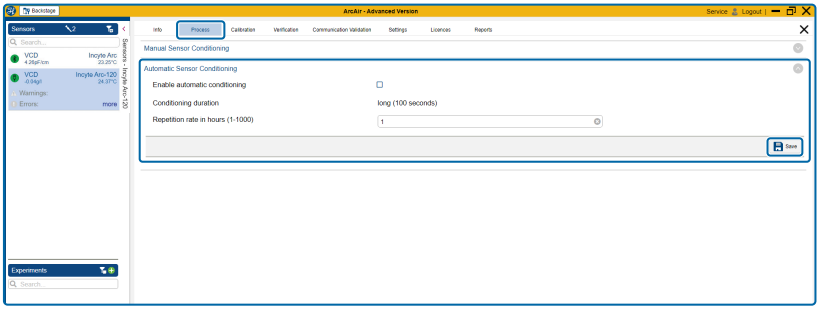
8. Remove the sensor from the conditioning solution and rinse off the Sodium Sulfite residue with deionized water.
9. Allow the sensor to rest for 4 hours after conditioning.
10. Do the sensor `Verification` process via the ArcAir application. The verification process helps maintain or improve the Quality Indicator (QI), thus, the performance and accuracy of the sensor. For additional information about the verification process, see Section 7.1.

7.2.2 Automatic conditioning

Automatic sensor conditioning procedure via ArcAir application

1. Navigate to `Automatic Sensor Conditioning` under the **Process** tab in the ArcAir application.
2. Check ☑ `Enable automatic Conditioning` option (see Figure 7-6).
3. Select either a `Short (10 seconds)` or `Long (100 seconds)` cleaning duration.
4. Specify the Repetition rate in hours. The repetition rate determines how often the cleaning cycle will be repeated. For example, a minimum rate of 1 is equal to one (1) cleaning per hour.
5. Click the **Save** button to save the settings.

Figure 7-6. Process screen: Overview of the automatic sensor conditioning process



7.3 Calibration

For calibration procedures and support, contact Hamilton Technical Support. Further information can be found in Section 8.4.

7.4 Cleaning

⚠ CAUTION

- *Only authorized/trained service personnel can assemble/install, operate, clean, calibrate, 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 cleaning.*
- *Do not use acetone and strong acid solutions to clean the sensor.*
- *Do not use abrasive tissues, cleaning materials, or cleaning chemicals other than the recommended cleaning solutions and materials to clean the sensor.*
- *We recommend using Hamilton's Saturated Sodium Sulfite Solution, also known as Solution B (REF 243742) for the reconditioning (manual/automatic conditioning) of the sensor.*
- *Only activate the Manual or Automatic Sensor Conditioning process if you detect or suspect cell aggregation/agglomeration on the platinum electrodes.*
- *Always start the cleaning with a short* `Cleaning duration` *and a long* `Reception rate` *(Auto-cleaning Period). We recommend at least 12 hours of cleaning duration. You can increase the cleaning duration or decrease the reception rate if you do not observe improvements.*

⚠ CAUTION

Observations and precautions for the sensor cleaning process:

- ***No measurements during cleaning***

  The sensor cannot be used for measurements during the cleaning cycle. This is a temporary interruption in data collection while the cleaning is in progress.
- ***Signal stability after cleaning***

  The signal from the sensor may be unstable for up to two hours after the cleaning process. This is a normal behavior, and the stability will be restored over time.
- ***Do not clean the sensor in media containing serum with proteins***

  Do not clean the sensor in culture media that contain serum, such as fetal bovine serum (FBS) or high lactate concentration. Do not use media with protein components for the in-process cleaning functionality.

Sensor cleaning involves applying an electrochemical cleaning pulse to the platinum electrodes of the sensor. It is important to note that the electrochemical cleaning process does not replace the CIP or SIP processes. We recommend that you do the verification process via the ArcAir application to assess whether additional cleaning or conditioning is necessary after every bioprocess and the CIP process.

If the verification process via the ArcAir application recommends cleaning the sensor, then you must follow the steps in the ArcAir application to recondition (manual/ automatic conditioning) the electrodes of the sensor. This will restore the electrodes as closely as possible to their factory condition. For the reconditioning process, you will require Hamilton's saturated Sodium Sulfite Solution, also known as Solution B (REF 243742).

