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BTRS-Jr[®] - PC



**Autoclave
Engineers** 

Division of Snap-tite, Inc.

General Information

The BTRS-Jr[®]-PC is a complete reaction system for vapor phase catalyst evaluation and continuous flow process analysis. The unit is comprised of three major sections, the feed section, the heated process sections, and the control module with supervisory computer system. The majority of the process components are housed within an oven enclosure that is maintained at an isothermal temperature.

System Ratings

Operating Pressure: Atm, 30 bar, 100 bar, 200 bar (Atm, 435 psi, 1450 psi, 2900 psi)

Reactor Temperature: 75°C to 1000°C (167°F to 1832°F)

Oven Temperature: 250°C (482°F)

Dimensions

Cabinet: 117 cm (46") wide x 84 cm (42") tall x 36 cm (14") deep.

Heated Oven: 31 cm (12") wide x 61 cm (24") tall x 21 cm (8") deep.

Power: 215 to 245 VAC, 50/60 Hz, 20 Amp, Single Phase

Wetted Materials: 300 Series Stainless Steel, Teflon[®] (PTFE), Kel-F[®] (PCTFE), Kalrez[®], Nitronic[®] 60, Vespel[®] (Polyimide), Nickel alloy A-286, Incoloy-800HT, HR-160, and Quartz.

Bulkheads: Compression fittings for stainless steel tubing with nominal 3.18 mm (0.125") OD x 1.6 mm (0.0625") ID.

Filter Size: 7 micron.

Metering Valves: 18 turn, 1.19 mm (0.047") orifice, 1" stem, 0.010 CV micro metering handle.

Ball Valves: 3-way, 180° actuation for directional flow switching and shut-off.

Check Valves: O-ring seal design, 1.4 bar (20 psi) cracking pressure.

Thermocouples: Type-K (Nickel-Chromium & Nickel-Aluminum).

Tubing: 3.18 mm (0.125") OD x 1.6 mm (0.0625") ID 316 Stainless Steel Seamless tubing.

Notes:

Kel-F[®] is a registered trade name of 3M Company. In 1996, 3M discontinued manufacturing of Kel-F & today, all PCTFE resin is manufactured by Daikin under the trade name of Neoflon[®] or by Allied Signal under the trade name of Aclon[®]. Kel-F is still the most commonly used trade name used to describe PCTFE. Teflon[®] and Vespel[®] are registered trademarks of Dupont Co., Wilmington DE. Kalrez[®] is a registered trademark of Dupont Dow Elastomer, Wilmington DE. Nitronic[®] is a registered trademark of AK Steel Corporation, Middletown OH produced under license by Electralloy Div. of G.O. Carlson Inc., Oil City PA.

Autoclave Engineers, A Division of Snap-tite, Inc reserves the right to substitute an equivalent material for trademarked material. Autoclave Engineers purchases substitute materials based on specification conformance, typically a widely accepted specification created by an industry standards organization.

The customer is responsible to confirm the compatibility of process fluids (at operating temperatures) with the wetted components of the reactor.

Operating Pressure Ranges and Component Ratings

| Maximum Operating Pressure | Gauge Range/ Transducer Rating | Maximum Allowable Working Pressure | Rupture Disk Rating |
|----------------------------|--|--|-----------------------|
| 435 psi (30 bar) | 600 psi (42 bar) / 500 psi (35 bar) | 500 psi @ 1,202°F (35 bar @ 650°C) | 35 bar (500 psi)* |
| 1,450 psi (100 bar) | 2,000 psi (138 bar) / 2,000 psi (138 bar) | 1,600 psi @ 1,202°F (110 bar @ 650°C) | 110 bar (1,600 psi)* |
| 2,900 psi (200 bar) | 5,000 psi (345 bar) / 3,000 psi (207 bar) | 3,200 psi @ 1,202°F (220 bar @ 650°C) | 216 bar (3,144 psi)** |

*The listed rupture disk rating is nominal. The specification range is +6% and -3%.

