Biotage® Endeavor™

User Manual

Biotage®

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User Manual

CONTENTS

Introduction

This manual is designed to help users become familiar with Biotage® Endeavor™, its components and related equipment, and how to use the system to collect, display, print, and save data.

Endeavor provides a platform for catalyst screening and the optimization of pressure chemistry. It enables users to adopt a single and consistent platform for parallel chemistry throughout the process.

Endeavor allows users to run pressurized reactions without intervention. It automatically controls the temperature and pressure of individual reactor vessels (RVs) and ends reactions by purging, venting, or quenching.

Chapter 1 provides an introduction to the Endeavor system and its capabilities.

Chapter 2 contains important safety information and requirements.

Chapter 3 gives an overview of the Endeavor system in preparation for the more specific details described in subsequent chapters, and includes system specifications.

Chapter 4 explains the pre-installation requirements.

Chapter 5 explains the Endeavor control panel operation and the computer interface.

Chapter 6 describes how to prepare the hardware components for a run, and how to set up a run using the Endeavor control panel.

Chapter 7 shows how to view the run in progress as well as saved data from previous runs.

Chapter 8 provides care and maintenance instructions.

Chapter 9 lists troubleshooting procedures along with suggested remedies for errors or other problems you may encounter while running the Endeavor system.

Appendix A contains a glossary of terms and abbreviations.

Appendix B contains an installation checklist to ensure the facility is prepared for installation and the installation is performed correctly.

Appendix C gives technical information and details on chemical compatibilities.

Appendix D describes the Endeavor Advanced Software and its use.

Appendix E contains instructions for using and maintaining the ball valves.

Appendix F lists the parts and consumable items used in the Endeavor instrument.

Patent License

Seller is selling the system (defined below) to Buyer under license from Symyx Technologies, Inc., Santa Clara, CA ("Symyx"), the owner of certain Licensed Patents (protected by WO00/09255 and foreign equivalents).

Biotage® Endeavor™ Overview

Warning

» Endeavor is designed to be used for potentially hazardous chemical reactions. The potential hazards of chemical reactions include but are not limited to burns, explosions, and exposure to toxic chemicals and carcinogens. Always wear eye protection, suitable gloves, and appropriate clothing. Operate the instrument in a fume hood.

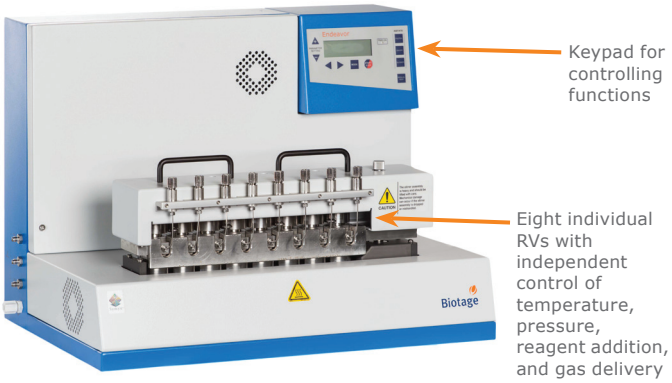

Figure 1. The Endeavor Catalyst Screening System.

Endeavor allows users to perform up to eight chemical reactions in parallel. The unique design of the system incorporates heating, stirring, and the inert environment needed for catalytic chemistry. The system's ease of use and intuitive operation allow new users to quickly integrate the system into their chemical research and development.

Endeavor consists of a compact reactor unit, equipped with precise control of gas flow to each of its eight RVs, and injection ports allowing the addition of reagents while the RVs are under pressure.

All parameters can be easily programmed using the simple control panel. Alternatively, a personal computer (PC) can be used in conjunction with the Endeavor Basic Software to record and display data as reactions take place. Figure 2 shows an example of a mole consumption curve for all eight RVs. Similarly, a PC can be used with the Endeavor Advanced Software to program the Endeavor instrument, in addition to recording and displaying data.

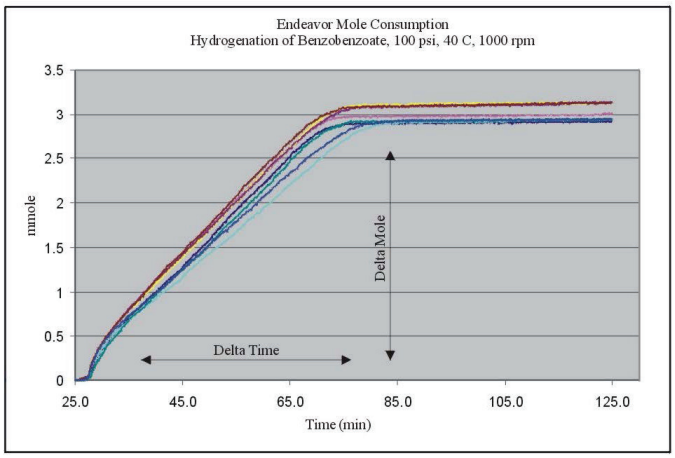

Figure 2. A typical mole consumption curve.

Safety

This chapter discusses safety issues related to the operation and use of the Endeavor system. All safety information should be read carefully before attempting to operate the system.

Safety Notices

Safety notices in this manual appear in the form of Notes, Cautions, and Warnings. Users should pay careful attention to these notices to help ensure safety and the proper function of the Endeavor instrument. Each notice implies a particular level of observation or an action as described below:

Note: Calls attention to information that should be followed during installation, use, or servicing of the Endeavor instrument or software program.

Caution

» Indicates potentially hazardous situations which, if not avoided, could result in minor or moderate injury and mechanical damage or loss of data. Cautions are also used to alert the user against unsafe practices.

Warning

» Used whenever an action or condition might potentially cause serious personal injury or loss of life. Mechanical damage could also result.

Labels Used on the System

The following labels are used on the system.

