HAMILTON

Optical Dissolved CO_2 Sensors

Real-Time and Maintenance-Free CO_2NTROL for Bioprocesses

Is Your Process in CO_2NTROL?

Increase Yield and Consistency

New research shows that active control of dissolved CO_2 (DCO_2) in bioproduction increases product yield and improves consistency of process scale-up and scale-down. Traditional electrochemical sensors indirectly measure DCO_2, are maintenance intensive, and are prone to measurement drift. CO_2NTROL is a solid-state optical sensor that directly measures DCO_2 and provides maintenance-free, real-time, and in-line control of this new critical process parameter.

Automated Control of DCO_2 Enables:

Increased Titer
Increased Product Titer

Reproducibility
Better Batch-to-Batch Reproducibility

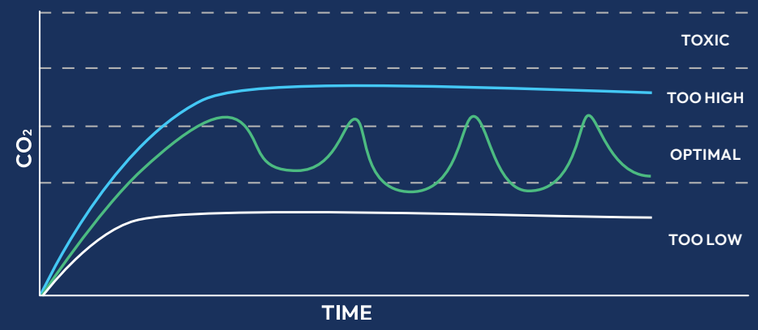
Consistency
More Consistency from R&D to Production Scale Reactors

Impact of CO_2 on Process Performance

Excessive Accumulation
During a process, excess CO_2 accumulation is common as cell concentration increases and more metabolic CO_2 is produced. This accumulation reduces intracellular pH, resulting in slower enzymatic activity or delayed lactate shift. The outcome is lower production quantity and quality.

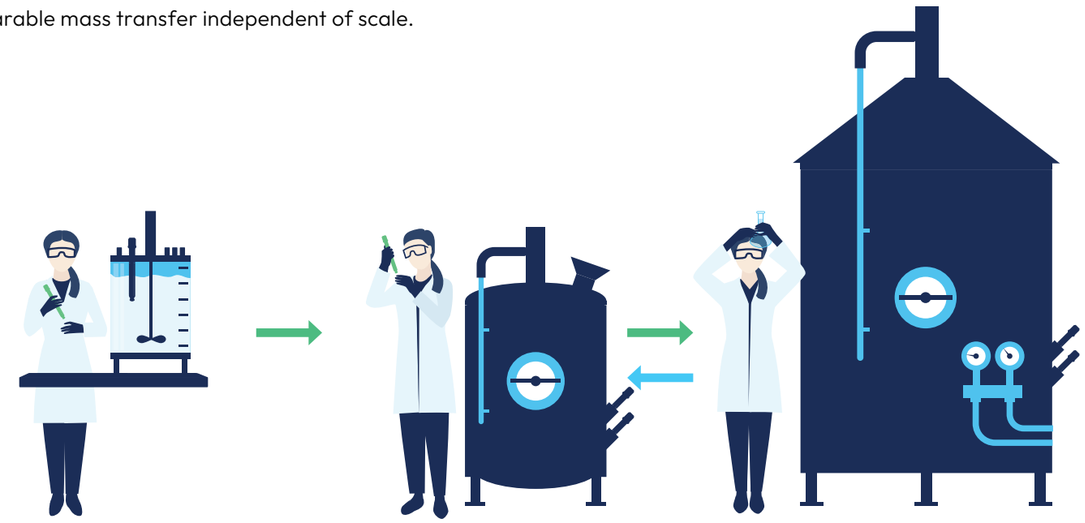
Excessive Removal
Aggressive aeration and mixing can prevent detrimental accumulation of CO_2. However, too little CO_2 can slow cell growth, metabolism, and productivity by starving cells of CO_2 needed for the formation of metabolic intermediates. Excessive removal can also reduce buffer capacity in bicarbonate systems.

Uncontrolled CO_2 range
Media addition and process adjustments can result in large swings in dissolved CO_2 that may go unnoticed with infrequent offline monitoring and adjustment. Continuous inline control at the optimal level yields increased viable cell density, production phase duration, and titer.



Bioreactor Size Impacts CO_2

Large and small bioreactors have Mass Transfer Coefficients (k_La) that change the dissolution and stripping characteristics from reactor to reactor. As a result the same control strategy will result in different CO_2 accumulation across R&D, PD, and Production scale reactors. Only real-time control of DCO_2 to an optimized profile will result in comparable mass transfer independent of scale.



R&D

OPTIMIZING YIELD

While the small surface area to volume ratio of a typical R&D reactor means that CO_2 accumulation is minimal, real-time control of CO_2 is critical to define the optimal setpoint and optimize product yield.

Process Development

SCALE UP

Mimicking sparging and stripping strategies optimized for R&D will result in different conditions as the surface-to-volume ratio decreases. Therefore, active control of an optimal DCO_2 profile ensures consistency across scales.

