EQUILIBAR
PRECISION PRESSURE CONTROL

Customer Case Study: **June 2014**

Equilibar Back Pressure Regulator Improves Fischer-Tropsch Fuel Research

Researchers around the world use the Fischer-Tropsch Synthesis process to produce liquid fuels from alternative energy sources such as biomass and natural gas. At Auburn University in Alabama, one graduate student has incorporated an Equilibar back pressure regulator to dramatically improve their research of Fischer-Tropsch catalysts.

Background:

Fischer-Tropsch Synthesis was developed by Franz Fischer and Hans Tropsch in the early 1900s. It is a relatively complicated chemical process that converts syngas, a mixture of carbon monoxide and hydrogen, into hydrocarbons, including many of the compounds in traditional liquid fuels. Syngas can be generated from almost any carbonaceous feedstock, so the Fischer-Tropsch process indirectly allows for the production of synthetic oil and fuel from resources such as coal, natural gas, and biomass.

David Roe, a graduate researcher in Auburn University's Department of Chemical Engineering, is conducting research using Fischer-Tropsch Synthesis to generate gasoline and diesel length fuel compounds. Roe contacted Equilibar to improve the existing pressure control method to aid the effort in making this nearly century-old process more viable for today's market.

Lab set-up showing Fischer Tropsch Synthesis reactor (forground, insulated) with flow control instrumentation

The Challenge:

Catalyst researchers often rely on back pressure regulators to maintain stable reaction pressures under the extreme reaction conditions. At Auburn, Roe's application requires the process to run at both high pressures (1000 psig) and high temperatures (up to 350°C). Originally, Roe used traditional manual back pressure regulators in his experiments, resulting in pressure deviations of approximately 30 psi. Traditional regulators are spring-operated and open as overpressure compresses the spring. The change in the spring constant as the spring is compressed is a major source of error, or overpressure, in traditional designs. In addition, the spring-operated regulators have limited pressure range and high hysteresis.

"In the old system I was never certain that the pressure I saw was stable or just a temporary deviation," Roe explained. Roe began looking for a higher precision method of control that was capable of smoothing out the disruptive pressure fluctuations.

He contacted Equilibar, which offers a dome-loaded back pressure regulator with a sensitive diaphragm. The unique diaphragm design also gives Equilibar its ultra-wide flow range, typically 100X wider than traditional back pressure regulators can provide. The Equilibar works by supplying a fixed air or nitrogen signal to the top dome of the regulator equal to the desired pressure to be maintained in the reactor (upstream of the regulator).

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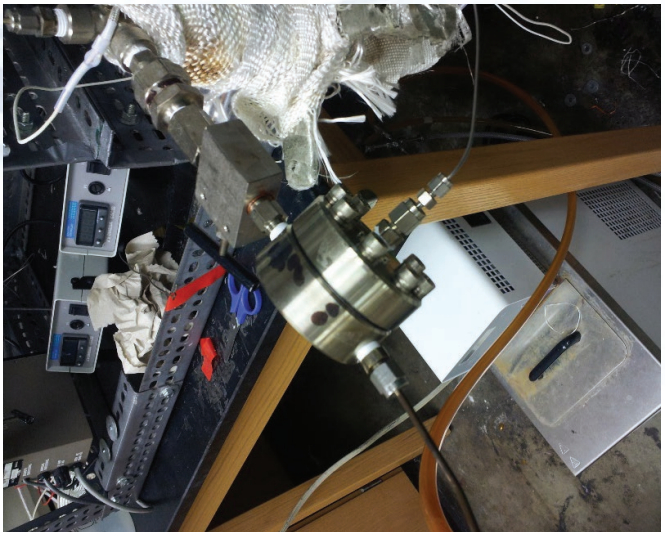
Solution: The Equilibar Back Pressure Regulator

In 2012, Roe's research team purchased the Equilibar Research Series Model EB1ULF1 in SS316 with 1/8" NPT process ports. Equilibar engineers specified a Polyimide diaphragm and Kalrez® 7075 o-rings to meet the high temperature and chemical compatibility of the process. The sensitive diaphragm with compressible pilot gas loading is designed to provide stable pressure across a 100,000:1 flow rate ratio. The unit allowed for the possibility of two-phase or biphasic process fluid to pass through the unit.

