

# FLOW REACTOR

ADVANCED CATALYST  
EVALUATION

[micromeritics.com/FR](http://micromeritics.com/FR)



**mi micromeritics®**

# THE FLOW REACTOR (FR)

The most advanced system for the evaluation of catalyst performance. Installed in the laboratories of the world's most innovative companies, universities, and government institutes.



**The FR system from Micromeritics is a bench-top turn-key flow reactor that provides:**

#### **A full range of process conditions**

- Reaction conditions up to 1000 °C and 200 bar including patented **wide-range control valves** with **stable control resolution to 0.1 bar**
- Up to 6 gas and 2 liquid feed streams
- Continuously measured gas or liquid output streams with ultra-low dead volume including **patented liquid/gas or liquid/liquid gas separators**

#### **A system that is quick to deploy and simple to use**

- Automated software for completely unattended operation
- Integrated safety systems featuring alarms, fail-safes, and automated response to undesired conditions
- Benchtop system that allows testing catalyst samples from a few milligrams to several grams

***De-risk your scale-up and shorten your development schedule with the FR system that matches your process.***

# FR-SERIES FEATURES

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**Thermostated environmental chamber** provides a stable isothermal process zone to eliminate condensation of vapors and provide long-term process stability.

**Interchangeable reactors** enable processes up to 1000°C and 200 bar in materials that are suitable for a wide variety of reaction chemistries and low bed volume, simplifying the transition from bench- to flow-reactor.

Independently-controlled **reactor furnaces** (FR-100: single, FR-200: dual) provide stable, uniform temperature control up to 1000°C.

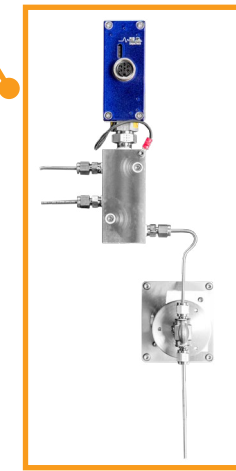
Patented **pressure-control valve** provides stable control with a unique combination of wide dynamic range, high resolution, and ultra-low dead volume for any stream type.

- ambient to 200 bar
- 0.1 bar control resolution
- gas, liquid, or multiphase streams

**Liquid feed** can be controlled through HPLC or syringe pumps for precise input flow control.

The large full-color **touchscreen** provides simple real-time status display and modification of system settings.