Label	Description
CE	In accordance with all essential requirements of all applicable European product directives. See the Declaration of Conformity document.
	This label indicates that the Endeavor system is ubject to the Waste Electrical and Electronic Equipment (WEEE) Directive; see "WEEE Compliance statement" on page 5.
	This label indicates a warning or caution. Consult accompanying user documentation.
	This label indicates a hot surface. Use caution when working on or near locations with this symbol. One of these warning labels is located on the base of the unit. When heating, the reactor vessels (RVs) and stirrer assembly are unsafe to touch. Allow these locations to cool before attempting to remove the stirrer assembly or touching the RVs.
	Earth ground. This label located inside the power input module indicates service access only.

Safety Class

This equipment is designed and manufactured in accordance with the requirements for laboratory instruments.

System Safety

During operation of the Endeavor system, hazardous chemicals are stored and manipulated, high pressure is generated, and high voltage electricity is used. The Endeavor system has been designed to deal with these inherent safety concerns. Following are some of the specific safeguards that have been implemented to enhance safety during system operation.

Emergency Stop Switch

To stop all system operations, press the *Manual Vent* button on the lower right of the control panel. This button vents all gas out of the RVs and manifold and turns off heating and mixing. This is intended as an emergency stop procedure and may result in contamination of the manifold by solvent and cross-contamination of the RVs, especially when the system is at high temperature.

Similarly, the red *Abort* button in the Endeavor basic or advanced software performs the same function as the *Manual Vent* button on the control panel.

Warning

» Turning off the power will not stop chemical reactions nor prevent the buildup of pressure associated with some chemical reactions. To stop the processes manually, press the *Manual Vent* button.

Mixing
Impellers provide mixing during operation. To stop stirring at any time, press the agitate *On/Off* button.

Injection Ports
The standard check valve style injection ports are intended for liquid injections only. For injection of slurries, see “Appendix E: Ball Valves” on page 57.

Warning

- Injecting solids into this system may result in clogging of the check valve and gas leaking out of the RV.
- For systems equipped with the ball valve style injection ports, always check that the valve is in the horizontal closed position before using the system and when the system is not in use. Always close the ball valve before removing the needle when performing an injection, otherwise gas leakage from the RVs will occur.

Instrument Venting
Endeavor has 1/4-inch vent tubing which must be rigidly secured to an appropriate laboratory ventilation system.

The ventilation system must be equipped with necessary fire precautions and gas treatment because all reaction gases are vented through this tube, including flammable and toxic gases.

Warning

- Failure to connect the Endeavor system to an adequate ventilation system may result in instrument damage, explosion, and personal injury.

Instrument Ventilation
In the event of a gas leak, flammable and toxic gases may be released. The instrument should be operated in an environment with adequate ventilation. A fume hood or similar environment with an air flow greater than 100 cubic feet per minute is recommended.

RV Temperature
The RVs are designed to maintain an inert seal at or below 200°C. Raising the temperature above 200°C will jeopardize seal integrity and may cause venting of the reaction and loss of reagent or solvent.

RV Pressure
Do not exceed 500 psi (≈ 34 bar) operating pressure for any RV.

The RVs are rated to 1450 psi (≈ 100 bar). For specifics on calculating the rating of a pressure vessel, please refer to page 18 of the “Pressure Vessel Handbook” by Eugene F. Megysey, Eleventh Edition, 1998.

Gas Inlet Pressure
Do not exceed 520 psi (≈ 36 bar) pressure for any of the three inlet gases to the Endeavor. Gas at pressures above 520 psi (≈ 36 bar) may be vented from the manifold.

Warning

- Personal injury and instrument damage may result if operators exceed the specified gas pressures or RV temperatures.

Pressure Relief Valve The Endeavor pressure relief valve made by Circle Seal is constructed of 303 stainless steel and designed to relieve at pressures greater or equal to 600 psi (≈ 41 bar). The seal is made of PTFE.

Safety Equipment
The Endeavor instrument has been designed to handle hazardous chemicals, but should only be operated in accordance with local safety regulations, by personnel trained to handle such chemicals safely. Protective hand and eye equipment should be worn during instrument operation.

Personal Protection
Biotage recommends that the following safety equipment be readily available during instrument operation:

- Eye and hand protection.
- Fire extinguisher.
- Eye wash station.
- Safety shower.
- Adequate ventilation.

All safety equipment must fulfil the requirements in applicable local and national regulations.

Gas Detection
When working with toxic gases such as carbon monoxide (CO), Biotage recommends that the facility be equipped with appropriate gas sensors providing audible and visual alarms when the toxic gas concentration exceeds safe limits.

Flammable and toxic gases should be housed in an adequately vented environment to prevent the buildup of such gases.

Flow Control
The high-pressure gas sources supplying the instrument should be equipped with automatic shut-off valves to interrupt the gas flow in the event of a leak in the supply line to the instrument.

Warning

- If safety equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Adequate eye and hand protection equipment should be worn during instrument operation.

Operating Environment

The Endeavor system has been tested and validated in the operating environments described below. Biotage cannot guarantee operation and safety of the Endeavor system when used in environmental conditions outside these ranges.

Operating Requirement	Specification
Laboratory Temperature	15°C to 30°C (regulated to within 1°C over 3 hours)
Laboratory Humidity	≤ 70% relative humidity
Chemical Environment	Non-corrosive environment

Reactor Sealing Capabilities

The Endeavor system has been tested and validated in the operating conditions described below. Biotage cannot guarantee operation and safety of the system when used outside these ranges.

Operating Requirement	Specification
Reactor Sealing with Stirrer Assembly Secured	Up to 500 psi (≈ 34 bar)

Warning

» If the pressure display shows the value "ERR" the pressure inside the RV is ≥ 510 psi (≈ ≥ 35 bar). In this situation, the experiment must be aborted immediately by pressing the *Manual Vent* button at the lower right of the control panel, as described on page 3.

Safety Data Sheets (SDS)

The SDS associated with each chemical used in conjunction with this equipment must be kept at the instrument facility for easy reference by employees. Adherence to the safety precautions listed in the SDS for each of these chemicals is mandatory for the safe operation of this equipment.

