

Microactivity Effi



A Bench-top Reactor Designed for the Researcher's Needs

The Particulate Systems Microactivity Effi is a highly-advanced customizable laboratory system for measuring the activity and selectivity of catalysts. The standard platform can be easily adapted to your catalytic testing needs with a variety of configurations and options. The system is compact, completely automated, and equipped with innovative process-control technology. This enables you to program a series of experiments on a personal computer and obtain real-time results with the highest degree of reproducibility and accuracy.

The Microactivity Effi has been developed to help save time and resources at both the catalyst development stage and the factory report process during screening. It can accommodate a wide variety of reactions. Patented control systems have been specifically developed for this equipment, providing the ability to operate on a micro-scale. The Effi performance is like no other system available on the market with micro-flow rates operating in a wide range from tens of mL/min to liters/min.

Major Design Features

PID Effi Features	Design Benefits
Quasi-Zero Dead Volume	Recovery of gas and liquid products in almost realtime
Temperature-Controlled Hot Box	200 °C closed hot box system avoids liquid condensation
Automatic Level Measurement	Patented capacitance level sensor with less than 1-cc dead volume
Accurate Pressure and Level Control	Patented high-precision micrometric servo-controlled valves
Ceramic Fiber Furnaces	Very low thermal inertia reactor furnaces go to 1050 °C
Distributed Control Ethernet Communication	Remote controlled automated and programmable reactor system

