EQUILIBAR®
PRECISION FLUID CONTROL

Equilibar Flow Control

Precision Control Valves for Research and Industry

How It Works

The Equilibar® control valve works in a completely different way than traditional flow control valves.

Instead of a single valve seat, the Equilibar valve uses multiple orifices sealed by a flexible diaphragm. The Equilibar valve is dome-loaded by a pressure on top of the diaphragm that controls the process fluid flow proportional to the "pilot pressure" on the diaphragm. As flow requirements change, the diaphragm moves a few millimeters to open and close over some or all of the orifices, providing instantaneous and frictionless control.

The Equilibar valve was conceived as a precision back pressure regulator but is easily configured to control flow rate in a flow control PID loop with an electronic pilot controller. Over the years, Equilibar customers have discovered the significant benefits of the Equilibar control valve in demanding flow control applications where the supply pressure is largely stable.

PATENTS

These regulators are subject to one or more of **these patents:** US6,886,591, US7,080,660, US7,673,650, US8,215,336, DE60322443D1, GB1639282, FR1639282

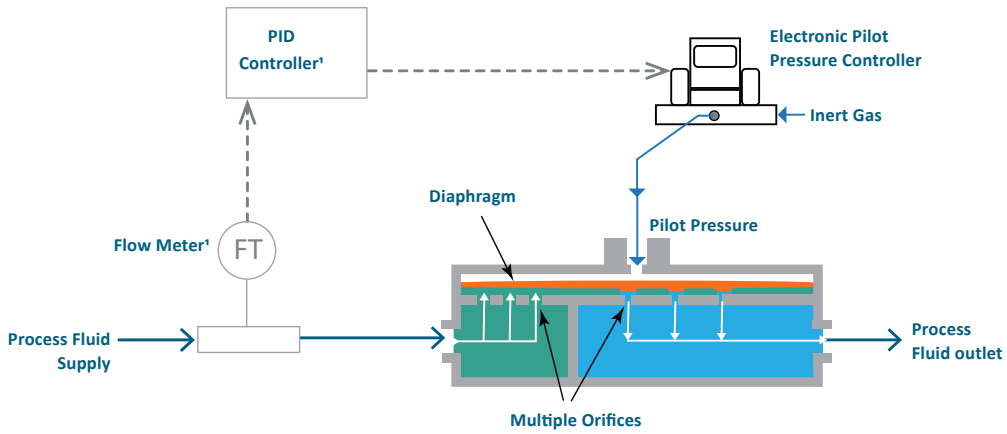

Fig. 1 Schematic of how the Equilibar regulator works in flow control

¹flow meter and PID controller are provided by the end-user and are not sold by Equilibar

HOW IT WORKS IN FLOW CONTROL

In a flow control configuration, the Equilibar® flow control valve (FCV) uses an electronic pilot pressure controller and a flow meter in a control loop. **See Fig. 1**. A proportional-integral-derivative (PID) controller monitors input from a flow transmitter (FT) and adjusts the pilot pressure to control flow. An electronic pressure controller translates the electronic signal from the PID into a pressure signal for the pilot pressure. Flow is decreased by raising the pilot pressure and increased by lowering the pilot pressure. **See Fig. 2.**

When using the Equilibar FCV, pressure and flow have an inverse relationship, so the control scheme will be set up differently then typical control valves. In flow applications, the PID loop must be used in ***direct mode*** instead of the more common inverse mode used by traditional control valves. Pressure must be ***increased*** in response to an ***increase*** in flow. Opposite flow responses of a traditional globe control valve (red) and an Equilibar FCV (blue) in response to actuation pressure are represented in Fig. 2.

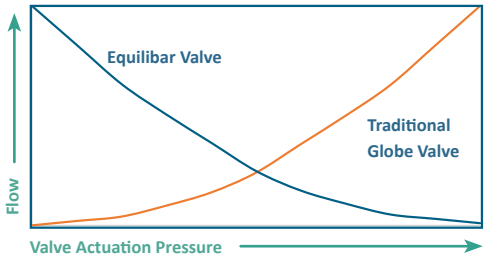

Fig. 2: Flow Response to Actuation Pressure for Traditional Flow Control Valve and an Equilibar Valve