WEEE Compliance Statement

Valid for customers in EU countries

We are committed to being a good corporate citizen. As part of that commitment, we strive to maintain an environmentally conscious manufacturing operation. The European Union (EU) has enacted a directive on product recycling (Waste Electrical and Electronic Equipment, WEEE).

Products falling under the scope of the WEEE Directive are identified with a crossed over "wheelie bin" symbol on the product label, as indicated to the left. To forward a product for recycling or proper disposal, return them to Biotage Sweden AB.

Before forwarding a product for recycling or disposal, it should be emptied of all liquid and cleaned from harmful residues. When returning a product to Biotage, this should be done in accordance with the material return procedures supplied separately by Biotage.

Warranty and Liability

See the "Biotage Terms & Conditions of Sale" document at www.biotage.com.

System Overview and Specifications

Endeavor enables parallel pressure reactions to optimize reaction conditions. It contains eight individual pressure reactors with individual temperature and pressure control, individual manual injection, and stirring. Reagents and solvents can be added prior to sealing the reactor vessel (RV), or via syringe injection after sealing. By using the pre-programmed purge cycles, a completely inert environment can be generated within each RV.

The main components of the Endeavor system are:

- **Control Panel** for programming and controlling pressure, gas flow, temperature, stirring, and run time. The Control Panel can be detached from the system.
- **Liquid Crystal Display (LCD)** to show the parameters as they are set and to monitor the progress of reactions. The LCD displays temperature, pressure, and gas consumption in real time.
- **Gas Manifold Assembly** for the individual control of each RV, including the introduction, regulation, and removal of gas. Mechanical and electronic valves as well as pressure sensors enhance the monitoring capability of the gas manifold assembly.
- **Eight RVs** ease product recovery and reduce cleanup time. These stainless steel pressure vessels have removable and disposable impellers and glass liners.
- **Stirrer Assembly** seals the RVs and provides stirring via magnetically coupled removable impellers. Injection ports are included for the manual addition of reagents to individual RVs.

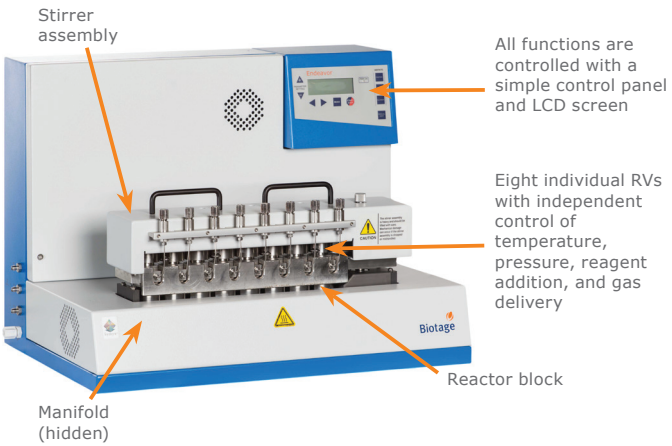

Figure 3. Major components of the Endeavor system.

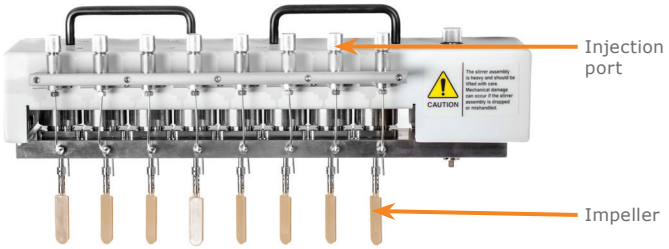

Figure 4. Stirrer assembly.

Figure 5. Reaction vessels (RVs).

Specifications

General

Dimensions (W X D X H)	22.5" x 16" x 18" (57 cm x 41 cm x 46 cm)
Weight	93 lbs (42 kg)
Electrical Ratings	100 to 120V/200 to 240 V at 50/60 Hz, 7.5 A
Fuse Rating	T8AH/250V
Environmental Conditions	15 to 30°C ambient temperature 30 to 70% relative humidity Non-corrosive environment
Ventilation Requirements	100 feet/minute

RV

Number of RVs	8 stainless steel reactors with disposable glass liners
Total Gas Space (Paddle Impeller)	20.2 mL
Working Volume	1 to 5 mL (solid and liquid)
Liquid Delivery	Manual additions through an injection port
Maximum Recommended Delivery Through Injection Port	500 µL at pressures up to 350 psi (≈ 24 bar)
Gas Delivery	Automated through a manifold valve system

Agitation

Impellers	Magnetically coupled PEEK impellers, all controlled by a common motor
Speed Range	250 to 1000 rpm
Maximum Fluid Viscosity for Agitation	1000 cP
Acoustic Noise	Less than 85 dB at 1 meter from the instrument

Thermal Control

Temperature Control	Individual thermocouples inside each reaction block; ambient up to 200°C; resolution of 1°C
Monitoring Accuracy	For set points from ambient to 100°C, the actual fluid temperature is ≤ 4°C of that reported by the system For temperatures above 100°C, the actual fluid temperature will be ≤ 8°C of that reported by the system
Heating Control Precision	At thermal equilibrium, the temperature reported by the system is within 2°C of the set point[1]
Reporting Resolution	Instrument front panel reports temperature to 1°C; software reports to 0.1°C
Set Point Overshoot	Maximum of 5°C of set point; returns to set point within 5 minutes from initially achieved set point
Adjacent RV Set Point Differential	30°C maximum temperature differential for adjacent RVs to maintain temperature For set points between 30 and 60°C, the maximum temperature differential is 10°C
Calibration	Single point slope calibration at 150°C; procedure references an external T type thermocouple