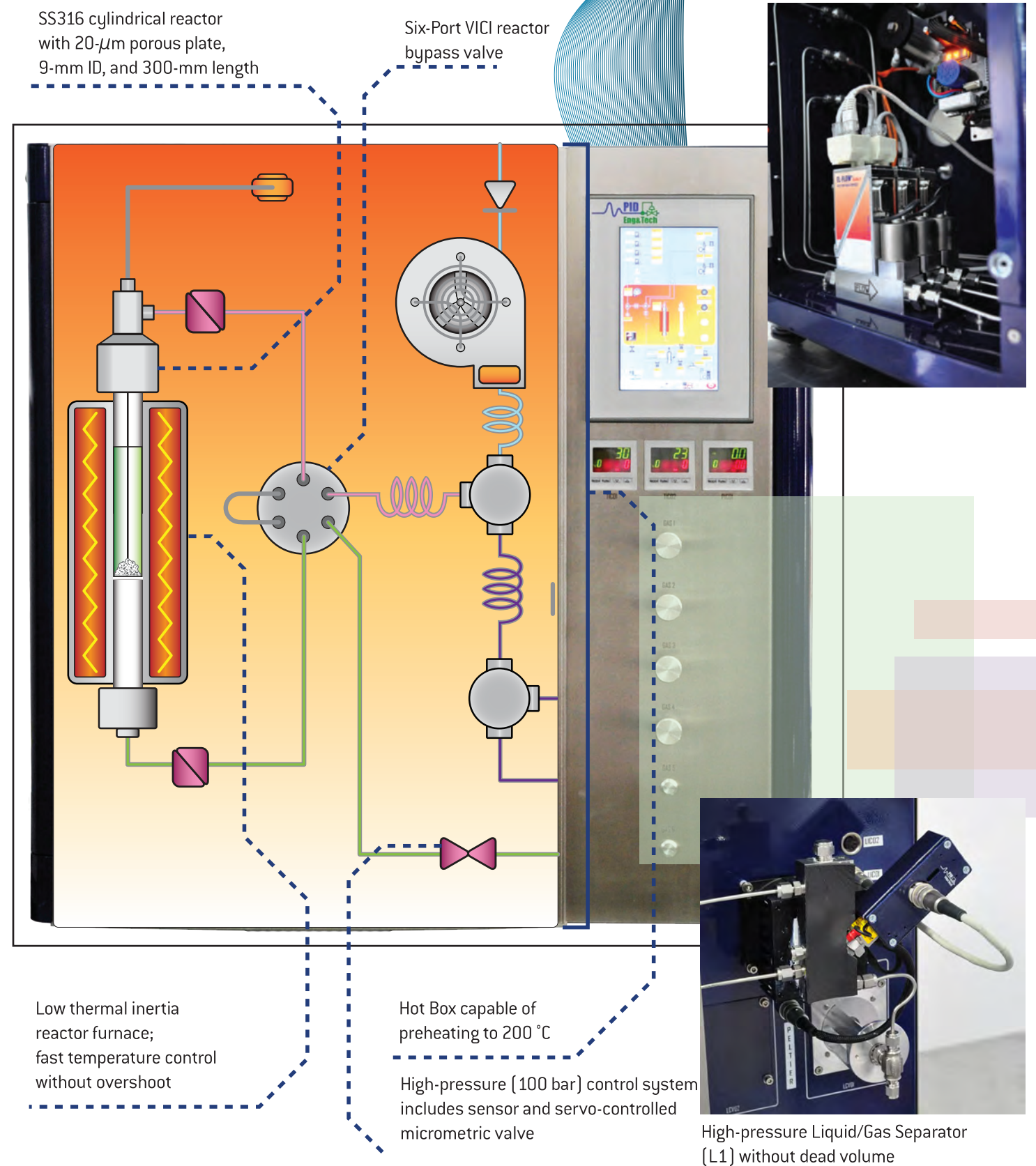
Example Reaction Types

- Hydrocracking
- Hydrotreating
- Isomerization
- Hydrogenation
- Hydrodesulfurization (HDS)

- Hydrodenitrogenation (HDN)
- Oxidation
- Reforming
- GTL (Fischer-Tropsch)

Effi Basic Unit Configuration

Each Effi comes equipped with the following configurations and options:



Effi Twin Configuration

The Effi Twin configuration provides the same features as the Effi basic unit with the addition of a second furnace and reactor. The twin configuration offers both parallel and series operation that can be switched with the activation of a selection valve.

Parallel Operation

Since the Effi Twin configuration includes identical but separate hardware for each reactor, true parallel operation can be achieved. Both reactors are housed in the same Hot Box. However, independent furnaces allow for each reaction to be controlled at different temperatures. The exact composition of reactant streams going into each reactor is known because dedicated mass flow controllers and HPLC pumps are used; there is no feed-splitting involved. The use of a second Liquid/Gas separator and isolated gas exhaust lines prevent mixing of both liquid and gaseous products between product streams. A true mass balance for each reaction can be obtained allowing excellent results.