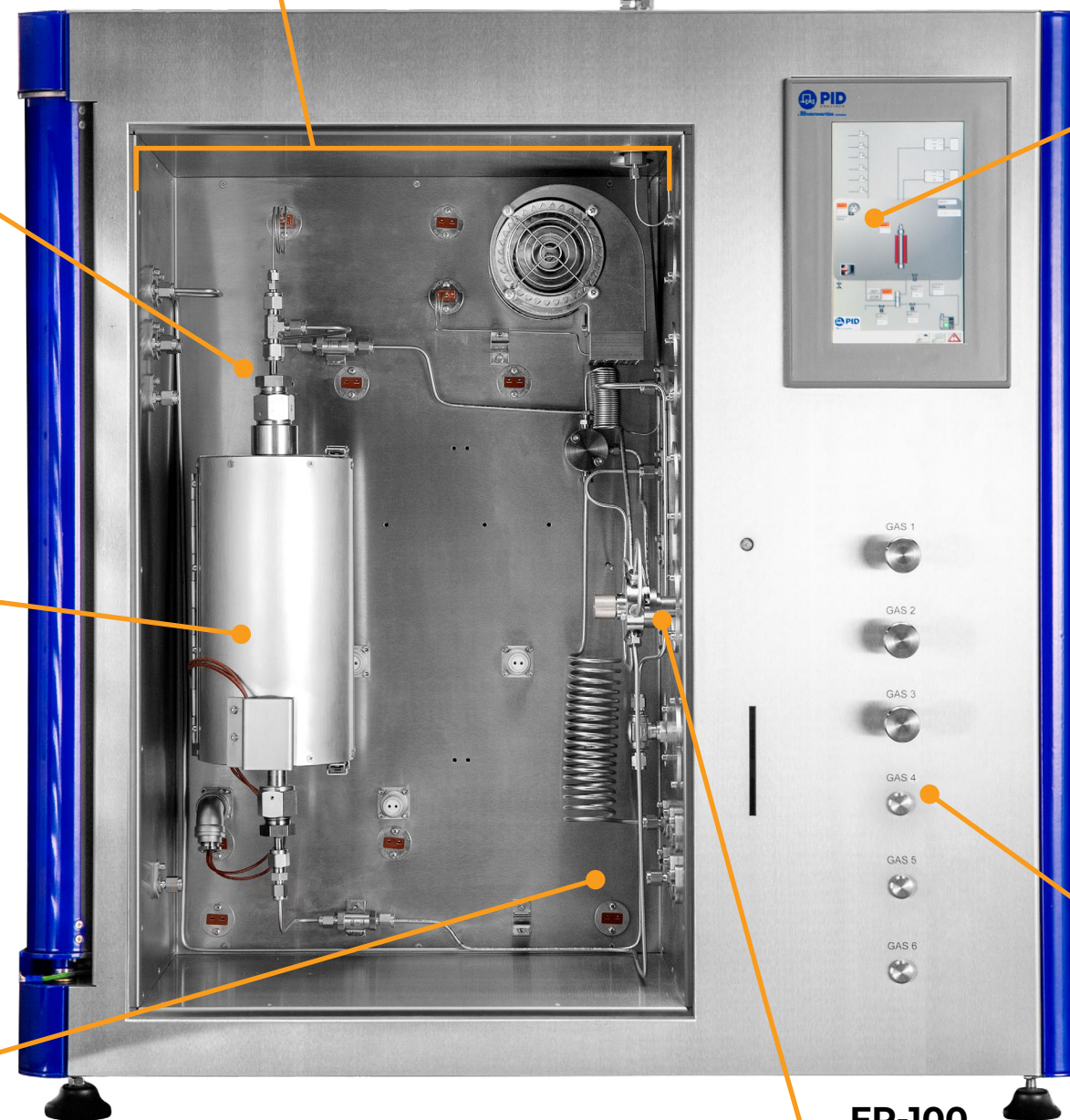
Patented **liquid-gas and liquid-liquid-gas separators** provide effective product separation, less than 1 cc dead volume, and continuous output flow without accumulation (US Pat 7,895,891 B2).



Up to six **gas inlets** with precision mass flow controllers provide complete flexibility and control of process inputs.

FR-100

**Automatic six port valves** for different flow paths such as reactor bypass or upflow/downflow operation.



# FR SAFETY

The **FR** includes multiple levels of safety features that make the system simple to deploy and safe to operate. Additional safety features such as automatic shut-off valves and gas detectors are available to add as appropriate.

## Alarms and Notifications

- User-defined alarm values
- Two-way communication with laboratory safety systems

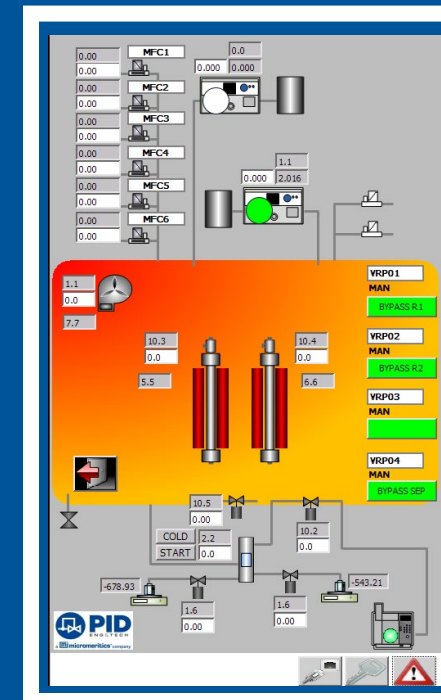
## Redundancy and Isolation

- Redundant thermocouples for high temperature alarms
- Safety system is separated from PC to provide uninterrupted communication integrity