Pressurization System

Pressurization	Up to 500 psi (≈ 34 bar)
Optimal Pressurization	Inlet pressure of 520 psi (≈ 36 bar) in a pressure range of 50 to 500 psi (≈ 3.5 to 34 bar)[2]
Gas Types	The type of gas used on the system can effect pressurization behavior. The Endeavor pressure system has been tested using nitrogen gas and helium gas. To run other gases and maintain the pressure ramping specifications, alteration of the pressurization parameters may be necessary. Consult the operator's manual for details.
Pressure Monitoring Accuracy	+/- 2 psi (≈ 0.14 bar) or 2% of displayed, whichever is greater[3]
Control	Pressure reported by the system will be from - 2 psi to + 4 psi (≈ 0.14 to 0.28 bar) of pressure set point[4]
Pressure Set Point Overshoot	Average vessel overshoot < 2 psi (≈ 0.14 bar); Maximum vessel overshoot < 5 psi (≈ 0.34 bar)[4]
Ramp Time to Reach Set Point Pressure	7 minutes
RV Leak Rate	< 2 psi/hr. or 0.13 mmol/hr. at 500 psi (≈ 34 bar), using nitrogen gas with no liquid in the RVs
RV Vent Rate	Manual and automatic "Vent All" feature will vent all RVs to < 1 psi (≈ 0.07 bar) in < 2 minutes

Performance

Relative Standard Deviation (rsd) of Total Mole Consumption	< 10% from a set of 8 identical reactions[5]
For Gas Consumption Rates	From 0.5 mm/h to 5 mm/h
Minimum Reaction Time	30 minutes from the beginning of the reaction (gas uptake) to the completion of the reaction (gas uptake)

Note: For an explanation on how the system calculates gas consumption, see "Appendix C: Technical Details" on page 44.

[1] With 0.5 mL of heat transfer fluid (boiling point must be greater than the temperature set point), thermal equilibrium: after 15 minutes of agitation once set point is reached.

[2] The instrument operates below 50 psi; however, the precision and accuracy performance may differ from the above specifications.

[3] For lab temperatures of 15 to 30°C.

[4] Constant temperature operation.

[5] Results are based on the hydrogenation of benzobenzoate (n-8) under the following conditions: 4 mL 0.5 M benzobenzoate, 50 mg catalyst (10% Pd/C), 1000 rpm, 50 psi, 40°C in ethanol.

[6] Results may vary depending on chemistry and procedure; rsd (%) = (std dev/ave)*100.

Installation

This chapter reviews the installation requirements for the Endeavor system and reviews the pre-installation instructions that should have been received and completed prior to the installation of the Endeavor instrument.

Installation, Training, and Support

On-site installation and an overview of basic operation are included with the purchase of the Endeavor system. The installation checklist can be found in “Appendix B: Checklists” on page 42.

Follow regional safety practices when handling and moving shipping boxes and containers, and moving the system.

During installation of the Endeavor instrument, the service engineer will train users on the basic operation of the instrument, including required user maintenance. Additional training can be purchased if needed.

Basic training sessions are limited to no more than two trainees. All trainees should be competent in the Microsoft Windows 2000 operating system before beginning a training session.

Warning

- Risk of injury. The Endeavor system weighs 42 kg.
- The Endeavor system must be installed by a trained person.

Laboratory Safety

Biotage service representatives have been trained to install the Endeavor instrument safely and have been instructed to comply with the safety rules and regulations in the customer’s laboratory.

To ensure the safety of all involved during the installation of the Endeavor instrument, Biotage requires that customers provide the service representative with the following during installation:

- Location of safety equipment, evacuation exits, and warning systems.
- A laboratory representative who will be in the vicinity and available at all times while the Biotage service representative is on site.
- Access to safety equipment such as fire extinguishers, an eye wash station, a safety shower, eye and hand protection, adequate ventilation, and protection from sources of radiation, such as lasers, radioisotopes, contaminated equipment, and radioactive waste.

Site Preparation

The actual installation of the Endeavor system will be carried out by a Biotage service representative, but it is the responsibility of the customer to prepare the site environmentally and to provide the required space, equipment, and services such as power, venting, bottled and compressed gases, permits, and approvals as specified below.

Environment

Minimum requirements for the environment are as follows:

- A chemical fume hood or canopy with an air exchange rate ≥ 100 CFM should suffice for most applications; however, it is the customers’ responsibility to confirm the suitability of the application with the safety regulations of their facilities.
- Ignition and spark-free, especially when working with flammable gases such as hydrogen and ethylene.
- Audible and visual gas sensor alarms for detecting gas leaks, especially when working with toxic gases such as carbon monoxide.
- Ambient temperature of 15 to 30°C.
- Relative humidity ≤ 70%.

Warning

- The electronic and mechanical components in the Endeavor system are susceptible to corrosion from prolonged external exposure to some chemicals such as concentrated HCl. The instrument should not be set up in an area where these chemicals are stored.
- To eliminate any risk of a static discharge, the systems and ancillary containers must be grounded before use as described below. Failure to follow these grounding instructions may result in equipment damage, personal injury, or death.
- The Endeavor system must be connected to an adequate ventilation system. Insufficient ventilation may result in instrument damage, explosion and personal injury.
- The Endeavor system has a ¼-inch vent tubing. This tubing must be securely fastned to an appropriate laboratory ventilation system. The ventilation system must be equipped with necessary fire precautions and gas treatmet, because all reaction gases, including flammable and toxic gases are vented through the tubing.

Space

Following are the minimum requirements for space.

Endeavor Reactor Module

Dimensions (W X D X H)	30 inch x 19 inch x 19 inch (76 cm x 48 cm x 48 cm)

The reactor must reside inside the fume hood.

Personal Computer (PC)

Dimensions (W X D X H):	30 inch x 24 inch x 18 inch (76 cm x 61 cm x 46 cm)

The PC must be located no more than 9 feet (3 meters) from the reactor module. Biotage provides a 9-foot cable to connect the Endeavor instrument to the PC.

Power Supply and Fuses

Use only power cords supplied by Biotage. Inspect the cord at regular intervals, and replace if damaged.