Both `Manual Sensor Conditioning` (see Section 7.2.1) and `Automatic Conditioning` (see Section 7.2.2) can be used to clean and restore the sensor to its optimal functionality. The `Automatic Conditioning` feature is deactivated by default. `Automatic Sensor Conditioning` is required when there is cell aggregation/agglomeration on the electrodes of the sensor. This cleaning process can help reduce cell aggregation/agglomeration on the electrodes of the sensor and it is necessary in specific processes, such as long-term cell culture or fermentation of filamentous fungi.

7.5 Firmware update

The firmware updates can be found on the Hamilton Process Analytics website (https://www.hamiltoncompany.com/process-analytics). You can update the firmware on the sensors via the ArcAir application.

The backstage area of the ArcAir application contains the location for the firmware update. Both the Arc sensors and the Accessories can be updated via this menu.

NOTICE

For more information about the ArcAir application, see the *Hamilton Arc Operating Instructions* (REF 10071115).

8 Troubleshooting

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 8-1.

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

Sensor status indicator: Traffic light ID system	Description
Green 	• The sensor is functioning correctly. • No errors or warnings have been registered.
Yellow 	• At least a warning has been registered. • Verify the warnings of the sensor under `Sensor Status`. • The Incyte Arc Sensor will show a Permittivity Measurement of `0 pF/cm`.
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

Sensor Quality Indicator (QI)

The Quality Indicator (QI) provides information about the measurement performance of the sensor, which is between 100% and 30%. During each verification process, the integrity of the sensor is checked at the relevant frequencies and aligned with the upper and lower acceptance limits (see Section 7.1). The outcome of the verification process is integrated into the QI value.

If the quality indicator remains below 30% after cleaning the sensor, contact Hamilton Technical Support (see Section 8.4).

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

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

8.1 Quick tips

Table 8-2. Overview of corrective actions for resolving sensor problems

Problem	Possible cause	Corrective action
Sensor is not displayed in the ArcAir application	Incorrect baud rate configured for sensor	• Make sure the connected Sensor ID is shown in the **Sensor** list filter in the ArcAir application. **NOTICE!** The Incyte Arc Sensor is configured to a baud rate of 19,200. If you change the baud rate from the default configuration, the ArcAir application may not recognize the sensor. • To resolve the baud rate issue: click the **Backstage** > **Setting** button > **Wired connection**, then select **Baud rate** > **Parity and Stop bit** according to your settings in the ArcAir application, and click the **Save** button.
	Global Operator Level S password has not been set for all Arc sensor	• Make sure a unique and global Operator Level S password is set for all Arc sensors to enable automatic sensor login. Configure this password in the ArcAir application under **Backstage** > **Settings Operator Level S Password**. • Verify the **Sensors** list on the dashboard to confirm whether the filter function includes `Sensor Type TCD` and if the checkbox is selected.
Wrong reading on the process control system	Disconnected power supply or sensor	A disconnected power supply (24 V ±10%) or disconnected sensor can cause the wrong reading on the process control system.

Problem	Possible cause	Corrective action
Sensor connection not possible	Sensor connection error	Verify if the sensor ID is displayed under the **Sensor** and **Offline** list of sensors. If the sensor ID is displayed in both **Sensor** and **Offline** list of sensors, then we recommend that you delete the sensor from the **Offline** list and try to reconnect it again.

8.2 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 Sections 5.3.2 and 5.5.5.6).

8.3 Sensor status

An overview of the condition of the sensor is indicated by the `Sensor Status` described in Sections 8.3.1 and 8.3.2.

NOTICE

For additional information about the sensor status and the diagnostics features refer to the Troubleshooting chapter of the *Incyte Arc Sensors Programmer`s Manual* (REF 695251).

8.3.1 Warnings

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

Warnings associated with the measurement

Table 8-3. Overview of the warnings associated with the measurement

Measurement troubleshooting		
Warning description	Possible cause	Corrective action
Signal-to-Noise Ratio (SNR) is excessively high	External interferences detected: Disruptions in the permittivity measurement due to external electrical interferences.	To resolve this issue, assess your environment and follow the grounding instructions outlined in Section 2.2.
Preamp over-temp (analog supply off)	• The ambient temperature is extremely high, which prevents the sensor from taking measurements. • Overheated electronics due to high ambient and process temperature.	Make sure that the temperature conditions remain below 90 °C.
Power supply is too weak (measure-ment off)	The power supply Wattage is too low, which prevents the sensor from taking measurements.	• Make sure that the power supply has an output Wattage of more than 1.5 W. • Make sure that you use the supplied external power supply in conjunction with the USB power cable, as the power supply via the USB port of the PC/notebook is not sufficient to supply the sensor with power.