** The listed rupture disk rating is nominal. The specification range is +1.5% and -0.75%.

Feed Components

Input streams are provided for four (4) reactant feeds, the reactor purge, and the GC carrier.

Reactant Feeds: Four reactant feed lines consisting of a bulkhead, inline filter, manual metering valve, manual 3-way diverter valve, and a reverse flow check valve. Each of these feeds may be used for liquid reactant.

Heated Oven Components

The heated oven contains the mixing, feed stream routing components, reactor, effluent stream routing components, and pressure control components for the system.

Mixer/Vaporizer: (*Optional*) The unit facilitates the preheating and mixing of the feeds into a homogeneous blend.

Reactor Status Valve: (*Optional*) Multi-port switching valve with 1/8" tube connections, 8-ports, 2-positions, air operator, and manual control. The reactor status valve controls the diverting of either the feed stream or the reactor purge gas through the reactor. When the feed stream is not routed through the reactor, it is routed to the effluent handling section where it can subsequently be sent to the GC. Includes reactor purge gas feed consisting of a bulkhead, inline filter, manual-metering valve, manual 3-way diverter valve, and a reverse flow check valve. The seat options for the valve are either Polyimide seat rated @ 250°C (482°F), or a Peek seat rated @ 200°C (392°F). The maximum pressure for the valve is 100 bar (1450 psi).

Notes:

1. The optional "reactor status valve" is not available on units greater than 100 bar (1,450 psi) models.
2. The Reactor Status Valve option includes a Reactor Purge circuit with inert gas.

Sample Valve: (*Optional*) Multiport switching valve with 1/8" tube connections, 8-ports, 2-positions, air operator, and manual control. The valve controls the diverting of a measured vapor phase effluent slug of either the feed stream or the reactor effluent to the GC. The seat options for the valve are either Polyimide seat rated @ 250°C (482°F), or a Peek seat rated @ @ 200°C (392°F).

(*Optional*) An isolation valve in series with a metering valve providing a Slip-Stream sample to the analytical equipment when the isolation valve is cycled open. This arrangement is located outside of the oven.

Notes:

1. If the optional Reactor Status Valve is used then the sample slip-stream will either be that of the reactor effluent or the feed stream depending on the state of the Reactor Status Valve.
2. The polyimide used in the multi-port valves has good resistance to most hydrocarbons and chemicals at 250°C (482°F). Polyimide has limited resistance to primary amines, ammonia and live steam. Contact the factory to discuss materials and process alternatives for solving compatibility problems

Tubular Reactor: The tubular reactor includes inlet filter, outlet filter and full-length internal thermowell. One reactor can be utilized in the sizes given in the table below.