Do not alter the plug in any way. Only connect the plug to a grounded outlet, in accordance with local and national regulations.

Use only the exact replacement fuses specified by Biotage. Incorrect fuses are a potential fire hazard.

An un-interruptible power supply capable of handling the following power requirements is recommended:

100-120 VAC or 200-220 VAC	50 to 60 Hz
Endeavor Reactor Module	One outlet 15 A
PC and Monitor	Two outlets 10 A

Gas

All gas connections are made with 1/8 inch outside diameter (OD) 316 stainless steel tubing and compression fittings.

The stainless steel tubing, fittings, and filters listed below are not included in the instrument ship kit and must be purchased prior to installation.

Note: Installation of the Endeavor instrument includes the connection of the gas lines to the instrument only if the fittings listed below are provided by the customer.

Supplies required for the installation include:

- Approximately 16 feet of 1/8-inch OD stainless steel tubing and a tubing cutter. The recommended stainless steel tubing is 1/8-inch OD x 0.08-inch inside diameter (ID). Three 5-foot lengths and three 4-foot lengths are required. The internal volume of the tubing must be clean and free from oils, machine residue, and other extraneous material.
- Three 1/4 nylon pressure tube (NPT) to 1/8-inch compression adapter tube fittings. These fittings connect the 5-foot lengths of tubing from the gas regulators to the inlet filter. Male or female NPT's should be ordered as required to connect to the regulator outlet fitting.
- 5-micron gas inlet filters. These filters are available from Biotage (P/N 900845). The number of gas inlet filters should correspond to the number of source gases used.
- Six 1/8-inch stainless steel compression fitting nuts and ferrules. These fittings, along with the 4-inch tube lengths, connect the gas filter outlet to the Endeavor gas inlet ports.
- Inert gas and regulator, such as Helium, Nitrogen, or Argon, to provide an inert environment for the reaction.
  Pressure-regulated: 520 psi (≈ 36 bar)
  Purity: ≥ 99.98%

Reagent/Solvent

One 4-liter bottle of Methanol is required for system testing and operator training.

Other Requirement

One 5 or 10 mL luer-lock syringe is needed for cleaning the injector ports.

Glove Box (Optional)

The optional 5-foot, 3-port glove box (front faceplate requires removal for installation) requirements are as follows:

- Three feed-through gas adapters (1/4 to 1/8-inch tube).
- One feed-through vent adapter (1/4 to 1/8-inch tube).
- RS232 cable feed-through connection (DB-9 pin, male to female).
- One RS232 DB-9 pin, male to female cable.
- Required power source located inside the glove box.

User Interface

This chapter gives an overview of the process of programming a pressure reaction on the Endeavor system.

Starting Biotage® Endeavor™

To start Endeavor, press the power switch on the upper-right side of the instrument. Figure 6 shows the control panel and LCD screen.

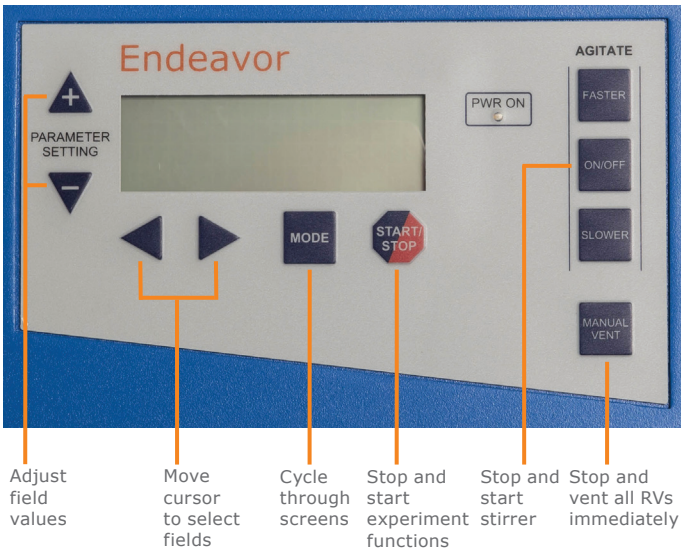

Figure 6. Control panel and LCD.

Operating Parameters

Note: The commands given in this user manual relate to firmware version 2.7. Future firmware updates will be accompanied by documentation of any changes.

Press *MODE* until the RV Parameter screen appears:

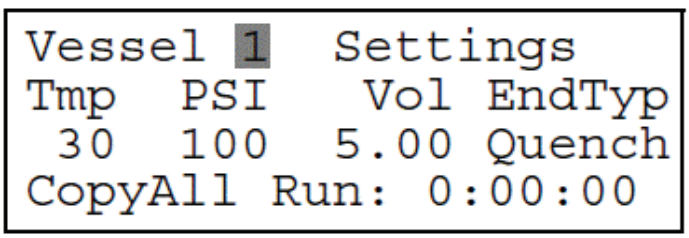

Figure 7. RV Parameter screen.

If the RV Parameter screen is accidentally passed, continue pressing *MODE* to cycle through all the screens until the RV Parameter screen is displayed again.

The RV Parameter screen shows the operating parameters associated with each reactor vessel (RV). RVs are numbered sequentially from left to right as they are located in the reactor block: RV1 through RV8.

Settings

Toggles between the settings for the RV and the readings for the current state of the RV.

Tmp

Shows the set point temperature of the RV in degrees Celsius.

PSI

Shows the set point pressure of the RV in psi or bar (14.5 psi = 1 bar).

Vol

Shows the volume of the solution in the RV in milliliters.

EndType

Shows how the reaction will be terminated when completed; one of four choices:

Quench:	Introduction of the gas from the quench gas (gas B) line to all specified RVs.
Purge:	Introduction of the gas from the inert gas line to all specified RVs.
Vent:	Release of gas in all RVs through the vent line.

Caution

» Reactors should not be purged or vented while hot. Reactions should be cooled to approximately 40°C prior to venting or purging of the reaction or quench gas.

Seal/Quit:	Closes the valve to all specified RVs and turns off the heat.