## Automated Response

- Automatic shutdown in critical safety scenarios
- Actively cool and ventilate the process zone to safe conditions

# FR SOFTWARE

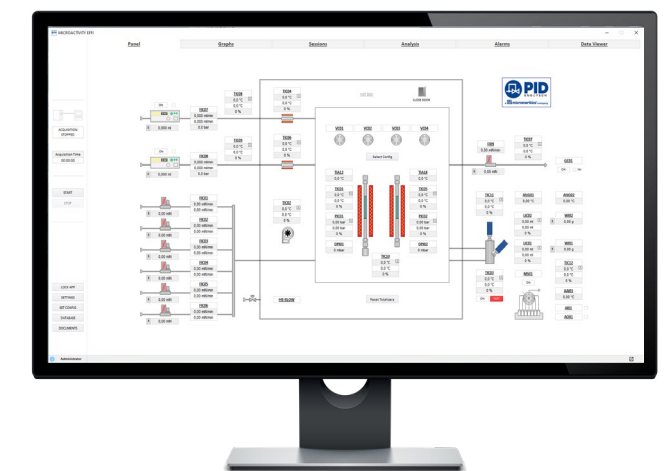


Onboard touchscreen enables convenient view and modification of all system controls.



## PROCESS@ SOFTWARE AND EXPERIMENT VIEW

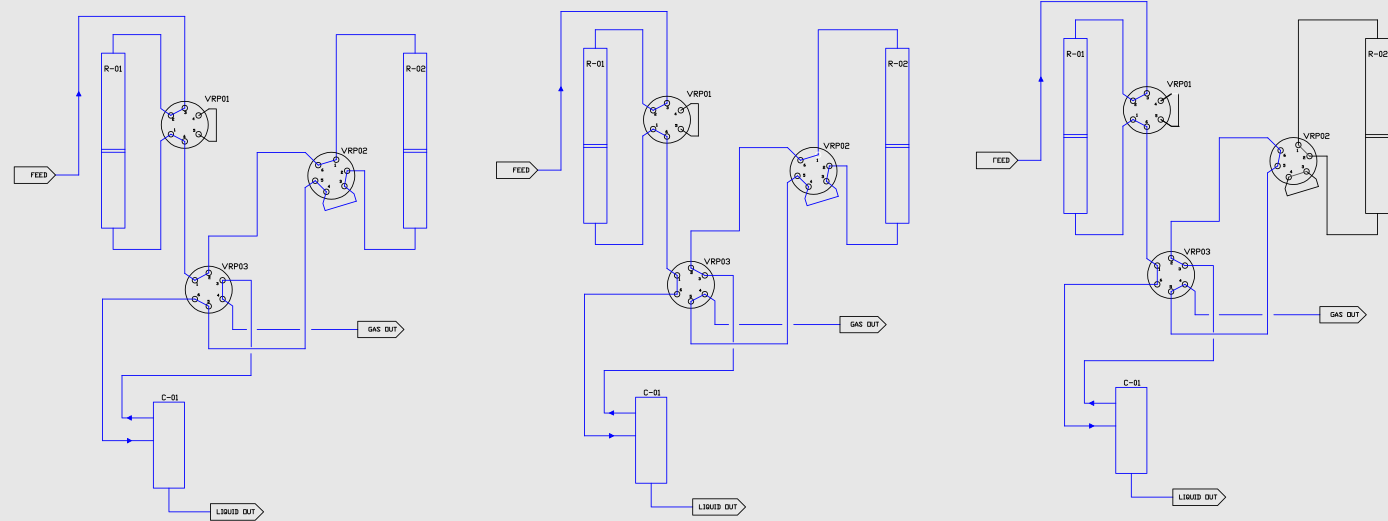
- **PROCESS@** is a user-friendly real-time control and data acquisition software based on **LabVIEW**
- Program complete processes for **unattended operation**, including conditional logic to adjust process conditions in real-time
- Monitoring and data acquisition for process and control variables
- Graphic and data visualization
- Complete data records **store all control and measured signals** through the duration of the program
- Simple export to facilitate additional data analysis



# FR-200 CONFIGURATIONS

The **FR-200** includes all the capabilities of the **FR-100** with two independently-controlled reactors. Three available configurations of the **FR-200** enable reactor flows of increasing complexity to mimic even the most intricate reactor process flows.