Tubular Reactor

| P/N | Wetted Material | Volume | Rating | Inside Diameter | Outside Diameter | Heated Length |
|-----------|------------------------|--------|--------------------------------------|--------------------|--------------------|---------------------|
| 301B-2101 | 316 Stainless Steel | 5 ml | 2900 psi @ 1200°F 200 bar @ 650°C | 0.31" (7.9 mm) | 0.56" (14.3 mm) | 6.0" (152.4 mm) |
| 301B-2102 | | 10 ml | 2900 psi @ 1200°F 200 bar @ 650°C | 0.31" (7.9 mm) | 0.56" (14.3 mm) | 12.0" (304.8 mm) |
| 301B-2103 | | 20 ml | 2000 psi @ 1200°F 138 bar @ 650°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 6.0" (152.4 mm) |
| 301B-2104 | | 40 ml | 2000 psi @ 1200°F 138 bar @ 650°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 12.0" (304.8 mm) |
| 301B-2105 | | 100 ml | 3200 psi @ 1200°F 220 bar @ 650°C | 1.0" (25 mm) | 2.13" (54.1 mm) | 8.0" (203.2 mm) |
| 301B-2106 | | 200 ml | 3200 psi @ 1200°F 220 bar @ 650°C | 1.0" (25 mm) | 2.13" (54.1 mm) | 16.0" (406.4 mm) |
| 301B-2246 | A-286 | 20 ml | 2900 psi @ 1200°F 200 bar @ 650°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 6.0" (152.4 mm) |
| 301B-2247 | | 40 ml | 2900 psi @ 1200°F 200 bar @ 650°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 12.0" (304.8 mm) |
| 301B-2248 | Incoloy 800HT | 5 ml | 725 psi @ 1652°F 50 bar @ 900°C | 0.31" (7.9 mm) | 0.56" (14.3 mm) | 6.0" (152.4 mm) |
| 301B-2249 | | 10 ml | 725 psi @ 1652°F 50 bar @ 900°C | 0.31" (7.9 mm) | 0.56" (14.3 mm) | 12.0" (304.8 mm) |
| 301B-2250 | | 20 ml | 725 psi @ 1652°F 50 bar @ 900°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 6.0" (152.4 mm) |
| 301B-2251 | | 40 ml | 725 psi @ 1652°F 50 bar @ 900°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 12.0" (304.8 mm) |
| 301B-2252 | | 100 ml | C/F | 1.0" (25 mm) | 2.13" (54.1 mm) | 8.0" (203.2 mm) |
| 301B-2253 | | 200 ml | C/F | 1.0" (25 mm) | 2.13" (54.1 mm) | 16.0" (406.4 mm) |
| 301B-2254 | HR-160 | 5 ml | 90 psi @ 1000°F 6.2 bar @ 1832°C | 0.31" (7.9 mm) | 0.56" (14.3 mm) | 6.0" (152.4 mm) |
| 301B-2255 | | 10 ml | 90 psi @ 1000°F 6.2 bar @ 1832°C | 0.31" (7.9 mm) | 0.56" (14.3 mm) | 12.0" (304.8 mm) |
| 301B-2256 | | 20 ml | 90 psi @ 1000°F 6.2 bar @ 1832°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 6.0" (152.4 mm) |
| 301B-2257 | | 40 ml | 90 psi @ 1000°F 6.2 bar @ 1832°C | 0.52" (13.1 mm) | 0.75" (19.1 mm) | 12.0" (304.8 mm) |
| 301B-2258 | | 100 ml | C/F | 1.0" (25 mm) | 2.13" (54.1 mm) | 8.0" (203.2 mm) |
| 301B-2259 | | 200 ml | C/F | 1.0" (25 mm) | 2.13" (54.1 mm) | 16.0" (406.4 mm) |
| 301B-2260 | Quartz | 5 ml | Atm @ 1832°F 0 bar @ 1000°C | 0.24" (6.1 mm) | 0.38" (9.65 mm) | 6.0" (152.4 mm) |
| 301B-2261 | | 10 ml | Atm @ 1832°F 0 bar @ 1000°C | 0.24" (6.1 mm) | 0.38" (9.65 mm) | 12.0" (304.8 mm) |

The standard end fitting of the tubular reactor is equipped with an unused (plugged) connection. It can be used to feed liquids (trickle feed) directly to the reactor through a dedicated line that bypasses the mixer/vaporizer assembly.

The reactor tubing configuration creates downward flow, i.e. in the top and out the bottom unless otherwise specified. Pre-bent tubing to produce reverse reactor flow (upward) is included as loose parts with the system.

Pressure Gauge: Isolator - 316 SS, silicon fluid filled (located in heated oven).

Gauge - 63.5mm (2-1/2") diameter face, dual scale psi...bar (located on front panel).

Transducer - Accuracy of +/- 0.13% of full scale at constant temperature.

Back Pressure Regulator: Electronic back pressure regulator used to provide automated closed-loop control of system pressure. The pressure portion is located in oven. The electronic back pressure regulator is not bubble tight.

Gas/Liquid Separator: *(Optional)* The gas/liquid separator is located on the outlet of the reactor before the back pressure regulator outside of the oven. Level control of the liquid hold-up is accomplished via a manual metering valve and a manual ball valve, or optional automatic control for draining to a collection tank. The volume of the separator vessel is 150 ml.