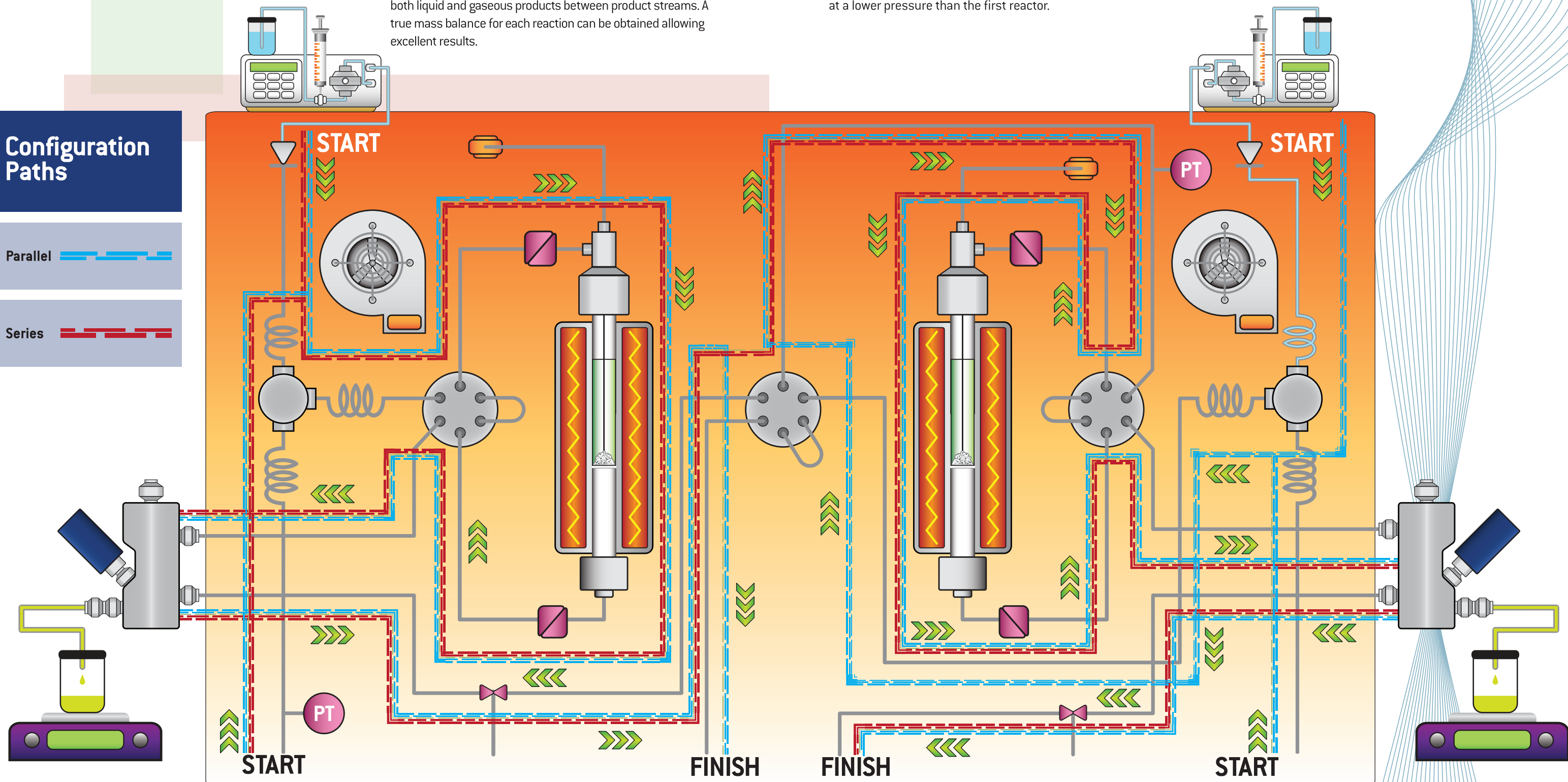
Series Operation

Simply activate the Parallel/Series selection valve to transform two parallel reactors into a series of reactors. When series mode is activated, the products from the first reactor are used as reactants for the second reactor. For example, you can load the first reactor with an alumina-supported cobalt catalyst for desulfurization of a natural gas feed stock and the second reactor with a platinum or nickel catalyst for hydrogenation of the desulfurized hydrocarbon feed. If applicable, the separate pressure control systems allow the second reactor to operate at a lower pressure than the first reactor.

Configuration Paths

Parallel 

Series 



Available Options



Mass flow meter on gas outlet

Completes the mass balance on the reaction system

Additional mass flow controllers for gas feed (six total)

Flexibility for inlet gas types and flow rates



Six-port valve for Liquid/Gas separator bypass

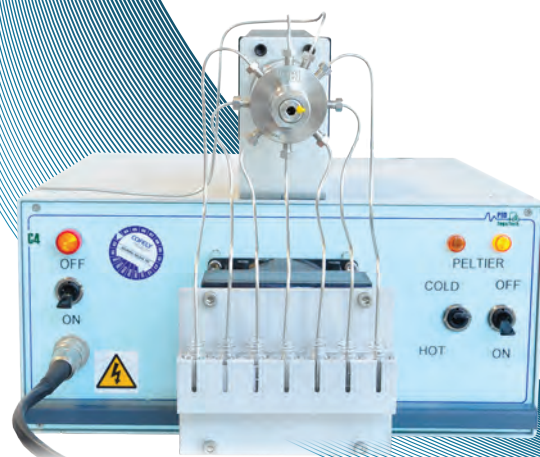
When condensable products are not produced

Six-port valve for up/down reactor flow selection

For liquid phase reactions; excellent liquid/solid interaction

Wax trap for heavy hydrocarbon collection at reactor outlet

Prevents condensation of paraffins and waxes downstream of the reactor



Liquid product multisampler; collects and cools eight samples
Analyze liquid product composition as a function of time

Syringe pump for microliter liquid injections

Dose catalytic promoters or other additives at rates down to 0.05 $\mu\text{L}/\text{min}$

Up to two HPLC pumps for liquid feed (0.01 mL/min – 5 mL/min)
Water, alcohols, hydrocarbons, among other solvents

HPLC pump heating system (up to 90 °C) for viscous liquids
Improves flow rate of heavy liquids into reactor

One or two liquid evaporators with temperature control up to 400 °C
For high liquid flow rates and viscous liquid feeds

Liquid/Liquid/Gas separator
For separating non-miscible liquid products

Digital scale for weighing liquid products in realtime
Know the exact rate of liquid product production

OPC Server documentation
Monitor and record Process@ operation from company network



Reactors

Each Effi is equipped with a SS316 reactor with a 9-mm inner diameter. A porous support plate (20 μm) retains the catalyst bed within the isothermal zone of the furnace and also

minimizes dead volume. The tip of the thermocouple is fixed 5 mm above the porous plate inside the catalyst bed for excellent temperature control.