Run

Shows how long the reaction will run in hours: minutes: seconds.

Copyall

Shows that the parameters associated with the RV will be copied to the other seven RVs.

Changing Parameters

Select an operating parameter by pressing the left/right arrows below the LCD display to move the blinking cursor into position.

Change the value of an operating parameter by pressing the +/- arrows at the left of the LCD display.

To run all RVs identically, first set up the desired reaction parameters for one RV, then move the cursor to the *Copyall* parameter field and press *MODE*. The display will indicate that the parameters have been copied to the other seven RVs.

Stirring

To start mixing, press the agitate *ON/OFF* button at the right of the LCD display. Increase the stirring speed by pressing the *FASTER* button, and decrease it by pressing the *SLOWER* button. Stop the mixing by pressing the *ON/OFF* button.

Starting the Software

The Endeavor Basic Software allows data acquisition and display. Either double click the program icon located on the personal computer (PC) desktop, or select the *endeavor.exe* file by selecting Start » Programs » Endeavor » Endeavor.

Click the *Listen* button in the bottom left of the screen to initiate the recording of data. Full details are available in the chapter “Viewing Data” on page 22

Preparation for Experiment

This chapter describes the overall operational procedure for preparing the Endeavor system and running an experiment. The major steps are as follows:

1. Remove the stirrer assembly and place it on the stand.
2. Remove and reinsert clean glass liners into the reactor vessels (RVs).
3. Change impellers in the stirrer assembly.
4. Seat the stirrer assembly into the reactor module.
5. Fit the front and rear clamps.
6. Pre-run the leak test.
7. Program the experimental run using the control panel.
8. Start the data acquisition via the personal computer (PC) (optional).
9. Start the experimental run from the control panel.
10. Add catalyst/reagent if and when desired using the injection ports (optional).
11. Initiate gas consumption measurement when ready using the control panel.
12. After completion of the experiment, clean all the injection ports that were used

Stirrer Assembly

Removing the Stirrer Assembly

Remove the front and rear clamps by loosening the four hex bolts with the provided wrench. Lift the stirrer assembly and place it on the stand (Figure 8 and Figure 9).

Figure 8. Removing the stirrer assembly.

Caution

» The stirrer assembly is heavy and should be lifted with care. Mechanical damage can occur if the stirrer assembly is dropped or mishandled.

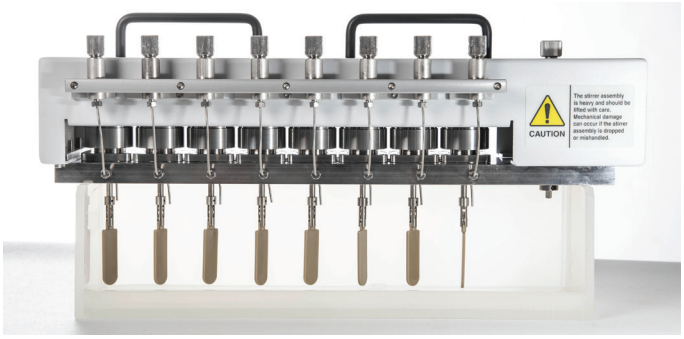

Figure 9. Stirrer assembly on the stand.

Reactor Vessels

Removing Liners

Remove any used glass liners from the reactor vessels with the special glass liner removal tool (Figure 11). Insert the rubber plunger end into the reactor vessel, turn the black plastic T-handle clockwise until the glass liner fits snugly, then pull the liner straight up out of the reactor vessel.

Warning

» Pull the liner out vertically to avoid breaking the glass; see Figure 10.

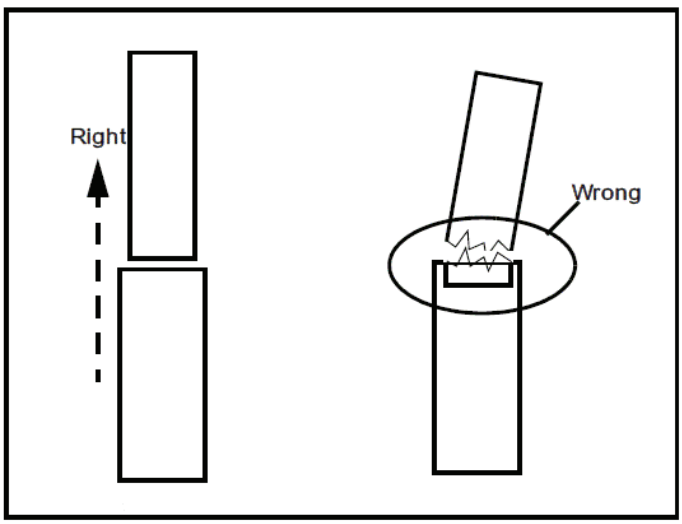

Figure 10. Remove the liner vertically.

Note: The following photographs show only the parts of the Endeavor system relevant to the instructions.

Figure 11. Glass liner removal tool.

Figure 12. Inserting the glass liner removal tool.

Clean the glass liner with acetone. Air dry and then oven dry if using the liner in a glove box or if concerned about moisture. Although the glass liners may be reused, removing and reinserting glass liners increases the risk of damage.

Note: Because the risk for breaking glass liners increases with reuse, the glass liners are designed to be disposable.

Inserting Liners

Load the glass liners with reagents, not exceeding the recommended working volume (typically 5 mL). Be sure to note the exact volume in each RV.

Note: Prior to inserting the glass liner into the RV, it is recommended that the glass liner is tested for "fit" by partially inserting the liner right-side up, then inserting the glass liner upside-down. If the liner cannot be inserted completely upside-down, the fit is not acceptable for proper loading. This test will screen any warped or oversized liners prior to insertion, preventing the liners from being broken inside the RV.

Note: If the glass liner slides to the bottom of the RV with no resistance when it is inserted right-side up, then the glass liner is too small and will spin during mixing, causing uneven stirring.