Separator Options:

- Ambient with no temperature control provided.
- Circulator Ready with a 1/4" copper tubing wrapped around the outside of the separator with bulkheads provided for connection to a Heater/Chiller unit.
- Electric heater for temperature control up to 204°C (400°F)

Heated Transfer Line: *(Optional)* The heated transfer line connects the sample valve to a GC. It ensures a complete sample arrives at the GC by delivering it at elevated temperature to prevent any condensation. Optional heated transfer lines can be used to connect between components outside of the oven and maintain higher temperature operation.

- Length: 1.83 m (6 feet)
- Inside Diameter: 0.027" (0.69 mm)
- Max Temp: 300°C (572°F)
- GC Adapter: Universal needle nut assembly including needles, septa, nut & ferrule.

Control System Operation

The control system utilizes Wonderware HMI software running on a standard PC. The HMI has five main screens used to operate the system: Overview, Recipe, History (1 and 2), and Alarm/Event Summary. To display any of the screens simply click on the pushbutton at the top of the screen. All of the screens and their function will be discussed in this section.

System Overview Screen (Fig. 1 and 2)

The Overview Screen shows the system status at a glance. Where possible the System Overview screen mirrors the P&ID drawing. The overview screen has four parts: The top menu, Process and Instrumentation Diagram, Alarm section, and the selectable sub windows.

Figure 1: System Overview

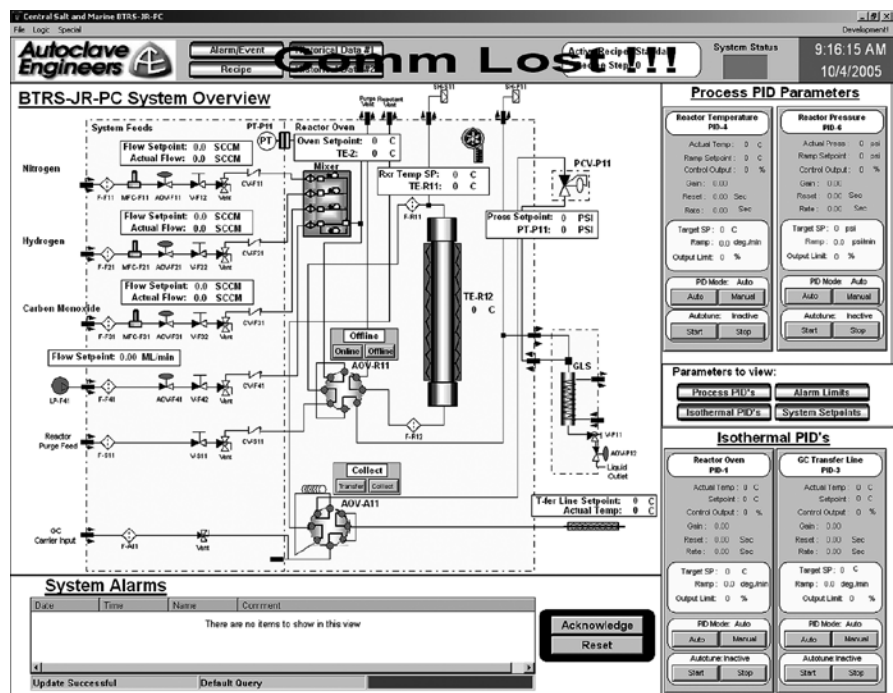
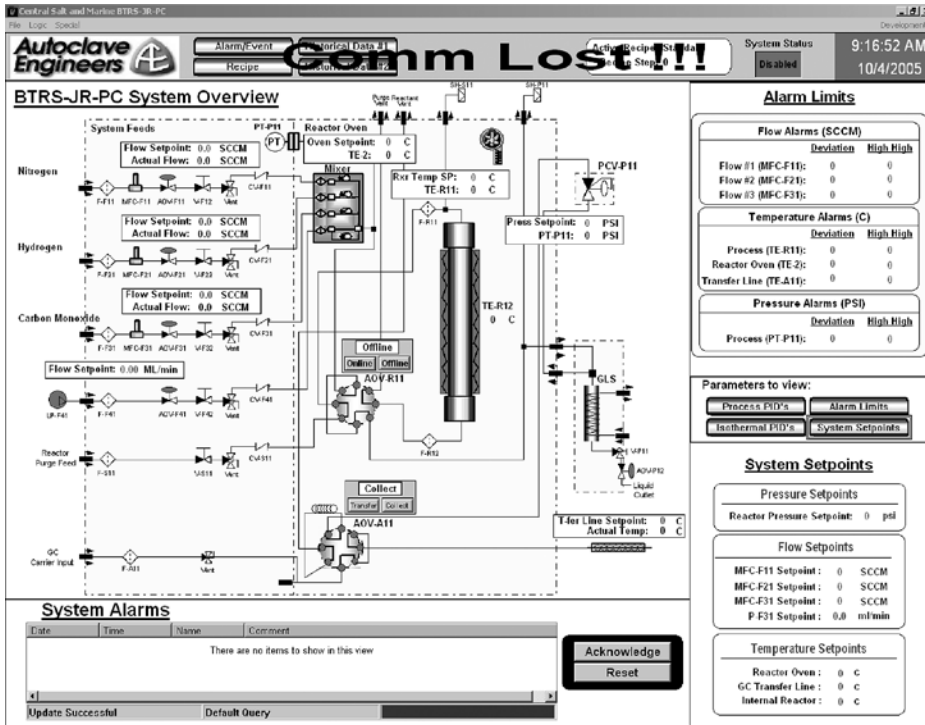