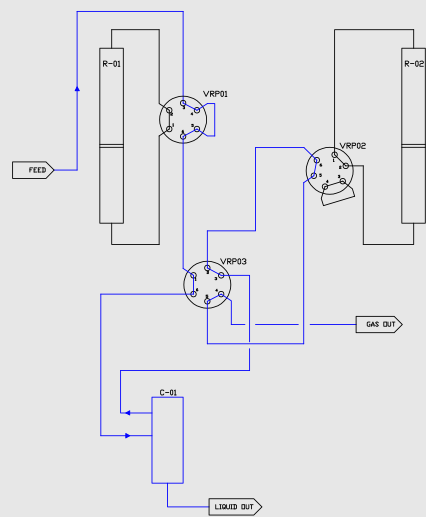
## FR-200 DUO



Both reactors in series with final liquid / gas separation

Both reactors in series with intermediate liquid/gas separation

Single reactor in flow (1 or 2)

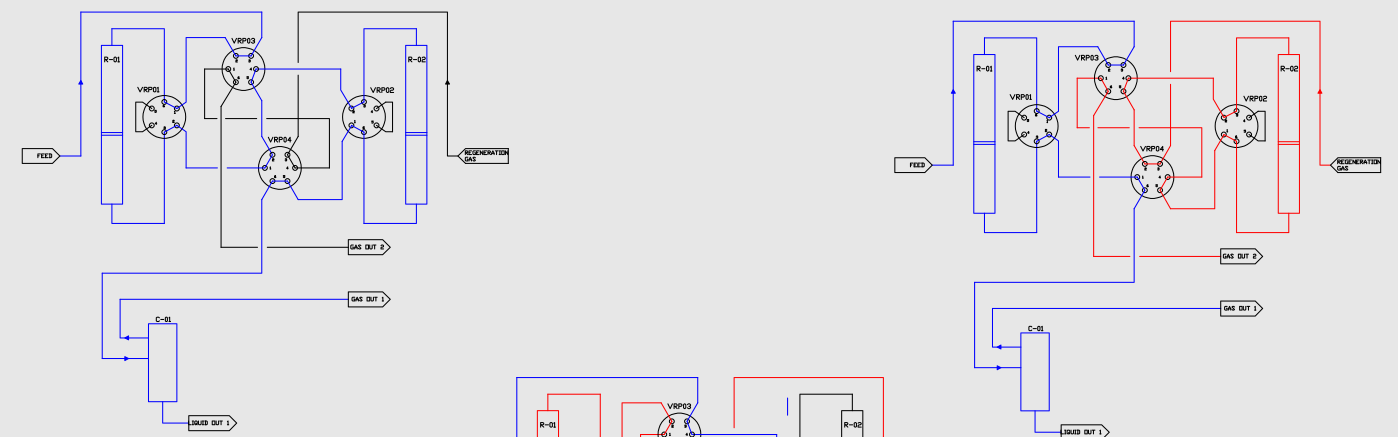


Both reactors bypass



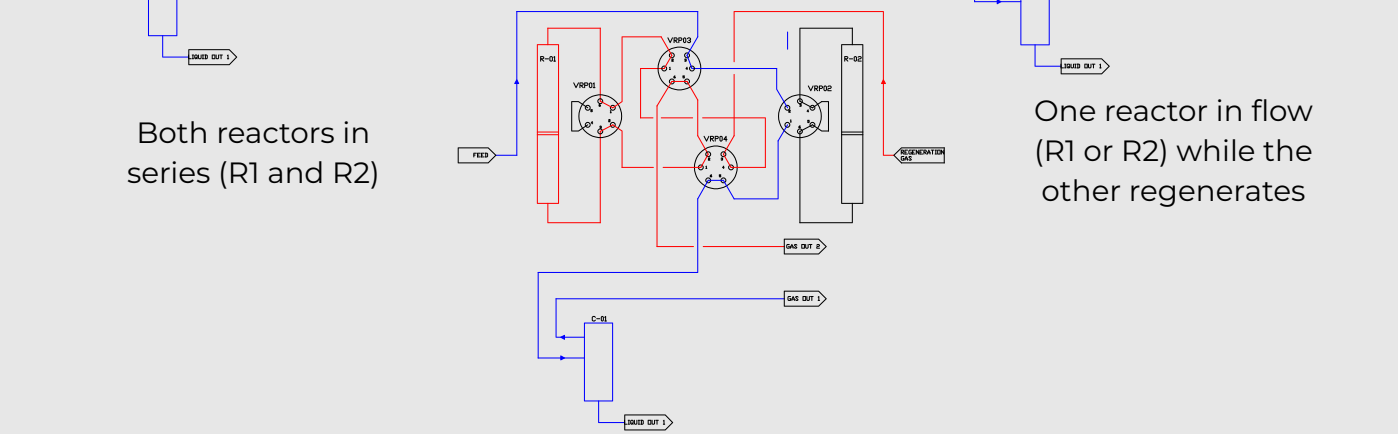
**FR-200**

## FR-200 TWIN



Both reactors in series (R1 and R2)