Production

SCALE DOWN

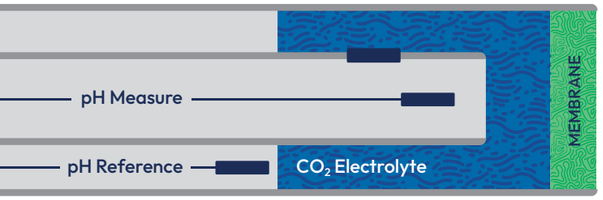
For existing processes that were developed without DCO_2 control, the efficiency of scale-down studies can be improved by actively controlling DCO_2 to mimic the profile seen in the production reactor.

Maintenance-Free Solid-State CO_2

Direct vs. Indirect

Traditional electrochemical sensors measure DCO_2 based on the Severinghaus principle. This indirect measurement method combines the challenges of measuring pH and electrochemical DO into one sensor. The result is significant maintenance effort and multiple sources of drift that must be compensated by time-consuming product calibration. Hamilton's CO_2NTROL is a solid-state sensor (no electrolyte) that directly measures DCO_2 and provides maintenance-free (no consumables), real-time, and in-line control of this important critical process parameter.

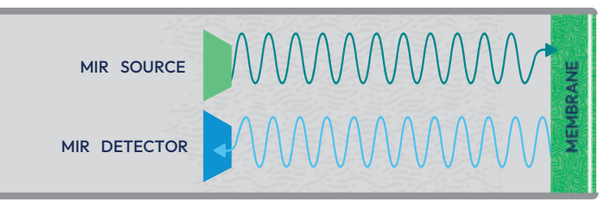
Automated control of DCO_2 enables increased titer, better batch-to-batch reproducibility, and more consistency from R&D to production-scale bioreactors.



CO_2 Measurement Principles

Severinghaus

CO_2 molecules diffuse through a gas permeable membrane into an electrolyte. CO_2 increases the acidity of the electrolyte which is measured by an internal pH sensor.



CO_2NTROL Optical Measurement

CO_2 molecules diffuse into a gas permeable membrane where the sensor measures the absorption of CO_2-specific middle infrared (MIR) wavelengths. This absorption correlates to the partial pressure of CO_2 in the media.

Streamlined Workflow

The CO_2NTROL development team recognized that for CO_2 to become a critical control parameter, the sensor had to be easy to use and maintain. To achieve this goal, we needed to reduce the complexity and eliminate liquid solutions and replacement parts. The team developed a solid-state MIR design calibrated with certified gas, eliminating the need for product calibration due to drift after sterilization processes.

Severinghaus Sensors

1. Grab Sensor
2. Remove Cap and Sleeve
3. Calibrate at pH 7
4. Calibrate at pH 9
5. Refill Electrolyte
6. Assemble the Sensor
7. Verify with CO_2 Gas Standard
8. Install into the Bio-reactor
9. Sterilize
10. Product Calibra-tion
    - Option 1: Sparge Reactor with Cal Gas to Known [DCO_2]
    - Option 2: Retract Sensor and Flow Cal Gas to Sensor
    - Option 2: Grab Sample for Offline CO_2 Analysis
11. Run the Process
12. Remove Sensor
13. Verify Sensor with Gas

CO_2NTROL Sensors

1. Grab Pre-Calibrated Sensor
2. Install into the Bioreactor
3. Sterilize
4. Run the Process
5. Remove Sensor
6. Recertify Sensor in Air and Certified Gas

Simple Calibration
In air and certified gas.

Measuring Range
Designed for bioproduction (5–1000 mbar).

Maintenance-Free
No liquids or replacement parts to change.