WHEN TO USE EQUILIBAR VALVES FOR FLOW CONTROL

In many chemical process flow control applications, a traditional globe or needle-style control valve will be the most economical and convenient solution, but there are advantages to using an Equilibar FCV for demanding application requirements including:

- Wide range of required valve flow coefficient (Cv)
- Highly corrosive gases and liquids (using exotic alloy bodies and diaphragms with FFKM)
- High temperature (seals available up to 500ºC)
- Sanitary and biopharmaceutical applications (available with USP Class VI diaphragms)
- Extremely low flow rates (controls Cv down to 1E-9)
- Mixed phase fluid flow control
- Small Footprint

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Key Performance Advantages

CONTROLS ACROSS RANGE OF FLOWS > 100 TO 1

One characteristic of traditional FCVs is that of limited flow range (or the max/min ratio of effective Cv, also called turndown ratio). Most control valves operating in research and process industries are limited to between a 10:1 and 15:1 ratio. An Equilibar valve can easily operate in a Cv range greater than 100:1 and have been used in applications requiring 250:1 Cv range.

CONTROLS MULTI-PHASE FLUIDS, MIXED FLUIDS, BUBBLES, AND FOAM

The unique design of the Equilibar valve enables it to handle two-phase or mixed-phase flow streams while maintaining high precision. This can include gas/liquid processes, water/oil flow streams, or supercritical fluids.

Traditional valves use a single annular valve seat, sometimes very small, so that when slugs of liquid flood the valve throat, volumetric flow rate drops suddenly as the denser fluid is accelerated through orifice. This momentary reduction in volumetric flow disrupts the stability of the upstream process pressure.

The unique Equilibar technology uses a direct-sealing diaphragm over multiple orifices to control the pressure drop. The supple diaphragm can vary its proximity to the orifices nearly instantaneously to adjust to the varying Cv requirements of the various fluid phases.

ISOLATES FROM DOWNSTREAM PRESSURE FLUCTUATIONS

An Equilibar valve provides a buffer against changes in downstream pressure. Because it is a back pressure regulator, the Equilibar valve will automatically adjust to keep its inlet pressure at setpoint regardless of changes at the outlet port. When using a traditional FCV, any change in downstream pressure will require a PID control adjustment to remain stable.

EASILY WITHSTANDS CORROSIVE FLUIDS

Equilibar valves can be constructed of exotic metal alloys and polymers including Hastelloy, Titanium, Zirconium, PTFE and PVDF. Combined with a selection of diaphragm and O-ring materials compatible with highly corrosive gases and liquids, Equilibar valves can be used in applications with corrosive fluids.

EASY TO MAINTAIN

With only one moving part, Equilibar valves are easy to disassemble for maintenance, reassemble, and return to use quickly and easily.

HIGH TEMPERATURE DESIGNS

Equilibar offers valve designs that can be in applications up to 450C (840F).

INCLUDES OPTIONS FOR SANITARY PROCESSES

Equilibar has a family of valves designed with ASME BPE specifications specifically for use in sanitary processes. These FD Sanitary Valves range in size from 1/2" ports to 3" ports and can be used in flow control for operations such as precision dosing and CIP.

GOOD FOR EXTREMELY LOW FLOW RATES

Application Spotlight

INJECTION AND IN-LINE BLENDING FLOW CONTROL

Traditional FCVs have difficulty in injection and metering applications where the downstream pressure is widely varying. Changes in required flow rate are compounded with changes in available differential pressure, creating a very wide range requirement for Cv. It is difficult for a single flow control valve to be sized to handle such a wide Cv range. The traditional solution has been to use two or three parallel control valves of different sizes to handle these widely varying conditions. The Equilibar FCV, however, can consistently function across a wide Cv range with flow rate variations of 100:1, regardless of changes in downstream pressure.

DEEP WELL INJECTION

Deep well injection applications involve the injection of a fluid into the bottom of the oil well to improve conditions of the well. These are a challenge for flow control valves because the downstream pressure of the wellhead can vary greatly with conditions and flow rate inside the well. In addition, the required injection flow rate can vary. See Fig. 3.

For example:

- Maximum Fluid Supply Pressure = 300 psig
- Range of injection pressure to wellhead = 0 to 270 psig
- Range of Flow Required = 0.25 GPM to 5 GPM
- Fluid density = water-like

The maximum Flow Coefficient required for injection is based on the maximum flow of 5 GPM with an available differential pressure of only 30 psid (300-270 psig). This results in a Cv (max) = 0.91.