One reactor in flow (R1 or R2) while the other regenerates

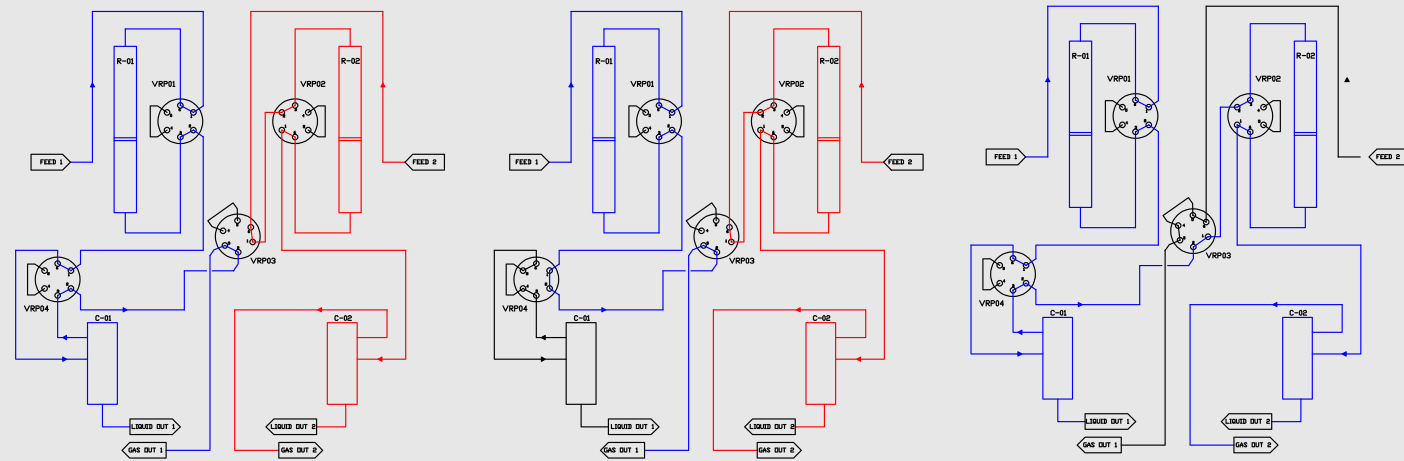


One reactor in flow (regeneration) while the other is bypassed

One reactor in flow while the other is bypassed

Both reactors bypassed

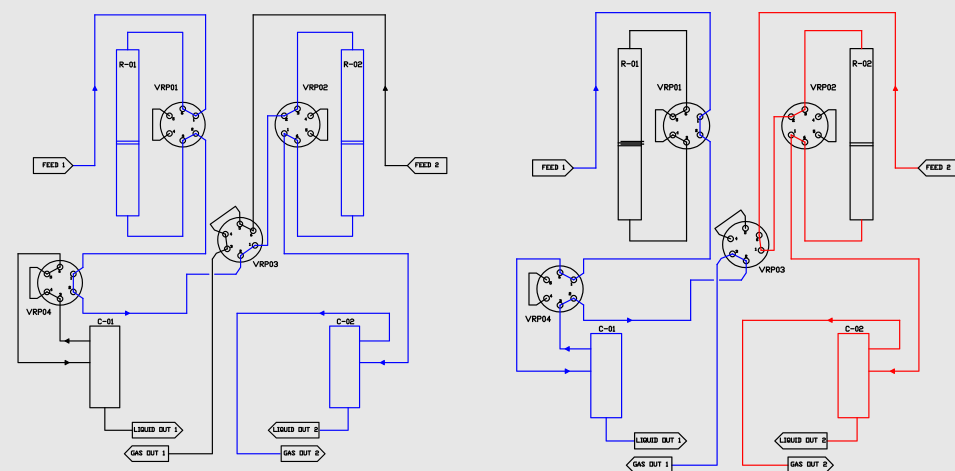
## FR-200 PARALLEL



Both reactors in parallel

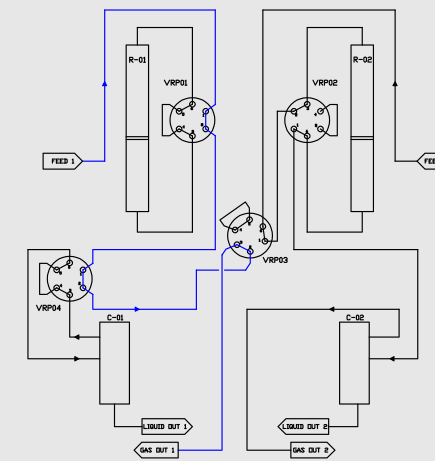
Both reactors in parallel and  
L/G Sep 1 in bypass

