HAMILTON®

Real-Time CO_2NTROL

Solid-State Optical CO_2 Sensors

IS YOUR PROCESS IN CO_2NTROL?

Increase Yield and Consistency

New research shows that active control of dissolved CO_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 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:

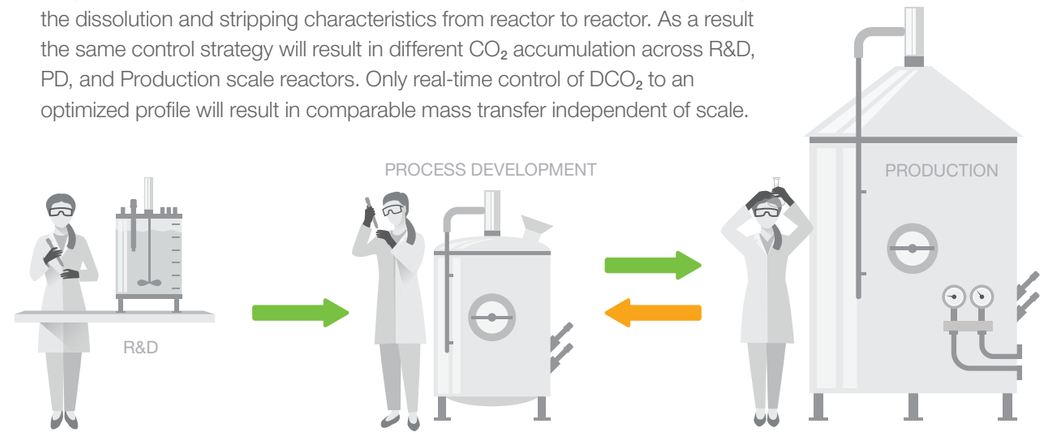
Increased Titer
Increased Product Titer

Reproducibility
Better Batch-to-Batch Reproducibility

Consistency
More Consistency from R&D to Production Scale Reactors

Bioreactor Size Impacts CO_2

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 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.



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.

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 DCO_2 profile ensures consistency across scales.

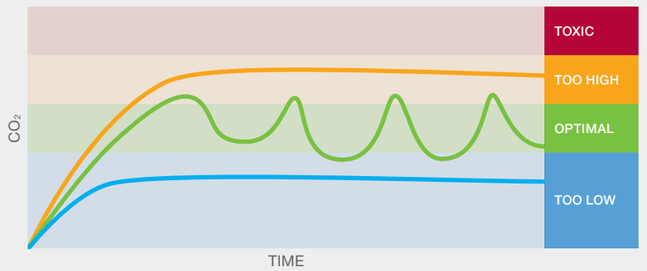
Scale Down
For existing processes that were developed without DCO_2 control, the efficiency of scale-down studies can be improved by actively controlling DCO_2 to mimic the profile seen in the production reactor.

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.

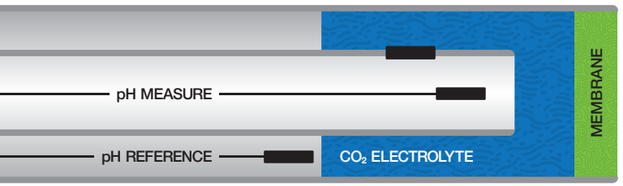
Uncontrolled CO_2 range
Media addition and process adjustments can result in large swings in dissolved CO_2 that may go unnoticed with infrequent offline monitoring and adjustment. Continuous inline control at the optimal level yields increased viable cell density, production phase duration, and titer.



MAINTENANCE-FREE SOLID-STATE CO_2

Direct vs. Indirect

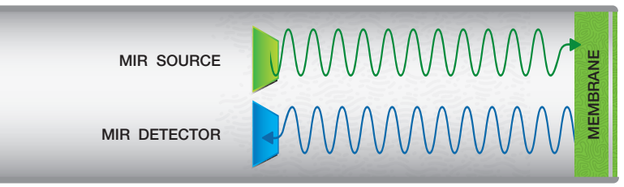
Traditional electrochemical sensors measure DCO_2 based on the Severinghaus principle. This indirect measurement method combines the challenges of measuring pH and electrochemical DO into one sensor. The result is significant maintenance effort and multiple sources of drift that must be compensated by time-consuming product calibration. Hamilton's **CO_2NTROL** is a maintenance free, solid-state sensor that directly measures DCO_2 resulting in better measurement accuracy and lower cost of ownership.



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 MID IR 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 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

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 Bioreactor
9. Sterilize
10. Product Calibration
    - 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 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 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.

HAMILTON arc™ USP CLASS VI

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.

ARC AIR

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.

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, 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.

CO_2NTROL 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
CO_2NTROL	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

**CO_2NTROL 225 have, in reality, a shaft length of 215 mm. This ensures optimal rinsing in replaceable armatures, such as Retractex.*

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