The minimum Flow Coefficient is based on the minimum flow of 0.25 GPM and an available differential pressure of 300 psig. This result is Cv (min) = 0.014.

In this example, the Max/Min ratio is **63** which is greater than the typical control valve range of 20:1 or 15:1.

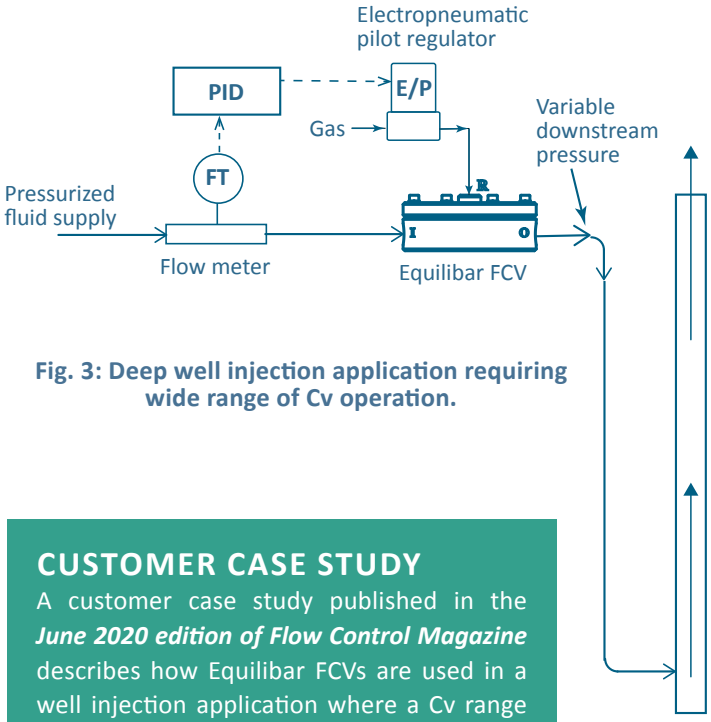
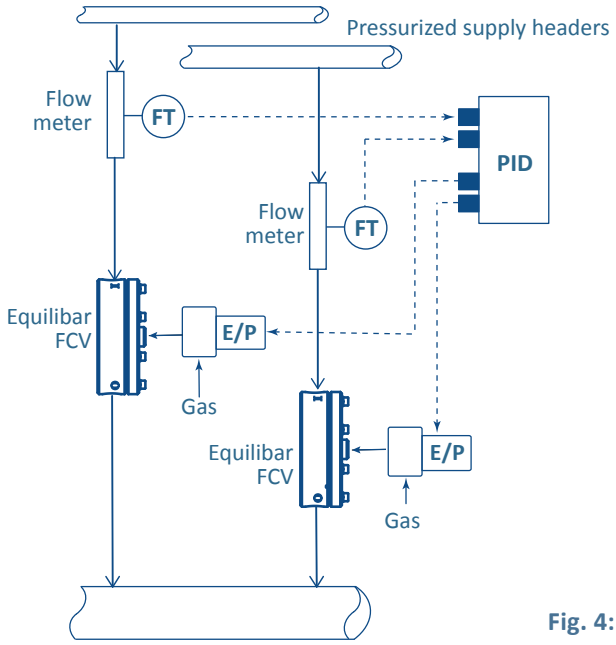


Fig. 3: Deep well injection application requiring wide range of Cv operation.

CUSTOMER CASE STUDY

A customer case study published in the ***June 2020 edition of Flow Control Magazine*** describes how Equilibar FCVs are used in a well injection application where a Cv range of **230:1 was required.**



PRODUCT BLENDING

Product blending is used to mix a relatively tiny amount of product into a much larger base. One example is blending a strong mint flavor into a base used for toothpaste. Another example is injecting germicides into a municipal water system. Wide flow ranges are required due to different product formulations or wide swings in the downstream base product flow. Traditional FCVs or positive displacement pumps cannot control over this wide range.

Fig. 4 at left details how Equilibar flow control valves can be set up in a control loop with a flow meter and PID controller to precisely blend the amount of additive desired for a specific formulation or recipe.

Fig. 4: Product blending application requiring large turndown ratio.

