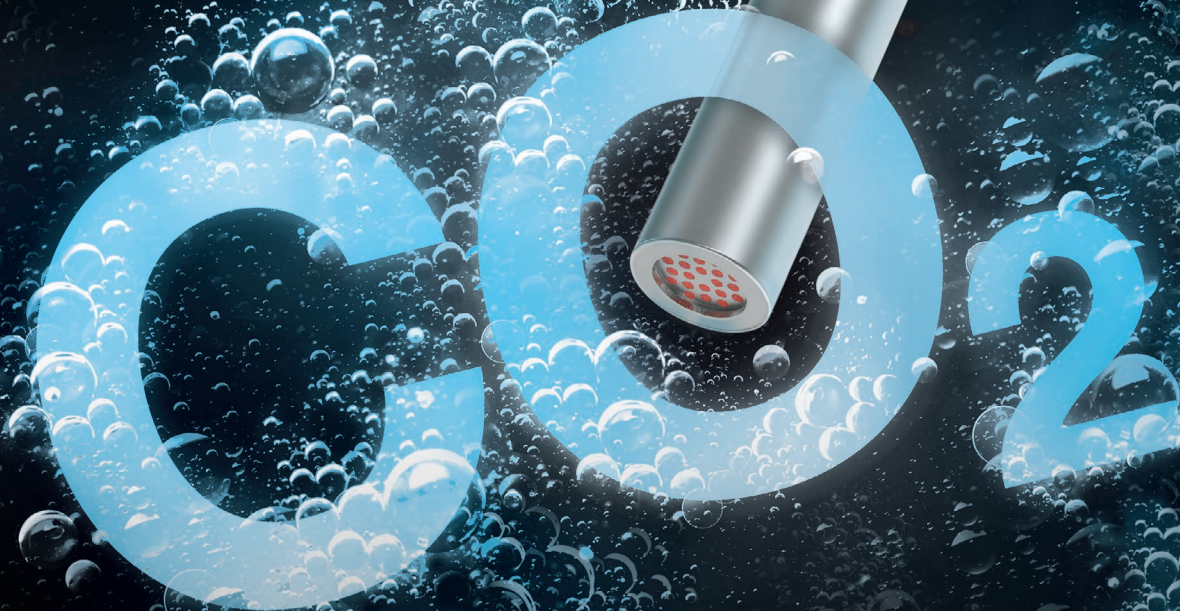


HAMILTON 

Real-Time CO₂ NTROL

Solid-State Optical CO₂ Sensors



IS YOUR PROCESS IN **CO₂NTROL**?



Increase Yield and Consistency

New research shows that active control of dissolved CO₂ in bioproduction increases product yield and improves consistency of process scale-up and scale-down. Traditional electrochemical sensors indirectly measure DCO₂, are maintenance intensive, and are prone to measurement drift. **CO₂NTROL** is a Solid State Sensor that directly measures DCO₂ and provides maintenance free, real-time, and in-line control of this new critical process parameter.

AUTOMATED CONTROL OF DCO₂ ENABLES:



Increased Titer

Increased Product Titer



Reproducibility

Better Batch-to-Batch Reproducibility

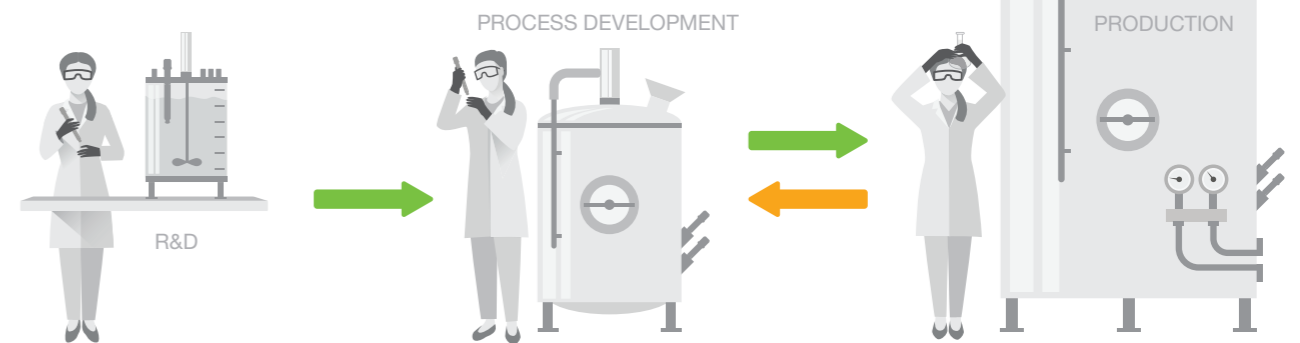


Consistency

More Consistency from R&D to Production Scale Reactors

Bioreactor Size Impacts CO₂

Large and small bioreactors have Mass Transfer Coefficients (KLa) that change the dissolution and stripping characteristics from reactor to reactor. As a result the same control strategy will result in different CO₂ accumulation across R&D, PD, and Production scale reactors. Only real-time control of DCO₂ to an optimized profile will result in comparable mass transfer independent of scale.