Both reactors in series

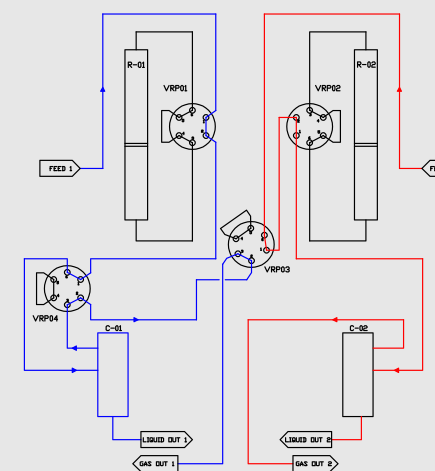


Both reactors in series  
and L/G Sep bypassed

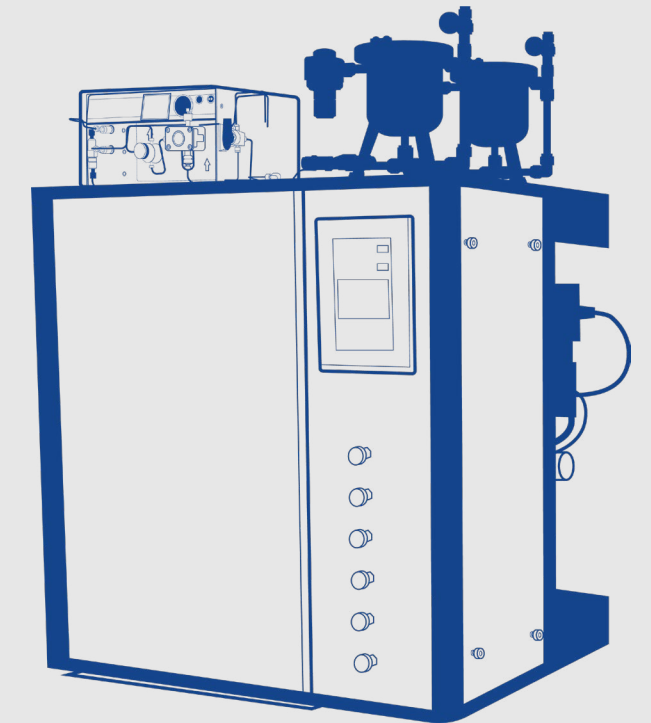
One reactor in bypass  
while other is in flow



Analysis of the  
raw material 1 or 2



Both reactors bypassed



# EQUIPMENT OPTIONS

## ADDITIONAL GAS INLETS

Up to six total gas inlets, each coupled with a high-precision mass flow controller.