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Flow Control Valve Specifications

Equilibar FCVs are available in a wide range of sizes, materials and port options. They are also available in sanitary design for consumer products, biopharmaceutical or food and beverage applications. Below is a chart of several popular sizes with dimensions shown for stainless steel. Other models are unlisted but available to suit specific application requirements.

Please contact an Equilibar application engineer to discuss your application to determine the best valve for your process.

An Equilibar FCV is controlled by an electronic pilot pressure controller. Equilibar sells models listed on page 7 with a range of signal outputs to communicate with the end-user's choice of PID controller.

BASE PART #	FLOW COEFF. (CV)		MAX PRESSURE PSIG (BAR(G))	PROCESS PORT SIZE IN (DN)	REFERENCE PORT SIZE	PORT THREAD OPTIONS	See Figures 5 & 6	
							DIM A	DIM B
	MIN	MAX					INCH (MM)	
LF1	1E-08	0.07	1000 (68)	1/8" (6)	1/8"	NPT; BSPP; Swagelok; custom	2.5 (64)	1.5 (39)
LF2	1E-08	0.07	1000 (68)	1/4" (8)			2.5 (64)	1.5 (39)
HF1	1E-05	0.41	1000 (68)	1/8" (6)	1/8"	NPT; BSPP; Custom	2.5 (64)	1.5 (39)
HF2		0.41	1000 (68)	1/4" (8)			2.5 (64)	1.5 (39)
GSD2	1E-05	1.20	750 (51)	1/4" (8)	1/8"	NPT BSPP Flange DIN Flange Custom	3.00 (76)	1.34 (34)
GSD3		1.80	400 (28)	3/8" (10)			3.50 (89)	1.40 (36)
GSD4		3.20	350 (24)	1/2" (15)			4.50 (114)	31.73 (44)
GSD6	1E-04	5.50	300 (21)	3/4" (20)			6.00 (152)	2.01 (51)
GSD8		8.50	150 (10)	1" (25)			7.80 (198)	3.33 (85)
Sanitary Options								
FDO4	1E-7	1.0	150 (10 bar)	1/2" (15)	1/8" NPT	Tri-Clamp Custom	3.4 (86)	1.4 (36)
FDO6	1E-4	4.0	150 (10 bar)	3/4" (20)			5.9 (151)	2.0 (51)
FDO8	1E-4	8.0	150 (10 bar)	1" (25)			8.1 (204)	2.4 (61)
FDO12	1E-3	12	150 (10 bar)	1.5" (40)			9.1 (230)	2.7 (69)
FDO16	1E-3	19	150 (10 bar)	2" (50)			11.1 (280)	3.6 (91)
FDO24	1E-3	36	150 (10 bar)	3" (80)			14.8 (375)	5.1(129)

Fig. 5: DIM A and DIM B for LF, HF & GSD models

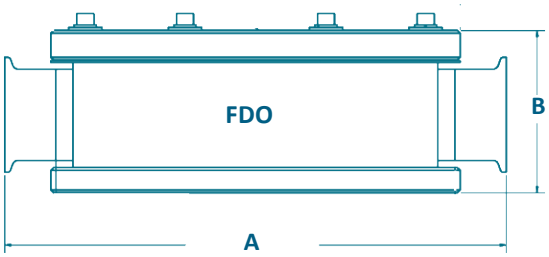
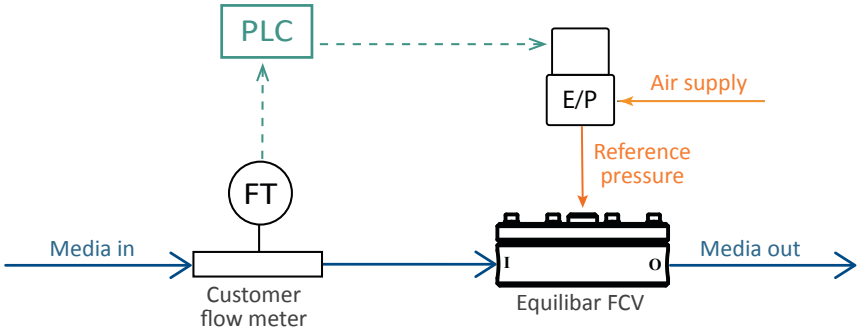