Optimizing Yield

While the small surface area to volume ratio of a typical R&D reactor means that CO₂ accumulation is minimal. Real-time control of CO₂ is critical to define the optimal setpoint and optimize product yield.

Scale Up

Mimicking sparging and stripping strategies optimized for R&D will result in different conditions as the surface to volume ratio decreases. Active control of an optimal DCO₂ profile ensures consistency across scales.

Scale Down

For existing processes that were developed without DCO₂ control, the efficiency of scale-down studies can be improved by actively controlling DCO₂ to mimic the profile seen in the production reactor.

IMPACT OF CO₂ ON PROCESS PERFORMANCE:

Excessive Accumulation

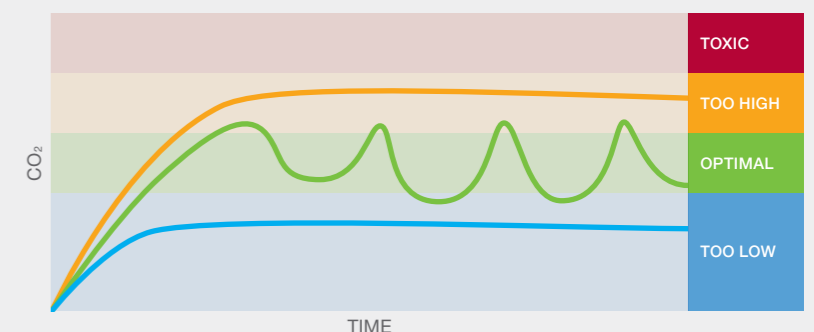
During a process excess CO₂ accumulation is common as cell concentration increases and more metabolic CO₂ is produced. This accumulation reduces intracellular pH resulting in slower enzymatic activity or delayed lactate shift. The outcome is lower production quantity and quality.

Excessive Removal

Aggressive aeration and mixing can prevent detrimental accumulation of CO₂. However, too little CO₂ can slow cell growth, metabolism, and productivity by starving cells of CO₂ needed for the formation of metabolic intermediates. Excessive removal can also reduce buffer capacity in bicarbonate systems.

Uncontrolled CO₂ range

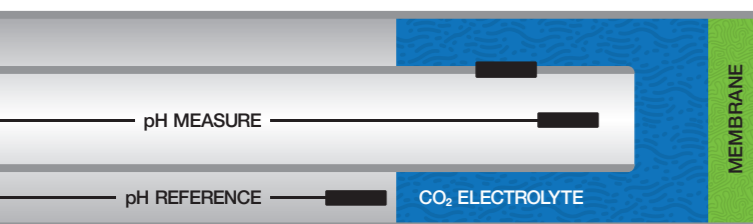
Media addition and process adjustments can result in large swings in dissolved CO₂ that may go unnoticed with infrequent offline monitoring and adjustment. Continuous inline control at the optimal level yields increased viable cell density, production phase duration, and titer.



MAINTENANCE-FREE SOLID-STATE CO₂

Direct vs. Indirect

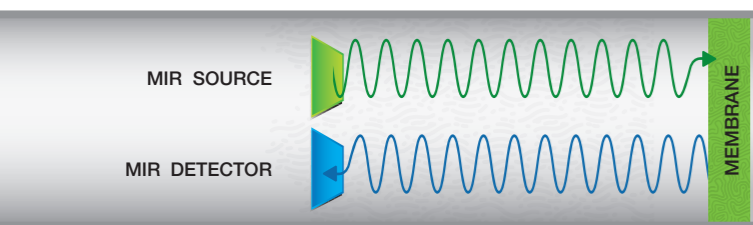
Traditional electrochemical sensors measure DCO₂ based on the Severinghaus principle. This indirect measurement method combines the challenges of measuring pH and electrochemical DO into one sensor. The result is significant maintenance effort and multiple sources of drift that must be compensated by time-consuming product calibration. Hamilton's **CO₂NTROL** is a maintenance free, solid-state sensor that directly measures DCO₂ resulting in better measurement accuracy and lower cost of ownership.



CO₂ MEASUREMENT PRINCIPLES:

Severinghaus

CO₂ molecules diffuse through a gas permeable membrane into an electrolyte. CO₂ increases the acidity of the electrolyte which is measured by an internal pH sensor.