Insert the glass liner in the appropriate RV as follows (RV1 is on the far left, RV8 is on the far right):

1. Gently place the glass liner into the RV (Figure 13). The glass liner will easily slide halfway inside the RV and rest on the internal glass liner gripper tubing.

   Note: The use of approximately 0.5 mL of heat transfer fluid between the RV wall and the glass liner is recommended. The reaction solvent can be used as the heat transfer fluid.

Figure 13. Inserting a glass liner—step 1.

2. Hold the supplied glass liner insertion tool by the narrow end, with the wide end pointed down.

Warning

» Be careful to hold the glass liner straight during insertion and removal (Figure 10). If the glass liner tilts, it may break on the side of the RV. Do not use excess force—the glass liner may break and cause injury!

3. Use the wide end of the glass liner insertion tool to gently press the glass liner into the RV (Figure 14).

Figure 14. Inserting a glass liner—step 2.

4. When the wide end of the glass liner insertion tool is flush with the top of the RV, turn the insertion tool over, and place the narrow end onto the glass liner (Figure 15).

Figure 15. Inserting a glass liner—step 3.

5. Gently press down on the glass liner insertion tool until the glass liner reaches the bottom of the RV.

Changing Impellers

» **Remove** the individual impellers by pulling in a downward direction.

» **Clean** impellers with methanol, ethanol, or other organic solvents and air dry. If you will use them in a glove box, dry the impellers in a vacuum oven at 100°C overnight. Compatible solvents are listed in “Appendix D: Advanced Software” on page 48.

» **Install** an impeller by aligning the impeller notch with the slot on the stainless steel shaft and pushing the impeller into the steel shaft until the impeller is fully inserted. Gently pull on the impeller to verify that it is properly seated.

Note: The impellers are intended to be replaced routinely. Impellers that fit loosely into the stainless steel shaft will provide inefficient and variable mixing, as well as potentially adversely affect the wear on the gear train.

Fitting the Stirrer Assembly

Caution

» The stirrer assembly is heavy—lift it with both hands.

Lift the stirrer assembly and place it on top of the reactor block assembly with the stirrer shaft on the right. Do not force the stirrer shaft into the slot of the motor drive.

Rotate the stirrer shaft knob on top of the stirrer assembly to ensure that the stirrer shaft locates in the slot of the motor drive on the reactor block. This is shown in Figure 16 and Figure 17.

Note: Avoid catching the injection ports on the face plate or the edge of the glass liner as the assembly is lowered.

Figure 16. Placing the stirrer assembly.

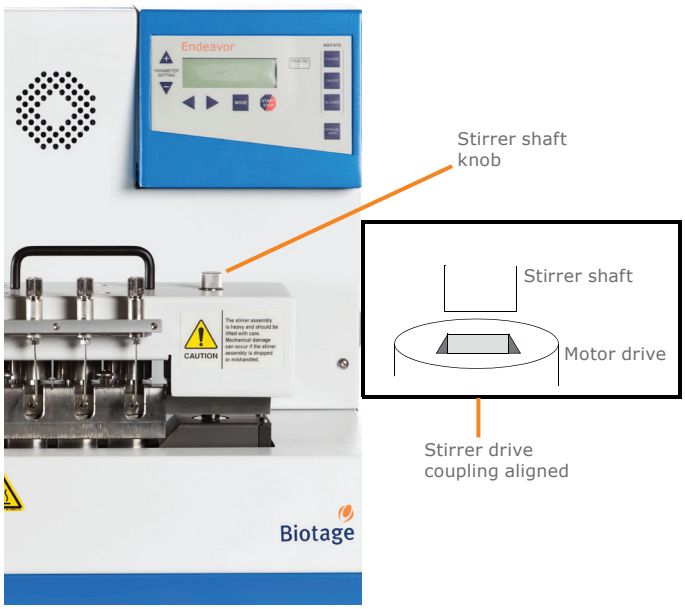

Figure 17. Aligning the motor drive and stirrer shaft.

Fitting the Clamps

Place the front reactor block clamp along the front of the stirrer assembly with the bolts facing up. The front reactor block clamp has multiple cut-outs which fit around the injection ports (Figure 18).

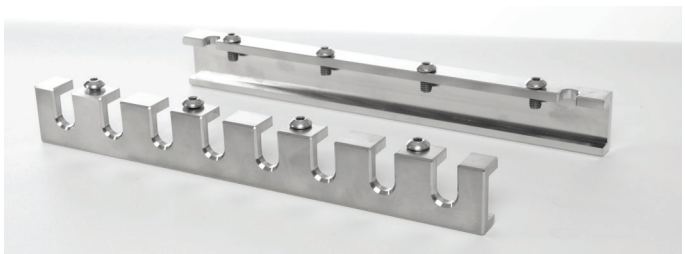

Figure 18. The front and rear Clamps.

Figure 19. Fitting the front clamp.

Note: Lowering the bolts to expose about 1/4 an inch of the bolt below the clamps will help align the clamps onto the stirrer assembly.

Align the clamps until the screws are seated properly into their corresponding holes.

While holding the clamp in place and lifting up with one hand, lightly tighten the four hex bolts with the provided wrench.

Tighten the bolts only enough to hold the clamp in place, then fit the rear clamp as follows.

Place the rear reactor block clamp along the rear of the stirrer assembly with the bolts facing up (Figure 20). Align the clamp until the screws align with their corresponding holes.

Figure 20. Fitting the rear clamp.

While holding the clamp, gradually tighten hex bolts with the provided hex wrench. Tighten the bolts only enough to hold the clamp in place.

Tightening the Clamps

Tighten each bolt in turn, a little at a time, following the sequence shown in Figure 21. Repeat the sequence three or four times to ensure that both clamps are secure and that all eight bolts are equally snug. Figure 22 shows the correct use of the hex wrench.

Caution

- It is important to tighten the bolts gradually and evenly to ensure a gas-tight seal. Apply light pressure to each bolt in turn and repeat the pattern until all bolts are snug but are not tight enough to distort the wrench.
- Overtightening the bolts can result in the bolt threads gauling and damaging both the bolts and the clamp. This can prevent the ability to remove the clamp from the reactor base.