Fig. 6: DIM A and DIM B for FDO models

Getting Started with Primary FCV Formats

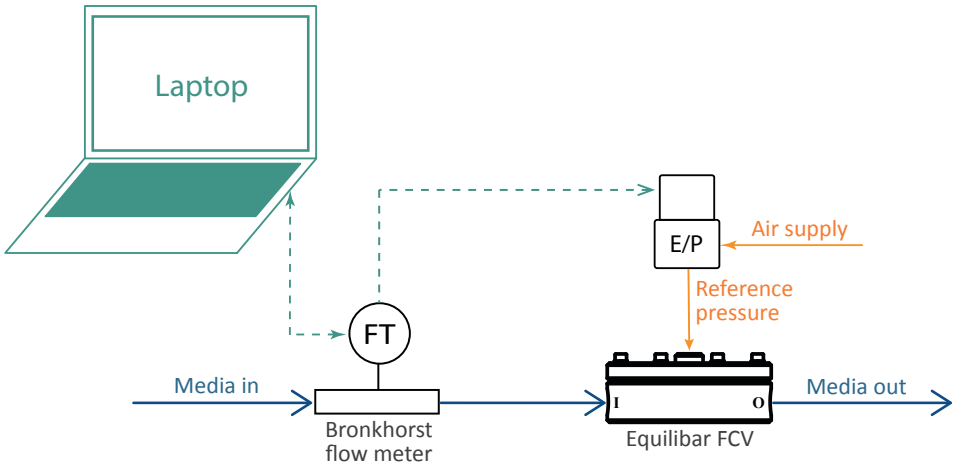
1. CONTROL USING EXISTING PLC AND INTERNAL PROGRAMMING PROTOCOLS:

Use an existing flow meter to provide feedback to the PLC. The PLC calculates and provides a command signal to an electronic pressure regulator (E/P) to adjust the air pilot pressure to the Equilibar FCV. An on staff programmer of the end user can tune the PLC settings to optimize the Equilibar FCV's performance for each specific application.



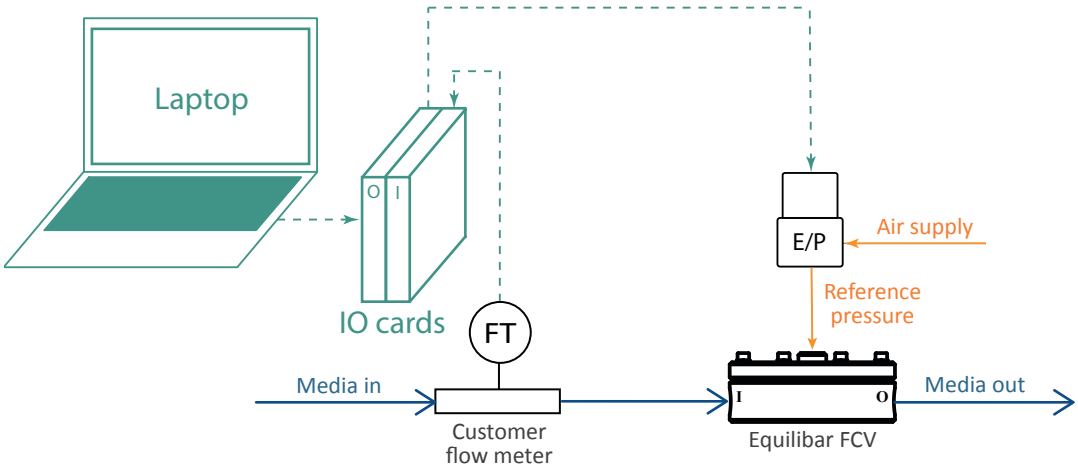
2. CONTROL USING BRONKHORST OR SIMILAR FLOW METER WITH BUILT-IN FLOW CONTROL SOFTWARE:

The software built into a Bronkhorst or similar flow meter can be used to provide an output signal to an electronic pressure regulator. The software is easily accessible through a laptop computer. Use this software to optimize settings for each specific application.



3. CONTROL USING LABVIEW, ARDUINO, OR SIMILAR NON-DEDICATED FLOW CONTROL SOFTWARE:

Use LabVIEW, Arduino, or other similar technologies to send signals between I/O control boards , the flow meter, and the electronic pressure regulator. In this program, tune PID settings to optimize the valve's performance for each application. It is up to the end user to develop the labVIEW instrument file or other program specific code for their application.