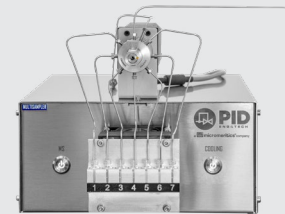
## LIQUID FEED CONTROL

HPLC pump with integrated Coriolis mass flow meter provides precise, stable feed control. Additional capabilities include syringe pumps for low flow rates and temperature control up to 80°C for heavy liquids.



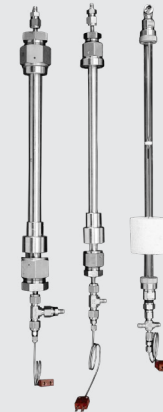
## LIQUID MULTISAMPLER

Automatic programmable liquid multisampler to collect up to seven liquid samples, including cooling to stabilize volatiles



## INTERCHANGEABLE REACTOR

Available in a variety of sizes and materials, including quartz, stainless steel, Inconel, and Hastelloy. Match the correct reactor to catalyst loading and operating conditions.



## HIGH PRESSURE

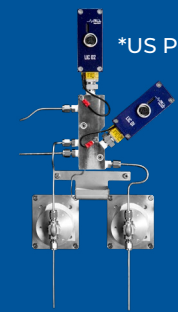
Pressure control up to 200 bar with patented high resolution control. Certified to comply with PED 2014/68/UE



\*US Pat. 8,740,181 B2

## LIQUID/LIQUID/GAS (L/L/G) SEPARATOR

The patented device provides separation of two immiscible liquids and a gas phase with ultra-low (<1 cc) dead volume and continuous flow without accumulation.



\*US Pat 8,800,301 B2

## GAS OUTLET FLOW METER

Measures outlet mass flow rates to determine reaction mass balance.



## LIQUID OUTLET MEASUREMENT

Measures and records outlet liquid to determine reactor mass balance and liquid phase yield.



## LIQUID EVAPORATORS

Temperature-controlled (50 to 450°C) evaporators enable vaporization of heavier species or higher flow rates.



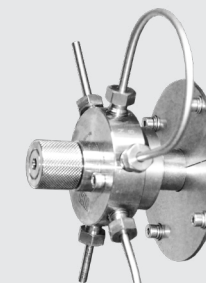
## FLUIDIZED BED REACTOR

Fluidized bed reactor with differential pressure measurement.



## AUTOMATIC SIX PORT VALVES

Dynamically direct process streams to the desired path with simple software control.



## WAX TRAP

Temperature controlled wax trap for heavy hydrocarbons collection just at reactor outlet, especially for Fischer-Tropsch and similar reactions.



■ \*patent

# SYSTEM CAPABILITIES

- Not available    ○ Optional    ● Included

SYSTEM CAPABILITIES		FR-50	FR-100	FR-200
Numbers of reactors		1	1	2
Automatic High Pressure Liquid/Gas Separator		0 Optional: 1	1 Optional: 2	Duo/Twin: 1 Parallel: 2
Reactor		1000°C Quartz 10 mm ID	800°C SST 316 9.1 mm ID	800°C SST 316 9.1 mm ID
Pressure (bar)	Standard	Atmospheric	100	100
	Optional	100	200	200
Gas Feed	Standard	2	3	Duo: 3; Twin/Parallel: 4
	Optional	4	6	6
Automatic Reactor Bypass		○	●	●
OPTIONAL CAPABILITIES				
High Pressure Liquid/Liquid/Gas Separator		-	1	2
Liquid Feed Pumps		1 HPLC	2 HPLC or syringe	2 HPLC or syringe
Heated Liquid Feed & Head Pump		1	2	2
Liquid Out Measurement		1	2	2
Gas Out Measurement		1	1	2
L/G separator bypass valve		-	○	Configuration Dependent
Up/down flow selection valve		-	○	N/A
Wax Trap		-	1	2
Fluidized Bed Reactor		-	1	1
Liquid Multisampler		-	2	4
Additional Reactors		Special alloys 5, 9, 13, 17, 23 mm ID	Quartz and special alloys 5, 13, 17, 23 mm ID	