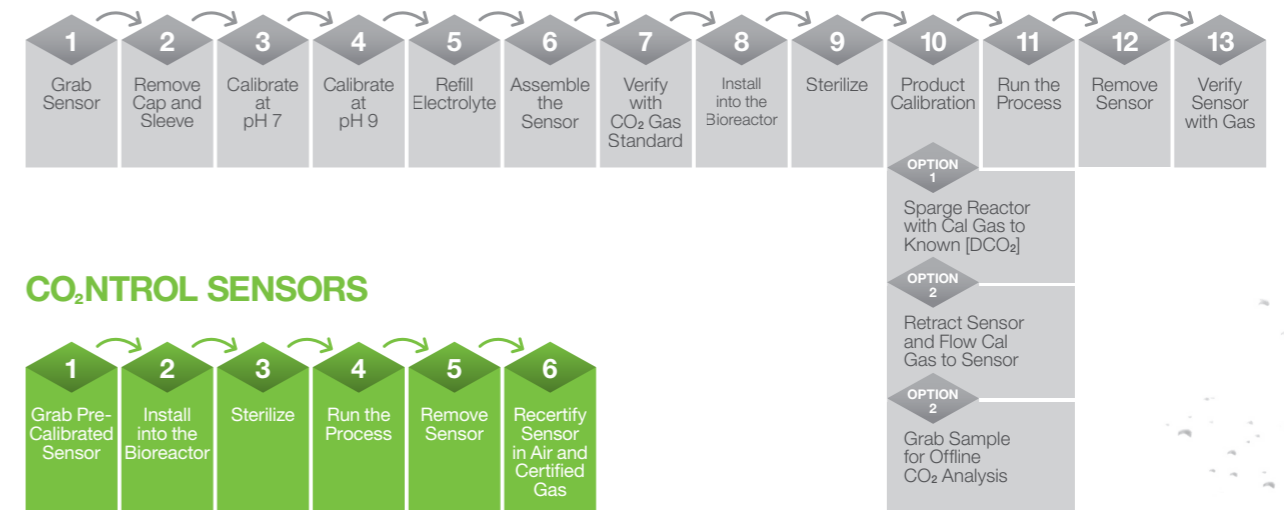
CO₂NTROL Optical Measurement

CO₂ molecules diffuse into a gas permeable membrane where the sensor measures the absorption of CO₂-specific MID IR wavelengths. This absorption correlates to the partial pressure of CO₂ in the media.

Streamlined Workflow

The **CO₂NTROL** development team recognized that for CO₂ to become a critical control parameter the sensor had to be easy to use and maintain. To accomplish this we had to reduce the complexity and eliminate liquid solutions and replacement parts. The team developed a Solid State MIR design that is calibrated in certified gas and does not require a product calibration because of drift after sterilization processes.

SEVERINGHAUS SENSORS



CO₂NTROL SENSORS



Simple Calibration

In air and gas standard.



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.



Inverted Installation

Not affected by mounting orientation.



No Ammonia Fouling

No interference from other dissolved gases.

GET CO₂NTROL

CO₂NTROL is the newest member to Hamilton's Arc Intelligent Sensor line. Embedded electronics convert the MIR CO₂ measurement into standard digital and analog signals that are easily integrated into your control strategy.



COMPLIANT HYGIENIC DESIGN

CO₂NTROL's hygienic design makes it compliant with requirements of biopharma applications. The sensor is EHEDG certified and is ready for GMP compliance.

ARCAIR

Seamless control of all Arc products from a PC or mobile device. CO₂NTROL 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.



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 CO₂NTROL sensor transmits process data through a hardwired connection. Communication options include modbus RTU and 4-20 mA, with additional compatibility for OPC, Profibus, and Foundation Fieldbus coming soon.

WIRELESS CONNECTIVITY

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



CO₂NTROL SPECIFICATIONS

Measurement Principle	Optical – CO ₂ Absorption in Middle Infrared (MIR)
Measuring Range	5 to 1000 mbar or 0.5 to 100 %-Vol or 7.5 to 1500 mg/L (in liquid phase at 101.3 kPa and 25°C)
Diameter	12 mm
Process Connection	PG 13.5
Wetted Parts	Stainless Steel 1.4435, EPDM (Ethylene propylene elastomer), FDA compliant silicone
Surface Quality of Steel	Ra < 0.4 µm (N5)
Steam Sterilizable	Yes
Autoclavable	Yes
CIP	Yes
Operating Temperature Range	From -10 °C to 60 °C

ORDERING INFORMATION

	A-LENGTH	REF
CO₂NTROL	120 mm	10087810-11
	160 mm	10087810-12
	225* mm	10087810-13
	325 mm	10087810-14
	425 mm	10087810-15

ACCESSORIES

Cables – M12:

Arc USB Power Cable M12 – 8 pole,
REF 243490-02
Open end – 3m, REF 355320
Open end – 5m, REF 355321
Open end – 10m, REF 355322

Cables – VP8:

Arc USB Power Cable VP8 pole,
REF 243490-01
Open end – 5m, REF 355265
Open end – 10m, REF 355266
Open end – 20m, REF 355268

Accessories:

Arc Wi 2G BT, REF 243470
Arc View Mobile Advanced (Tablet), REF 10071113
Arc Wireless Converter BT, Advanced REF 242333
Calibration Station, REF 243575

*CO₂NTROL 225 have, in reality, a shaft length of 215 mm. This ensures optimal rinsing in replaceable armatures, such as Retractex.

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REF 10111675/00 – 03/2021

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