

Unlocking New Possibilities in Bioreactor Design

The Power of Customized Gas Control Solutions



A fast-growing biotech company faced challenges in designing compact, high-performance benchtop bioreactors, particularly with the gas control system for sparging and headspace management. Alicat Scientific's engineering team developed a custom BASIS Gassing Module that not only met the client's stringent requirements but also reduced the sparger's footprint by 3x. By leveraging innovative design approaches, Alicat provided a solution that surpassed the client's expectations, enabling more efficient operations and greater flexibility in research processes.

Challenge

The biotech startup was developing benchtop bioreactors intended for large-scale production. Their primary challenge was designing a gas control system that could perform at a high level while maintaining a minimal footprint. The system needed to handle multiple gases (air, CO₂, O₂, N₂) for both sparging and micro-bubblers, along with an option for headspace management. The bioreactor needed to support various experiments, and the gas controllers needed to be built to avoid issues like backpressure contamination, which could compromise critical flow sensor elements.

Key requirements included:

1. Designs for running experiments with anywhere from two to four gases.
2. Compact designs to save lab space.
3. A single addressable cable per gassing module to streamline communications.
4. Control capabilities for multiple modules from a single control system.
5. Flow rates under 100 SCCM and continuous operation at full duty cycle for extended periods.

Additionally, the system had to be lightweight to keep shipping costs low and easy to integrate into their existing infrastructure. Our engineering team evaluated two product lines to determine the best fit for the application:

BASIS™ Mass Flow Controllers

- ▶ Employs MEMS thermal mass flow measurement technology, minimizing footprint and manufacturing costs.
- ▶ Compact design ideal for high-volume applications.
- ▶ Compatible with 9 gases, including Air, CO₂, O₂, N₂.
- ▶ Supported standard communication protocols: RS-232, RS-485, and Modbus RTU.
- ▶ Downstream valves would protect the thermal elements from backslash which could damage them.

MC-Series Mass Flow Controllers

- ▶ Utilizes laminar differential pressure (DP) measurement technology, resulting in high accuracy measurement.
- ▶ Maintains accuracy across 98 gases without need for recalibration, making them ideal for research.
- ▶ Available with an extensive range of communication protocols.
- ▶ Sensors would not be destroyed with any backslash that made it past the downstream valve.

Decision

The BASIS controllers were chosen due to their small size and their ability to exceed the company's accuracy and repeatability requirements. The downstream valve options also aligned well with the project's needs.



BASIS Quick Specs

Dimensions	2.70" W x 0.88" D x 1.55"
Accuracy	± 1.5% reading for most gases
Repeatability	± 0.25% reading
Control range	1,000:1 turndown
Control response	As fast as 100 ms

Balancing Performance and Design

The client needed a gas control solution that would integrate seamlessly into their bioreactor design while minimizing footprint and maximizing performance.

Solution

Alicat proposed three design options using BASIS controllers:

- ▶ **Standard Design:** Configurations with 2, 3, and 4 manifolded BASIS controllers, set up in a gas mixing configuration, optimized for space. Each BASIS controller is equipped with an LED indicator light for easy troubleshooting and a GH connector to limit footprint. However, each bioreactor would only be equipped with one of the three options. If the researcher wanted to use a different number of gases, the gas control system or benchtop bioreactor would have to be swapped out.
- ▶ **Modular Design:** Because the company would be using different number of gases, the team proposed an entirely modular design where the customer could add controllers on one by one to a control module. The downside of this solution was a reduction in operational time while the control module was being adjusted.
- ▶ **Custom Design:** The team designed a tailored solution featuring four gas controllers on a manifolded plate, with adaptable three-way valves allowing quick switching between two output channels. This design decreased total gas controller footprint by two-thirds by combining three manifolds into one and supported both sparging and micro-bubbling operations, as well as headspace management. It would save the customer significant time, while making each bioreactor completely adaptable.

Design Process

The customer reached out to the Alicat Scientific applications engineering team and received a response a few hours later. The customer was then connected directly to our engineering team where they worked through the following design process.

1. **Specification Review:** Our engineering team collaborated closely with the company's engineering team to ensure each design would meet all technical specifications, particularly regarding pressure differentials throughout the system.
2. **Design Options:** The team developed and presented the three design options to the customer and discussed the advantages and disadvantages of each.
3. **Client Feedback:** The customer preferred the custom design with four controllers and three-way valves, which reduced their part count by two-thirds and provided full gas options for each bioreactor.
4. **Design Adjustment:** Based on the customer's feedback, the team made minor modifications, including modifying mounting holes to fit existing hardware to ensure a snug fit within the benchtop bioreactor.
5. **Beta Testing:** The customer tested the system in their lab, confirming the design's success in meeting their operational needs. The customer appreciated the quick turnaround and delivery of early products to test.
6. **Production:** Following approval, Alicat scaled up production to deliver the custom gassing modules in the required quantities.



The custom gassing module design chosen by the customer. Each BASIS controller is equipped with a valve underneath. The system's 3-way valves on the outlet increased the usability of each module.

Results

The custom BASIS Gassing Module significantly improved the efficiency and flexibility of the client's bioreactor operations. The solution reduced the system footprint by 3x by integrating multiple gassing modules into a single control system, which enhanced the overall design efficiency. This allowed the client to offer a more versatile testing platform, ultimately leading to reduced operational costs and faster experiments.

Custom Engineered Solutions at Alicat

Alicat Scientific's engineering team is comprised of experts in gas and liquid flow and pressure measurement, flow and pressure control, leak checking, and gas mixing. We thrive on solving complex challenges for our customers, tailoring our products to meet their exact process needs. For example, we can modify our standard product lines, such as transforming an MC series mass flow controller into a specialized MCT configuration built to combine multiple gases into two separate streams.



Our FusionFlow division leverages the capabilities of our M/MC and P/PC series to create advanced gas mixing modules, delivering precise gas mixtures while optimizing time, space, and cost efficiency. Alicat Scientific excels in custom engineering and high-volume applications, thanks to our deep expertise and commitment to innovation.

Do what you want, faster.

Since 1991, Alicat has worked closely with those at the forefront of scientific discovery and technological development. We provide fast instruments, fast delivery, and fast answers so you can focus on getting fast results.

Alicat offers:

- ▶ Custom-engineered flow and pressure devices with multivariate measurement and control
- ▶ ISO 9001 certification, NIST-traceable calibration, ROHS, REACH and CE compliance, ATEX, IECEx and North America hazardous area certifications
- ▶ Lifetime warranty and free technical support from our skilled applications engineers
- ▶ Worldwide service, calibration and sales

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