Figure 2: System Overview with Sub Windows



Top Menu

The top menu covers the upper 10% of the screen. It contains the navigation push buttons to open any of the four system windows. Also displayed is the time and date as well as recipe status information.

Process and Instrumentation Diagram

- Open valves and active pumps are displayed green, closed valves and inactive pumps are dark gray.
- Vessel furnace elements turn red when the corresponding furnace contactor is closed by the PLC.
- All process values are displayed in blue text. Operator adjustable values are in dark green text.
- **GC Ready:** This indicator will become visible when the GC signals a ready indication.
- **GC Trigger:** This indicator will become visible when the BTRS-JR-PC has sent a signal to the GC to prepare for injection.
- **Reactor Status Valve:** This icon shows the current flow path through the Reactor Status valve. To change the valve position, press the Online/Offline push button.
- **Reactor Sample Valve:** This icon shows the current flow path through the Reactor Sample valve. To change the valve position, press the Transfer/Collect push button. Clicking on the valve icon will open the BTRS-JR-PC Sample Screen.
- **Gas Liquid Separator (GLS):** Clicking on the GLS icon opens the “BTRS-JR-PC GLS” window. On this screen you can place the GLS in auto mode using the “GLS Auto/Manual Mode” push button. The operator can also enter the GLS Drain time and GLS Drain Interval.
- **Air Operated Valves (AOV):** Clicking on any of the AOV icons opens the “BTRS JR PC Override” screen. This screen has 3 position switches for each valve which are On, Automatic, and Off.

Alarm Section

The lower portion of the HMI screen is dedicated to alarm indication. Up to four alarms can be displayed simultaneously. If there are more alarms a scroll bar is used.

Sub Windows

There are four selectable sub windows on the Overview screen. They are: Process PID's, Isothermal PID's, Alarm Limits, and System Setpoints. These sub windows are on the right side of the screen and are selected using the “Parameters to view” push buttons.

Process and Isothermal PID (Proportional, Integral, Derivative)

These sub-windows contain the system PID parameters as well as the setpoints and ramp rates.