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Pilot Control Options

Equilibar FCVs are pilot operated with a setpoint pressure, called 'reference' or 'pilot' pressure, applied to the top port. When combined with a high resolution electronic pilot regulator, the Equilibar FCV provides precision flow control with instantaneous response to changes in setpoint and process fluctuations. Below are some options for electronic pilot control for Equilibar FCV. For best performance, we recommend using a responsive flow meter and PID controller with guidance from the end-user's on-site controls engineer. Equilibar does not sell flow meters, it is up to the end user to choose one appropriate for each application.

REGULATOR		DESCRIPTION	KEY FEATURES
QPV Series		High Precision Low Pressure Regulator Controls up to 150 psi (10 bar) 4-20 mA or 0-10 VDC Lower cost option	• Controls to 150 psi • Available in gauge, absolute, vacuum and vacuum-positive ranges • Superior proportional valve action • Tuned ready for setpoint pilot service • Optional DeviceNet / Serial communication • IP65 enclosure
EPR Series		High Resolution Electronic Pressure Regulator Controls up to 3000 psi (200 bar) 4-20 mA or 0-5 VDC Analog RS232 or RS485 Digital	• Models control to 150 psig; 500 psig; 1000 psig; 3000 psig • Available in gauge, absolute • Proportional inlet & outlet valves for maximum stability • No gas wasted at steady state • Factory set for your pressure • Digital or analog communication • Direct control from the keypad • IP40 enclosure

Fig. 7: Equilibar Sanitary FDO8 with QPV pilot controller

Fig. 8: Equilibar FDO4 control valve in a flow control loop with an Equilibar EPR electronic pilot regulator and a high resolution flow meter. PID controller not shown.

[1]flow meter is supplied by end-user; it is not for sale through Equilibar

Contact an Equilibar application engineer to discuss your flow control application

About Equilibar

Equilibar provides innovative and robust fluid control technology for researchers and engineers worldwide. We are proud to design, manufacture and test our patented back pressure regulators and flow control valves in our factory overlooking the Blue Ridge Mountains near Asheville, NC. We are equally proud to work with clients around the world each and every day.

APPLICATION ENGINEERING – WHAT SETS US APART

Unlike mass-market valve distributors, we focus on working with you, the scientist or engineer with a complex fluid control scenario.

Our application engineers work collaboratively with clients to identify the optimal model, trim, and diaphragm for each application's unique challenges. No matter where you are on the globe, you can stay in close contact with your engineer by email, telephone, videoconferencing or fax.

After installation, your application engineer will support you with start-up information and fine-tuning as needed.

EQUILIBAR®
PRECISION PRESSURE CONTROL

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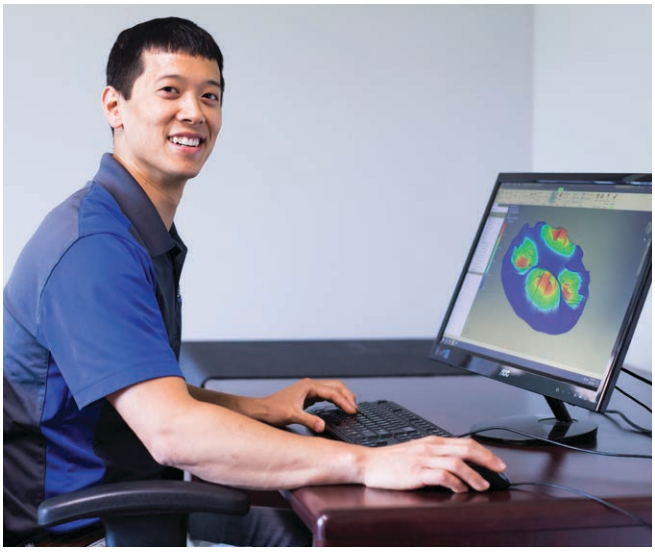
Each application is reviewed by our engineering team to ensure quality performance of our products.



Our engineers offer custom designed solutions for the most difficult fluid control challenges. Feel free to contact us to discuss your situation.

Made in the USA

Equilibar's quality system is **ISO 9001:2015** certified.

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