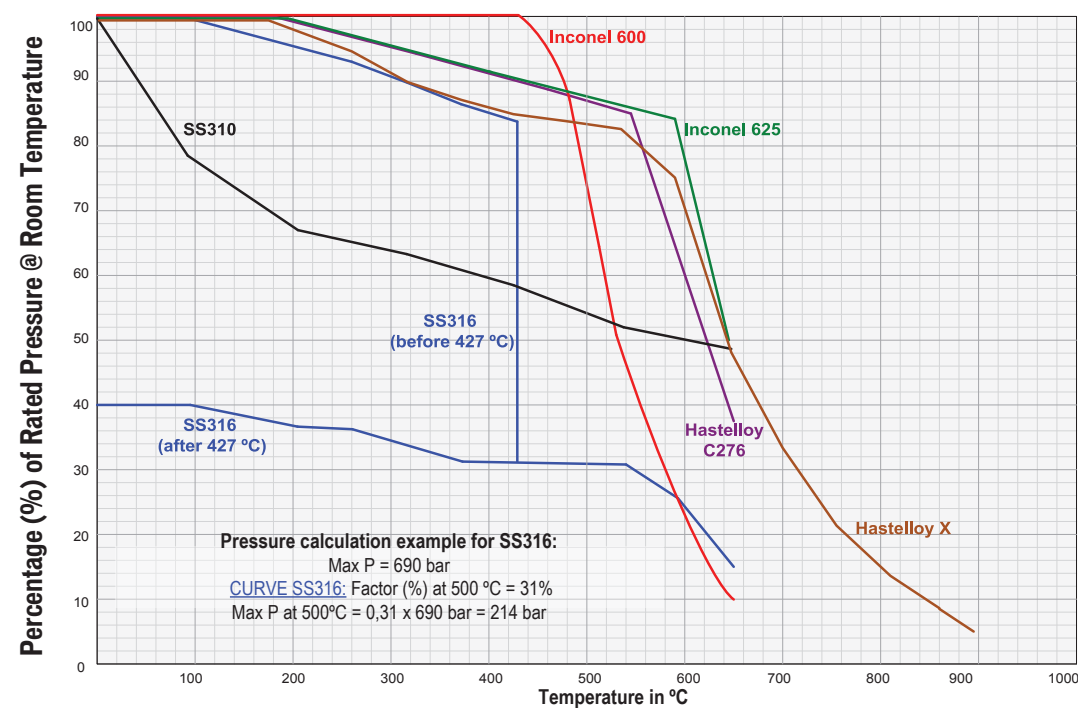
Additional reactors forged from other alloys are available:

Alloy Type	Ni	Mo	Cr	Fe	W	Nb+Ta	Mn	Co
SS316	10.5 - 13.5%	2.5%	16.5 - 18.5%	BAL				
Hast X	47%	9%	22%	18%				1.5%
Hast C276	55%	15 - 17%	14.5 - 16.5%	4 - 7%	3 - 4.5%			
Inconel 600	72		14 - 17%	6 - 10%				
Inconel 625	58% min	8 - 10%	20 - 23%	5% max		3.2 - 4.2%		
SS310	19 - 22%		24 - 26%	BAL			2%	

A quartz reactor is available for ambient pressure reactions up to 1050 °C.

	SS316	HAST C276	HAST X	INCONEL 600	INCONEL 625	SS310
MAX. TEMPERATURE [°C]	800	1093	1200	1212	980	1100
MAX. PRESSURE [BAR]	690	418	617	356	827	441
P[BAR]@500 °C	214	364	525	243	728	262
P[BAR]@650 °C	104	155	308	36	414	241
P[BAR]@790 °C			100			