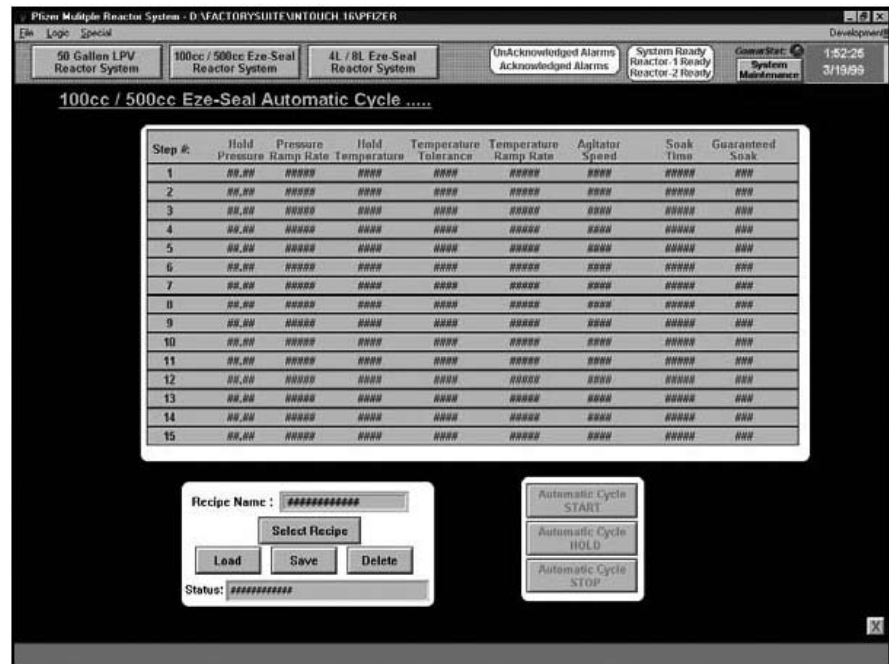
System Setpoints

The System Setpoints sub window displays all flow, temperature and pressure setpoints and allows the operator to set them from one convenient location.

Recipe Screen (Fig.3)

The system recipe is a method for performing, storing, and retrieving commonly used sequences. All setpoints and ramp rates can be controlled allowing the operator to bring the system to the desired operating conditions, perform the run, and return the system to ambient conditions automatically.

Figure 3: Recipe



The recipe screen is divided into five blocks: Recipe status, Start/Stop, Recipe Block, Recipe Sequence, and Load/Save.

Recipe Status Block

The recipe status block is located at the top of the recipe window. It contains the following information: Active recipe name, Active Recipe Step, Dwell Time Remaining, Current Recipe Number.

Recipe Start/Stop Block

When the recipe start push button is pressed, the recipe listed in the Recipe Sequence block next to "Recipe1 Name" will be run.

Main Recipe Block

The recipe block located on the recipe screen contains ten discrete steps. The recipe will begin with step one and, when the requirements of that step have been fulfilled, will move on to step two and so on. If a step with zero in the dwell time and transition time is reached the current recipe will stop and the next recipe in sequence will be loaded.

The temperature, pressure, and flow setpoints are self-explanatory. Simply click on the desired setpoint and enter the value.

Transition minutes: This is the desired time for the pressure and temperature to reach setpoint. i.e. if the current temperature is 20 deg. and the temperature setpoint is 80 deg. and the transition time is 60 minutes the temperature setpoint will ramp from 20 to 80 at one degree a minute.

Dwell Time: This value controls how long the system will hold once the pressure and temperature setpoints have been reached. To start the dwell timer, the reactor pressure and temperature Process Variables must reach their respective setpoints.

Rxr Status Valve: The reactor status valve can be either online or offline for the duration of the step.

Recipe Sequence Block

In addition to the ten recipe steps displayed on the screen, up to ten recipes may be run sequentially. These are labeled recipe 1 through 10 in the recipe sequence block. To load a recipe simply click on the gray box to the right of the recipe name and select the recipe from the list.

Recipe Load/Save Block

Commonly used recipes can be stored and retrieved for later use.

Alarm/Event Summary Screen

The Alarm/Event summary screen is accessed by pressing the “Alarm/Event” push button on the top menu. This screen displays all system alarms with a time and date stamp along with valve opening and closing times.