# DISCOVER THE POSSIBILITIES WITH MICROMERITICS SUPPORT

## CUSTOM REACTOR ENGINEERING

Want to move beyond the capabilities of the FR-series? The Micromeritics custom reactor engineering team has more than 25 years experience developing high-performance custom reactors and small-scale pilot plots.

- Custom mini pilot plants
- Up to 50 g typical catalyst capacity
- Automated 24/7 operation
- Pre-designed modular components reduce construction time and cost

### EXAMPLE PROCESSES

- Hydrotreating/Reforming/Cracking
- Biofuel Production
- Exhaust/Emission studies
- Gasification and Pyrolysis
- Super-critical extraction





## APPLICATION SUPPORT

[micromeritics.com/apps](http://micromeritics.com/apps)

Micromeritics' team provides industry-leading, high-quality application support and training to assist scientists, engineers, and analysts in the field of material characterization. Our application support team is composed of scientists and engineers to help users obtain the highest quality data and information about their material from Micromeritics Instruments. The Micromeritics team is dedicated to helping users successfully use their Micromeritics Instruments for the life of their instrument.

Expert, lifetime, applications support for Micromeritics customers.

Free training courses, application notes and how-to videos available on [www.micromeritics.com](http://www.micromeritics.com)

Applications specific, hands-on training available in Micromeritics USA, Germany, and China facilities

Collaborations with industrial and academic partners to continually improve the quality of measurements and interpretation of material characterization data

## MATERIALS CHARACTERIZATION SERVICES

WORLD-CLASS ACCREDITED LABORATORY



Need to characterize your materials or supplement your current lab's capabilities? Want access to top-of-the-line instruments and expert scientists?

## PARTICLE TESTING AUTHORITY

The Micromeritics PTA lab is the leading contract laboratory for the characterization of adsorbents, catalysts, and membranes. The same engineers and scientists that develop and support our market-leading technologies are available to help you develop methods, test samples, and analyze the results.

- ISO 17025 accredited and FDA registered.
- Globally recognized scientists.
- Typical turnaround time: 7 business days
- Over 25 analytical techniques.

Contact PTA today to learn how our world-class laboratory can advance the development of your materials for the Net Zero economy.

## WORLDWIDE PRESENCE

[micromeritics.com/worldwide](https://micromeritics.com/worldwide) →

**MORE than 10,000 Micromeritics systems** are used every day in the labs of the most innovative companies and the most prestigious government and academic institutions.

**MORE customers choose Micromeritics for their catalyst characterization systems**, than all of our competitors combined.

Get **MORE**  
from Micromeritics

**MORE PERFORMANCE**

**MORE RELIABILITY**

**MORE VERSATILITY**

**MORE SCIENTISTS & ENGINEERS TO SUPPORT YOU**

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## About Micromeritics Instrument Corporation

Micromeritics is the world's leading supplier of high-performance systems to characterize particles, powders and porous materials with a focus on physical properties, chemical activity, and flow properties. Our industry-leading technology portfolio includes: pycnometry, adsorption, dynamic chemisorption, intrusion porosimetry, powder rheology, activity testing of catalysts, and particle size.

The company has R&D and manufacturing sites in the USA, UK, and Spain, and direct sales and service operations throughout the Americas, Europe, and Asia. Micromeritics systems are the instruments-of-choice in more than 10,000 laboratories of the world's most innovative companies, prestigious government, and academic institutions.

Our world-class scientists and responsive support teams enable customer success by applying Micromeritics technology to the most demanding applications.

For more information, please visit [micromeritics.com](https://micromeritics.com)