Pressure Vs. Temperature Rating Curves

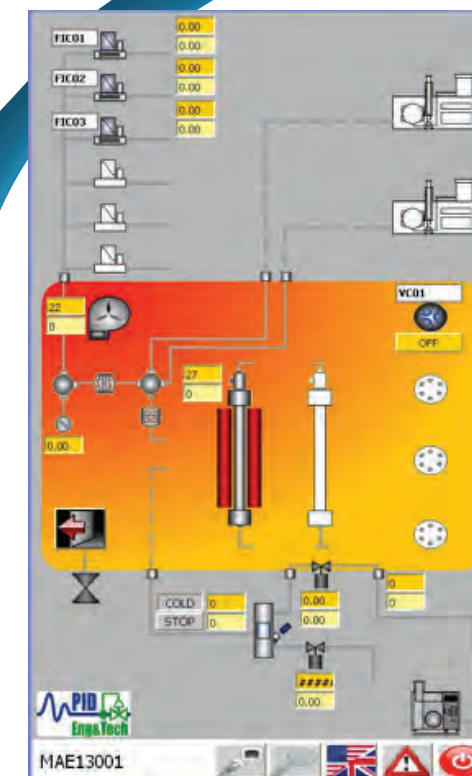


Larger volume reactors are available in the illustrated sizes (inner diameter)



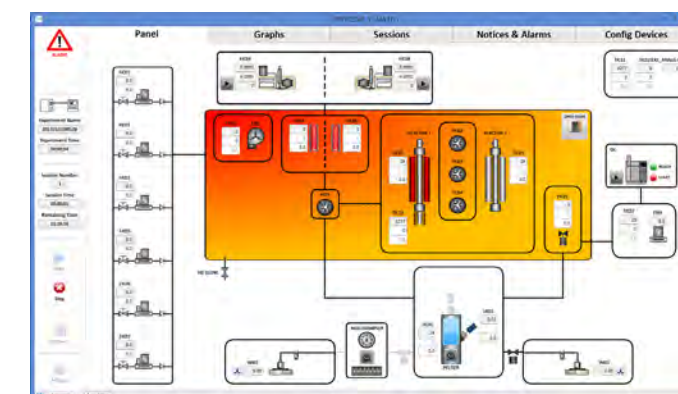
The Touch Screen

All devices in the Effi system can be controlled via the PLC touch screen on the front of the unit for easy manual operation. The touch screen is also used to configure safety alarms.



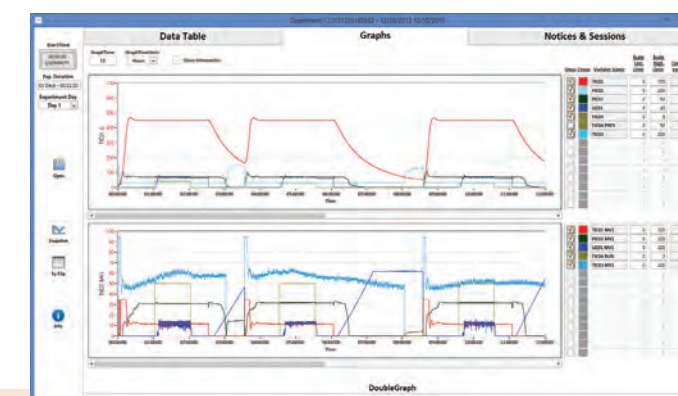
Process@ Software

Fully interactive software allows for easy device management and programming of reaction sequences. The main panel provides easy control and monitoring of process values. A session table is created with specific control of each instrument device at desired time increments. Conditional statements can be used to save time and keep reactions running efficiently. Process and control values are plotted in realtime for complete monitoring of current reaction conditions.