History Screen (Fig. 4)

The Historical Trend screens are accessed by pressing the Historical Data push buttons on the top menu. Using this screen the operator can access all logged variables (T/C values, pressure transducer values...) for the last 60 days.

To save the chart in a .CSV format, click on the file name box and enter a unique file name. Press the Save To File push button and the file will be saved.

The Historical trend can be used as a real time trend by pressing the “Auto update” push button.

Figure 4: History



Optional Equipment

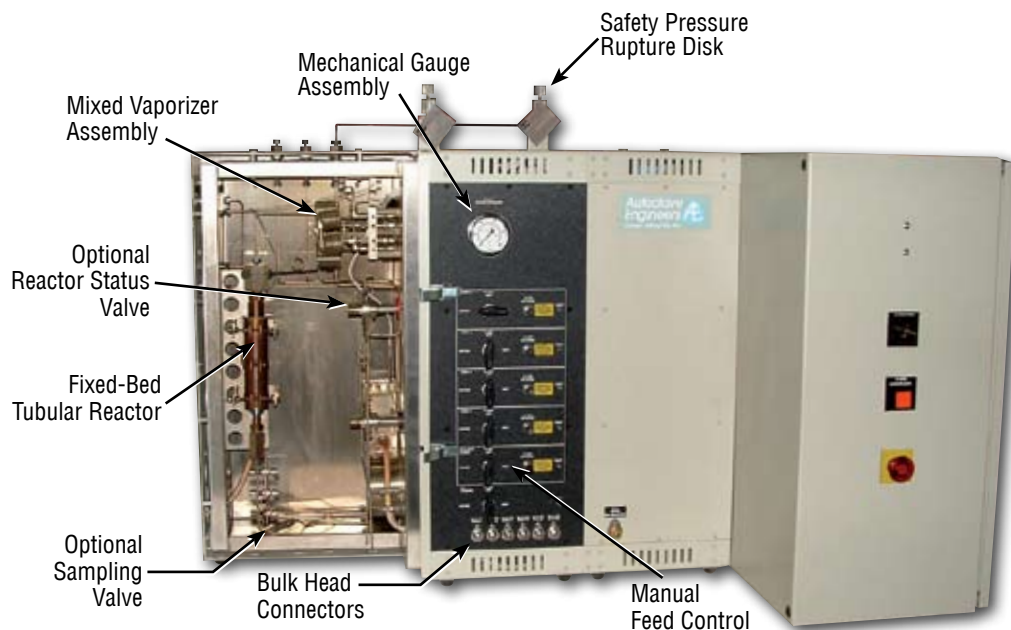
Mass Flow Controllers: Up to four mass flow controllers can be housed within the module. The limits for the flow controllers are 200 bar (2900 psi) and 10,000 sccm (610 in³/min).

- MFC-1: Gas: _____
Pressure: _____ bar
Flow rate: _____ sccm
- MFC-2: Gas: _____
Pressure: _____ bar
Flow rate: _____ sccm
- MFC-3: Gas: _____
Pressure: _____ bar
Flow rate: _____ sccm
- MFC-4: Gas: _____
Pressure: _____ bar
Flow rate: _____ sccm