Measurement troubleshooting		
Warning description	Possible cause	Corrective action
Sensor supply voltage is too low	The power supply voltage to the sensor is too low, which prevents the operation of the sensor.	• Verify that the power supply voltage is above 21.6 VDC. • Make sure that you use the supplied external power supply in conjunction with the USB power cable, as the power supply via the USB port of the PC/notebook is not sufficient to supply the sensor with power.
Sensor supply voltage is too high	The power supply voltage to the sensor is too high, which prevents the operation of the sensor.	Verify that the power supply voltage is below 26.4 VDC. **NOTICE!** The electronics are regulated to prevent damage when the voltage exceeds this limit.
FSCAN fitting poor input data (R2)	Parameter fitting cannot be applied because the input data quality is insufficient. The Cole-Cole parameter fitting cannot be calculated due to the measured viable cell density (VCD) values being too low. This may occur when the sensor is in a medium-only environment, at the beginning of a process, or in cultures with low density.	• Make sure there are no gas bubbles attached to the Pt electrodes of the sensor. • Adjust the orientation of the sensor in the bioreactor (see Section 5.2).
T reading below lower limit	The temperature is below the specified lower limit, which prevents the sensor from taking measurements.	Make sure that the operating temperature of the sensor is within the specified range.
T reading above upper limit	The temperature is above the specified upper limit, which prevents the sensor from taking measurements.	Make sure that the operating temperature of the sensor is within the specified range.

Measurement troubleshooting		
Warning description	Possible cause	Corrective action
Recording memory full	The internal memory of the sensor is full, and as a result, no further recordings can be made.	To resolve this, download the data, then reconnect the sensor (see Section 5.5.5.5).

Warning associated with the calibration

Table 8-4. Overview of the warnings associated with the calibration

Calibration troubleshooting		
Warning description	Possible cause	Corrective action
Out of calibration range: lower limit	The conductivity measurement is below the specified range, which prevents the sensor from taking measurements.	To resolve this, you must do the Verification procedure to increase the conductivity measurement value: `x > 1 mS/cm`.
Out of calibration range: upper limit	The conductivity measurement is above the specified range, which prevents the sensor from taking measurements.	To resolve this, you must do the Verification procedure to decrease the conductivity measurement value: `x < 80 mS/cm`.

8.3.2 Errors

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

Errors associated with the hardware

Table 8-5. Overview of the errors associated with the hardware

Hardware troubleshooting		
Error description	Possible cause	Corrective action
Temperature (T) sensor defective	The internal temperature sensor is defective.	Contact Hamilton Technical Support for assistance (see Section 8.4).
Other error or malfunction: The sensor is not functioning as expected or intended.	–	Contact Hamilton Technical Support for assistance (see Section 8.4).

8.4 Request for technical support

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

8.5 Returning the sensor for repairs

⚠ WARNING

- Make sure you decontaminate the Incyte Arc 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.*
- *Incyte Arc Sensors that are returned without an RMA number will be sent back to the customer without being repaired.*

Before returning an Arc sensor to Hamilton for repair, contact our Technical Support and request a Return Material Authorization (RMA) number (see Section 8.4).

9 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 9-1).

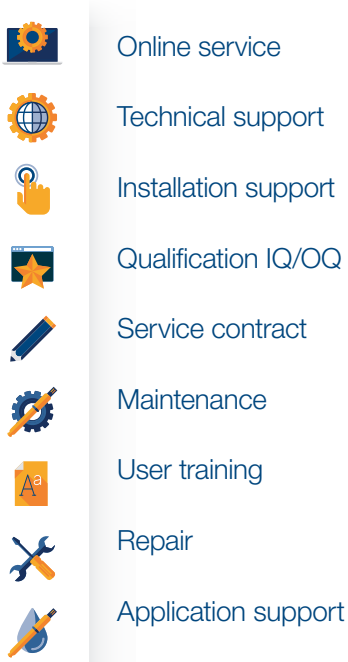
Table 9-1. Symbols used on the sensor labels and packaging

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)

10 Services

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

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



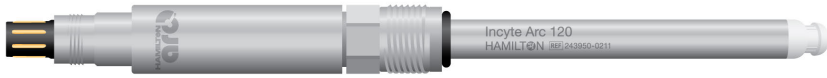
11 Ordering Information

This chapter provides an overview of the different types of Incyte Arc Sensors and accessories that are available to order.

11.1 Incyte Arc Sensor

The Incyte Arc Sensor offers full functionality, including Dual Frequency Measurement, Scan, Cole-Cole Fitting, and offline/online correlation through ArcAir Data Modeling. It also complies with GMP standards when used with ArcAir Advanced.