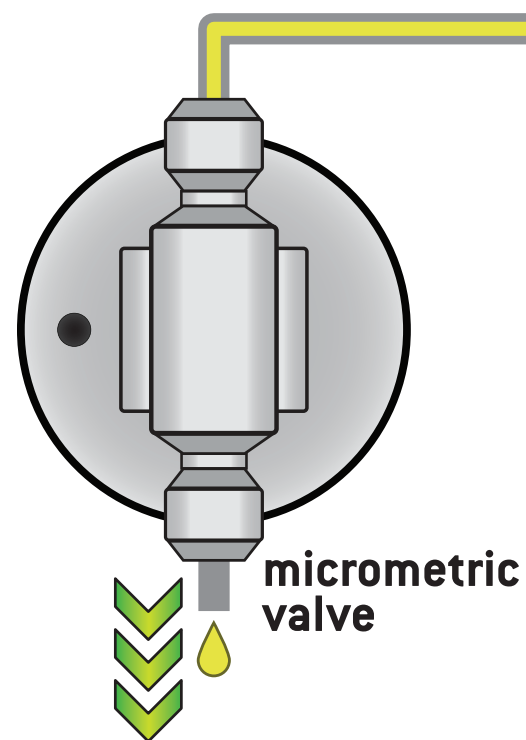
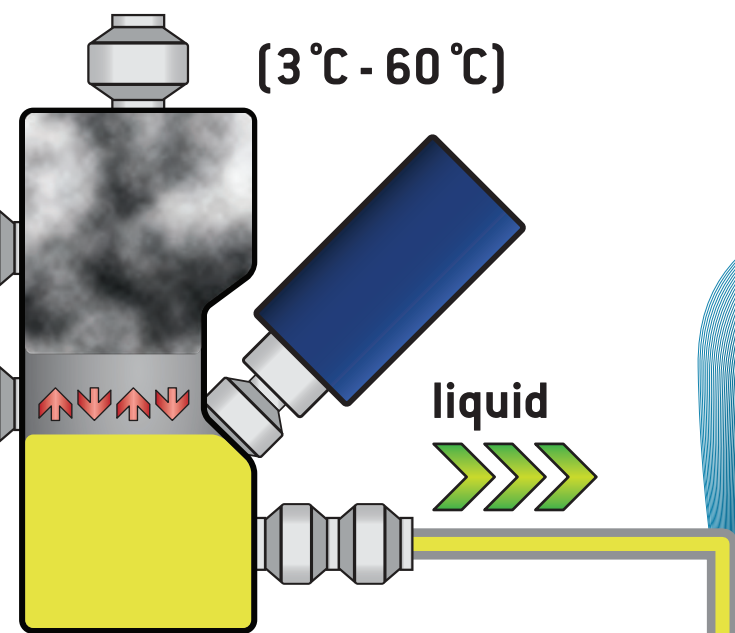
Experiment Viewer

All process and control data collected during each reaction can be opened later and plotted using the Experiment Viewer tool. Data can be exported to Microsoft® Excel for further data reduction.



Liquid/Gas Separator (L1)