Gaseous reactants and the liquid reaction media are fed into the system using mass flow controllers and a high pressure pump, respectively. (see schematic page 2). The reactor pressure is maintained by the Equilibar back pressure regulator downstream. The Equilibar regulator is piloted manually via a pressure reducing regulator on an air cylinder which provides the control signal for the unit. The process effluent is separated in a cold trap. Uncondensed gases proceed directly to a gas chromatograph for analysis, while liquid is periodically collected for offline analysis.

Successful Results

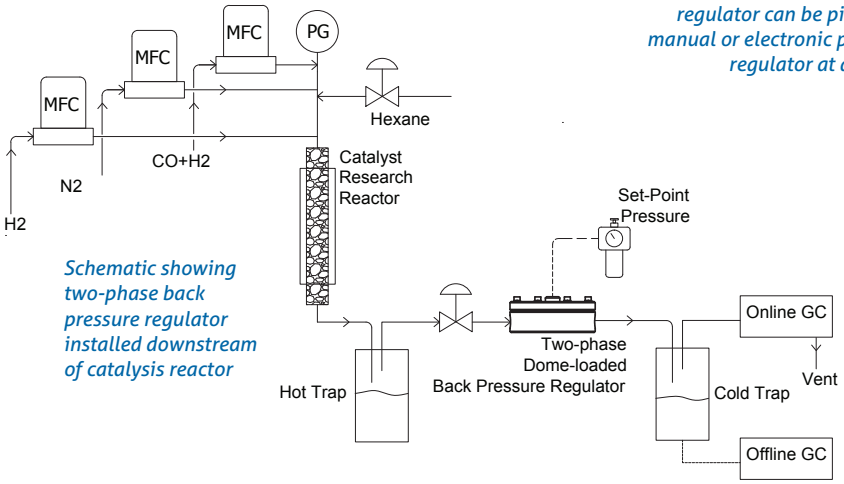
The Equilibar regulator enables Roe to set a pressure and begin building pressure without uncertainty about where the system will equilibrate. This saves significant time by avoiding the frequent manual adjustments necessary with a spring-based regulator.



Close-up of Equilibar dome-loaded back-pressure regulator

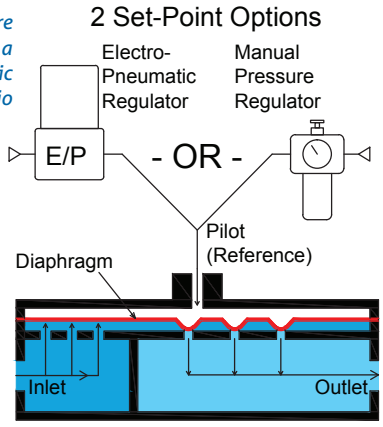
The unit has been in service since 2012 with minimal issues. The unit is used for approximately one test a month which can last over two weeks. This includes start up, catalyst testing and system pressure reduction.

Roe reports unparalleled pressure stability in the application now that the Equilibar regulator is in place. "My system generally stays within 5 psi of its set point."



Schematic showing two-phase back pressure regulator installed downstream of catalysis reactor

The Equilibar back pressure regulator can be piloted by a manual or electronic pneumatic regulator at a 1:1 ratio



David P. Roe *is a Graduate Research Assistant in the Department of Chemical Engineering at Auburn University in Alabama. He works for Dr. Christopher B. Roberts researching Fischer-Tropsch synthesis, nanoscale catalysts, and supercritical fluid reaction media. He obtained his B.S. in Chemical Engineering from Auburn University in 2010 and can be reached at roedavi@auburn.edu or 1-334-844-2071.*

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