Figure 11-1. Overview of the Incyte Arc Sensor



Ordering information

Table 11-1. Different types of the Incyte Arc Sensors

REF	Product description
243950-0211	Incyte Arc 120 – Expert
243950-0212	Incyte Arc 220 – Expert
243950-0213	Incyte Arc 320 – Expert
243950-0214	Incyte Arc 420 – Expert

11.2 Parts, accessories, and software

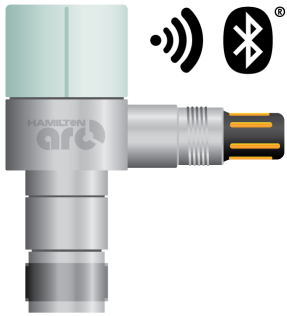
⚠ CAUTION

Use only original spare parts or accessories when replacement is necessary.

Arc Wi 1G BT adapter

The Arc Wi 1G BT Adapter enables wireless communication between the Arc sensors and mobile devices via Bluetooth®.

Figure 11-2. Arc Wi 1G BT adapter



REF	Product description
243460	Arc Wi 1G BT adapter

Arc Wi 2G BT adapter

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

Figure 11-3. Arc Wi 2G BT adapter

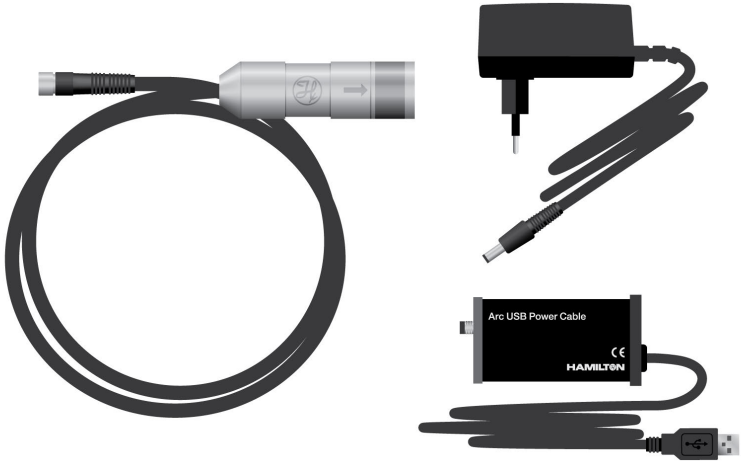


REF	Product description
243470	Arc Wi 2G BT adapter

Arc USB power cable: USB/VP8 and USB/M12-8 Pole

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

Figure 11-4. 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.

Sensor data cable: VP8 double coaxial / open-end data cable

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

Figure 11-5. Arc sensor data cable: VP8 double coaxial / open-end wiring

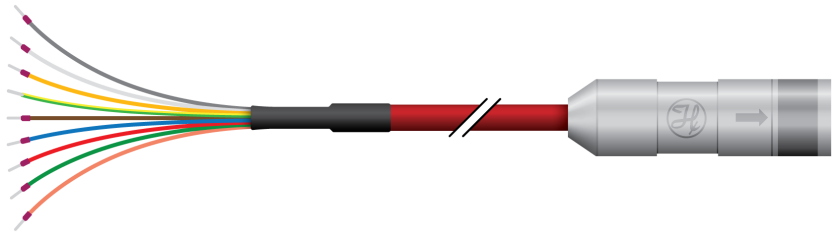


Table 11-2. VP8 double coaxial / open-end data cable

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

Sensor data cable: VP8 open-end / 4-wire data cable

Table 11-3. VP8 open-end / 4-wire data cable

REF	Product description	Length
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 11-6. M12-8 pole with open-end cable

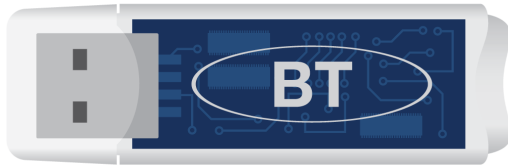


REF	Product description	Length (in meters)
355320	M12-8 pole/open-end cable	3 m
355321	M12-8 pole/open-end cable	5 m
355322	M12-8 pole/open-end cable	10 m

Arc wireless BT converter

The Arc Wireless BT Converter is designed to enable wireless communication between the Arc sensor and the ArcAir application.

Figure 11-7. Arc wireless BT converter



NOTICE

The internal Bluetooth® of the PC can be used instead of the Arc wireless BT converter.