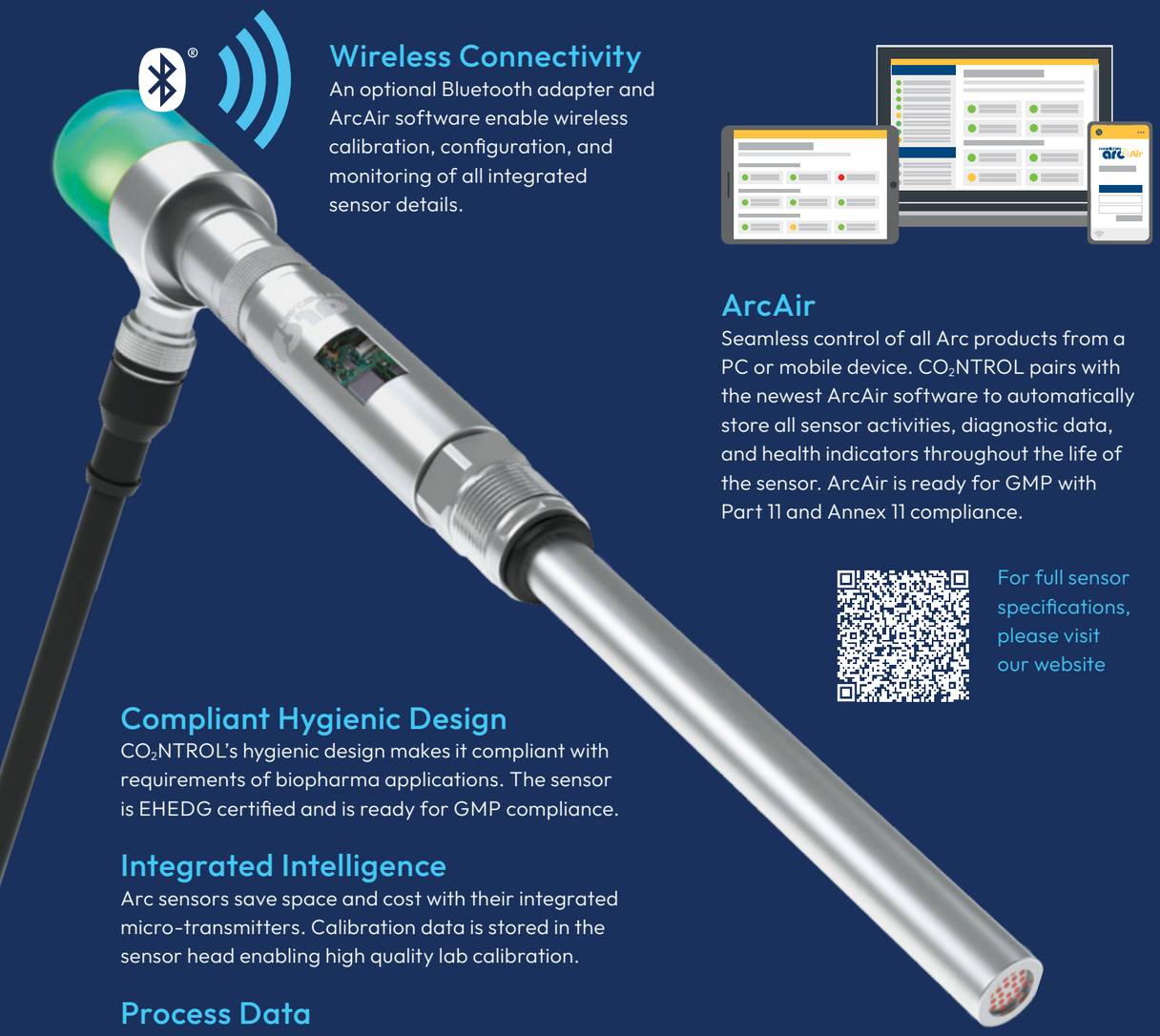
Hygienic Design
Compatible with Autoclave, SIP, or CIP. Certified EHEDG.

Inverted Installation
Not affected by mounting orientation.

No Ammonia Fouling
No interference from other dissolved gases.

Get CO_2NTROL

CO_2NTROL is the newest member to Hamilton's Arc Intelligent Sensor line. Embedded electronics convert the MIR CO_2 measurement into standard digital and analog signals that are easily integrated into your control strategy.



Wireless Connectivity

An optional Bluetooth adapter and ArcAir software enable wireless calibration, configuration, and monitoring of all integrated sensor details.

ArcAir

Seamless control of all Arc products from a PC or mobile device. CO_2NTROL pairs with the newest ArcAir software to automatically store all sensor activities, diagnostic data, and health indicators throughout the life of the sensor. ArcAir is ready for GMP with Part 11 and Annex 11 compliance.

For full sensor specifications, please visit our website

Compliant Hygienic Design

CO_2NTROL's hygienic design makes it compliant with requirements of biopharma applications. The sensor is EHEDG certified and is ready for GMP compliance.

Integrated Intelligence

Arc sensors save space and cost with their integrated micro-transmitters. Calibration data is stored in the sensor head enabling high quality lab calibration.

Process Data

The CO_2NTROL sensor transmits process data through a hardwired connection. Communication options include modbus RTU and 4-20 mA, with additional compatibility for OPC UA, PROFINET, PROFIBUS, and FOUNDATION Fieldbus.

HAMILTON arc™ USP CLASS VI

Unlock The Secrets of Bioprocessing Excellence

Download And Find Out More

Should CO_2 be a Critical Process Parameter?
White Paper, Pt 1

Should CO_2 be a Critical Process Parameter?
White Paper, Pt 2

Real-Time Monitoring of DCO_2 in Addition to DO
CO_2 App Note

Biopharma PAT
White Paper

Innovative Solutions
Biopharma Upstream & Downstream Brochure

Intelligent Sensors
Brochure

We invite you to join us in our commitment to environmental responsibility by embracing digital documentation.

At Hamilton Company, we value sustainability and strive to minimize our impact on the environment by reducing paper waste, conserving natural resources, and minimizing our collective carbon footprint.

Explore Hamilton's Field Services

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- Qualification IQ/OQ
- Maintenance and Calibration Services
- On-site Training

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Note: Our sensors are made to last. To increase sensor lifetime and avoid down-times, Hamilton suggests maintaining their sensors at least once a year by a Hamilton factory trained technician.

Years of Experience
75+

Locations Worldwide
22+

Employees Internationally
3,000+

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