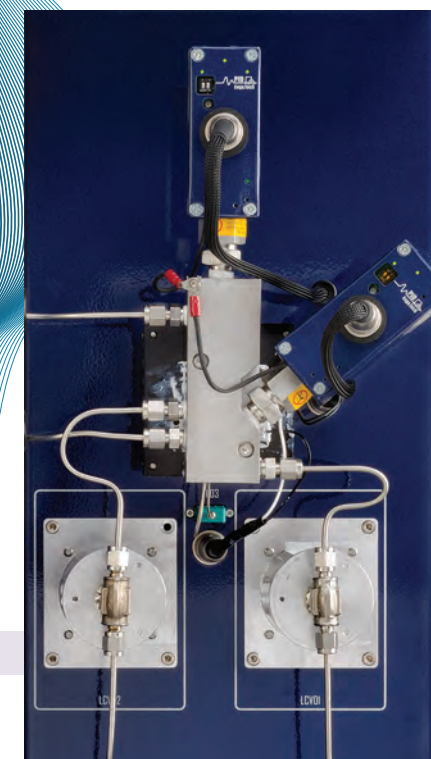
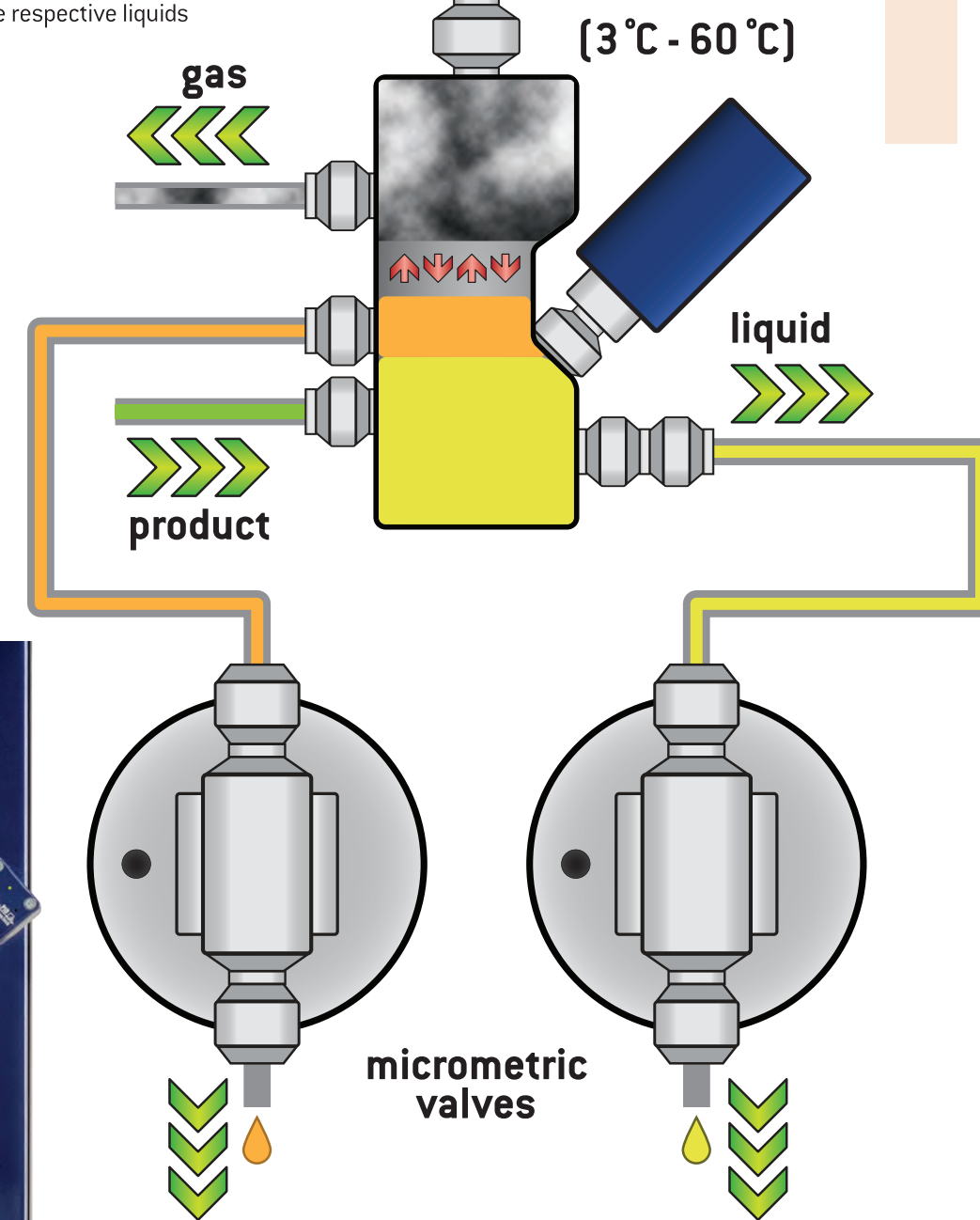
- Low-volume (1 mL) Liquid/Gas separator condenses vaporous products formed during the reaction and pumps them out for further analysis
- Equipped with temperature-controlled Peltier cell that can operate in a range from 3 °C – 60 °C
- Patented capacitive level sensor based on the dielectric constant of the liquid to measure the volume of the liquid in the cell within ± 0.1 mL
- Precision micrometric valve opens to release a few drops of liquid product at a time as the volume of the liquid increases while maintaining a hydrostatic seal, maintaining the high pressure of the system
- Liquid/Gas separator is easily accessible from the side of the Effi
- Digital scale can be interfaced with the unit to record liquid production



Liquid/Liquid/Gas Separator (L2)

Some reactions generate two liquid products that are immiscible, therefore making each component in the binary system difficult to recover in real time. For example, gas to liquid (GTL) reactions (like the Fischer-Tropsch reaction) convert a syngas of CO and H₂ to water and hydrocarbons. This process requires an advanced method of recovery.

- Utilizes the same technology as the Liquid/Gas separator
- State-of-the-art design that easily recovers drops of each product as they condense
- Capacitive level sensors are calibrated based on the dielectric constant for each of the respective liquids





Physical Height: 79 cm [31.1 in.]
Width: 75 cm [29.5 in.]
Depth: 58 cm [22 in.]
Weight: 120 kg [264.6 lb]

Electrical Voltage: 220 VAC \pm 10%
Frequency: 50 to 60 Hz

Environmental Temperature: 0 °C to 40 °C [32 °F to 104 °F]
Humidity: 10% to 60%



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