Arc wireless BT converter advanced

The Arc Wireless BT Converter Advanced enables wireless communication between the Arc sensor and the ArcAir application. It includes the license to activate ArcAir Advanced functions for GMP (Good Manufacturing Practice) compliant production.

REF	Product description
243499	Arc wireless BT converter
242333	Arc wireless BT converter advanced

Basic Arc view tablet for non-Ex environments

The pre-configured Basic 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 (see Figure 11-8).

The Basic Arc view operates on the Samsung Galaxy Tab Active tablet and is pre-configured with the Basic ArcAir software and an App Blocker application.

The Basic Arc view tablet comes with a Power Supply Cable, a Manual, and Hamilton's Quick Start Guide.

Figure 11-8. Basic Arc view tablet for non-Ex environments



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

Advanced Arc view tablet for non-Ex environments

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 operates on the Samsung Galaxy Tab Active tablet and is pre-configured with the Advanced ArcAir application. This includes features for CFR 21 Part 11 and Eudralex Volume 4, Annex 11 Compliance, along with an App Blocker application.

The Advanced Arc view tablet comes with a Power Supply Cable, a Manual, and Hamilton's Quick Start Guide.

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

Arc Modbus OPC converter

The Arc Modbus OPC Converter is designed for OPC UA communication between the Incyte Arc Sensor and SCADA System.

Figure 11-9. Overview of the Arc Modbus OPC converter



REF	Product description
10089359	Arc Modbus OPC converter

Process housings

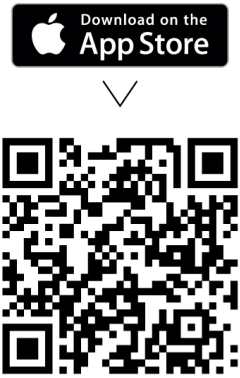
Table 11-4. Overview of the process housings offered by Hamilton Process Analytics

FlexiFit REF	Retractex REF	RetractoFit REF	Hygienic Sockets REF
237344	243240	237240	242535
237345	243275	237490	242545
237380-OP	237730	237440	242548
	237735	237480	242550
	237740		
	237745		
	243200		
	243255		
	243220		
	243265		
	243210		
	243260		
	243230		
	243270		

ArcAir application download

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

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





11.3 Consumables for verification

The Conductivity Standard is also known as the Permittivity Verification Standard (Conductivity standard: 0 pF/cm and Permittivity standard: 12.88 mS/cm). It is essential for verifying the correct operation of the Incyte Arc Sensor during the sensor verification procedure.

Table 11-5. Consumables for verification: Conductivity standard

REF	Product description
238988	Conductivity standard: 12880 µS/cm, Basic line

batch
Refers to the data recorded during a process. For example, data is recorded for inline (culture file) and offline.

BT
Bluetooth® is a technology standard that enables short-range wireless communication between electronic devices.

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.

CSV
A CSV (comma-separated values) file is a text file that has a specific format that allows data to be saved in a table-structured format.

fouling
Unwanted attachment of cells to surfaces, for example, the surface of the sensor.

Inoculation
Inoculation is the process of marking the time point after the cells have entered the cultivation system. This event is unique, and it occurs once in a process cycle.

model
The Arc Data Model, also known as the Correlation Model, refers to a model created using the ArcAir Data Correlation software. This model can be transferred to the sensor to enhance correlation throughout the entire process.

Moving Average
A moving average is the mean value of a defined number of measurements taken over some time.

offline
Offline refers to a data collection method where samples are taken from a bioreactor and measured separately. Offline measurements may have a time offset and spatial distance compared to the real-time data collected from the bioreactor.

Online
Online refers to real-time measurements conducted as part of the ongoing process. These measurements are collected while the process is running and are often used for process monitoring and control.

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.

Permittivity Measurement

Permittivity Measurement refers to the fundamental measurement principle used by the Incyte Arc Sensor to determine the permittivity of the medium in which it is immersed.

Pt electrodes

Platinum (Pt) electrodes are commonly used in various electrochemical applications due to platinum's inert nature, conductivity, and resistance to corrosion.

Record Rate

The Record Rate is a parameter that defines the time interval between two consecutive measuring points recorded and stored by the ArcAir application on the sensor head. The Record Rate determines how often data is collected and saved by the ArcAir application during a monitoring or data-logging process using the sensor.

Sampling Time

Defines the time between two measuring points recorded by ArcAir in an experiment.

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.

Sensor ID

The Sensor ID contains unique attributes for the identification of the sensor. The Sensor ID consists of the REF Number and Serial Number.

SIP

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

Wi-Fi

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

More information and free software simulation:
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