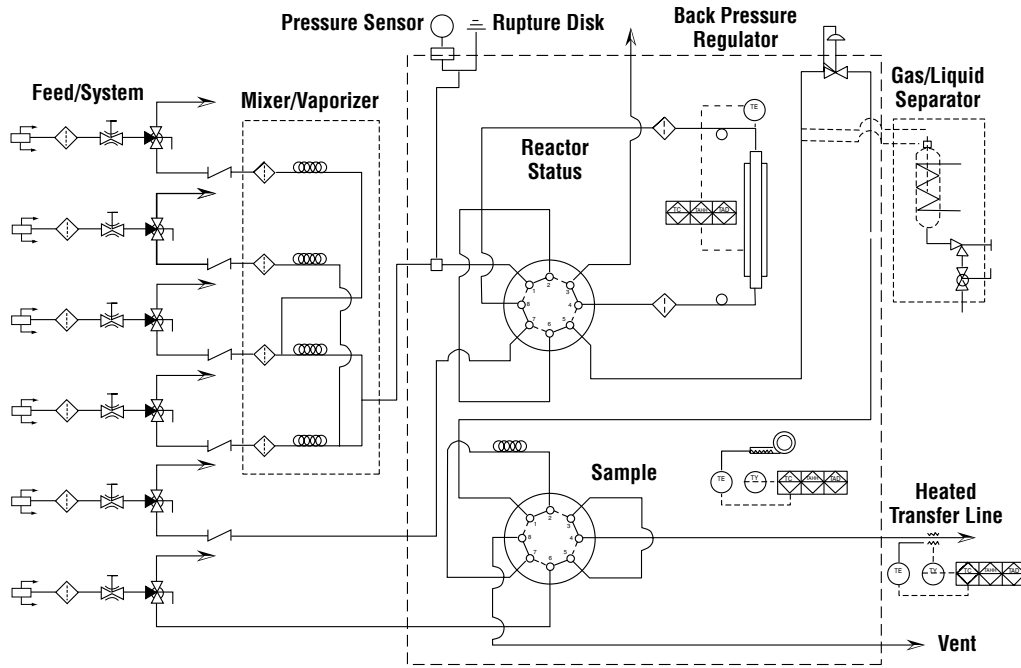
Liquid Pumps: High Pressure Liquid Pumps can be added to the BTRS-Jr[®]-PC. These pumps generate high pressure with accurate flow. The pumps have a maximum pressure of 400 bar (5,800 psi) at up to 10 ml/min, 100 bar (1450 psi) at up to 40 ml/min, and 50 bar (725 psi) at up to 80 ml/min.

- Pump-1: Gas: _____
Pressure: _____ bar
Flow Range: _____ mL/min
- Pump-2: Gas: _____
Pressure: _____ bar
Flow Range: _____ mL/min

General Arrangement



Flow Schematic



BTRS-JR-PC

A B C D E F G H J K L

Part Number Example: **BTRS-JR045005SS01211542** (See chart below)

Ordering Guide

| A - Base BTRS-Jr [®] | | F - Sample Valve | |
|-------------------------------|---------------------|---------------------------|--|
| 045 | 450 psi (30 bar) | 0 | No |
| 145 | 1450 psi (100 bar) | 1 | Slip Stream |
| 290 | 2900 psi (200 bar) | 2 | Multi-Port |
| B - Reactor Size | | G - Heated Transfer Line | |
| 005 | 5 ml | 0 | No |
| 010 | 10 ml | 1 | Yes |
| 020 | 20 ml | | |
| 040 | 40 ml | | |
| 100 | 100 ml | | |
| 200 | 200 ml | | |
| C - Reactor Material | | H - Gas/Liquid Separator | |
| SS | 316 Stainless Steel | 0 | Ambient & Manual Drain |
| A2 | A-286 | 1 | Ambient & Timed Drain |
| HT | Incoloy 800 HT | 2 | Circulator Ready & Manual Drain |
| HR | HR-160 | 3 | Circulator Ready & Timed Drain |
| QU | Quartz | 4 | Heated to 400°F (204°C) & Manual Drain |
| | | 5 | Heated to 400°F (204°C) & Timed Drain |
| D - Mixer/Vaporizer | | J - Mass Flow Controllers | |
| 0 | No | 0 | None |
| 1 | Yes | 1 | 1 Mass Flow Controller |
| | | 2 | 2 Mass Flow Controller |
| | | 3 | 3 Mass Flow Controller |
| | | 4 | 4 Mass Flow Controller |
| E - Reactor Status Valve | | K - Liquid Pumps | |
| 0 | No | 0 | None |
| 1 | Yes | 1 | 1 Liquid Pump |
| | | 2 | 2 Liquid Pumps |



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Bulletin BTRS-Jr-PC

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