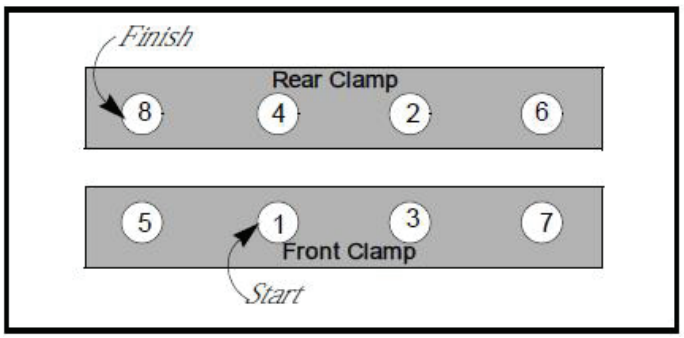

Figure 21. Typical clamp tightening sequence.

Note: When removing the clamps, it is not necessary to follow an ordered sequence for loosening the bolts.

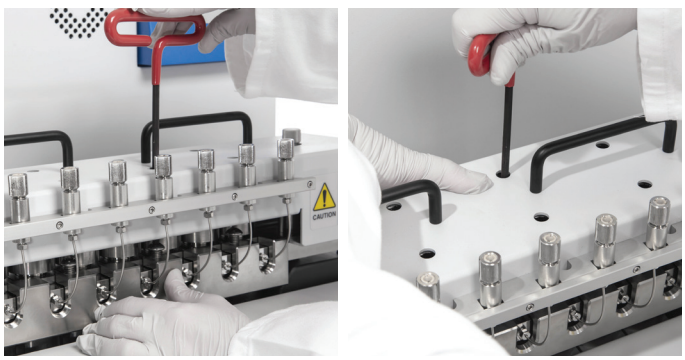

Figure 22. Tightening the front clamp (left) and rear clamp (right).

Checking the System for Leaks

Prior to running reactions on the Endeavor system, it is highly recommended to run an RV leak test. RV leaks can develop due to:

- Dirty or damaged O-rings,
- Deformed or flattened O-rings (due to "compression set")
- Injection ports contaminated with solid particles, and
- Loose compression fittings.

Leaks in the system will increase the gas consumption data.

Warning

- A leaking RV may result in the complete loss of solvents from the RV during an Endeavor run. Take appropriate safety precautions against possible reactions of dry catalyst and/or reagent in the event of complete solvent loss.

Leak Test Procedure

For accurate results from the leak test, the RVs should contain empty glass liners and the impellers should be installed on the stirring assembly. Nitrogen should be used as the test gas.

Note: Do not exceed 510 psi (≈ 35 bar) on the test gas tank regulator.

Biotage® Endeavor™ Advanced Software

Refer to "Appendix D: Advanced Software" on page 48 for leak test information using the Endeavor Advanced Software.

Biotage® Endeavor™ Basic Software

With the basic software, the leak test is done manually.

1. Pressurize the RVs with nitrogen to ≤ 510 psi (≈ 35 bar) or to the setting on the nitrogen inlet gas source regulator, which should be set to ≤ 510 psi by default.
2. Select *Override* and click the *Listen* button.

Note: The *Listen* button records data in the same manner as the Endeavor Advanced Software.

3. Wait 40 minutes and click *Stop Listening*.
4. The drop in pressure from time = 10 minutes to time = 40 minutes should not exceed 1 psi (≈ 0.07 bar).

If a Leak Is Present

Note: If the leak test is being run with RVs containing reagent and solvent, the results must be viewed qualitatively, as gas can dissolve in the reaction solvent, causing a pressure drop in the RV and giving the appearance of a leak. In this case, look for a significant pressure drop, rather than the more rigorous 2-psi/hr. limit (2 psi ≈ 0.14 bar). However, because the seal between the faceplate and the stirring assembly can be affected when the stirring assembly is removed and replaced, it may be preferable to run the leak test with the RVs already loaded.

The most common sources for RV leaks are O-rings and injection ports.

O-rings

Two O-rings are typically responsible for leaks:

- the face seal O-ring, which is more likely to be the cause of a leak, and
- the gland seal O-ring, which is less likely to be the cause of a leak.

Changing the face seal O-ring is usually the first step in remedying an RV leak. Refer to "Replacing the O-Rings" on page 29.

Injection Ports

The injection ports on the Endeavor system are essentially springloaded check valves that allow fluid to be injected into the RV but prevent gas from escaping the other direction. This directional flow feature is accomplished by springloading a circular plate that seals against an O-ring in the injection port assembly. Particulates, lint, dust, or residual reagent present on the injection port O-ring seal or sealing plate can cause a gas leak from the RV through the injection ports.

To test for an injection port leak, use a dropper or pipette to place a small amount of solvent, soapy water, or water in the inlet hole of the injection port. A gas leak can be seen from bubbling or other agitation of this solvent. If an injection port leak is found, the port should be rinsed with solvent. If the leak persists, the port needs to be cleaned or replaced. Refer to the back cover or www.biotage.com for information on contacting a service engineer to order parts.

Note: A drop in lab temperature can result in a pressure drop in the Endeavor RVs during the leak test. If the leak test fails, check the run log for a drop in temperature. Re-run the leak test at a constant lab temperature, use the mole count, or compensate the pressure drop result for the temperature change. For example, at 500 psi (≈ 34 bar), a change in temperature from 25 to 24°C is equivalent to about a 2 psi (≈ 0.14 bar) pressure drop).

Setting the Reaction Parameters

Programming the Endeavor system through the use of a PC can only be done using the Endeavor Advanced Software (see “Appendix D: Advanced Software” on page 48).

1. Turn on power to the Endeavor with the power switch at the upper right corner of the system.
2. Press *MODE* until the RV Parameter screen appears (Figure 23).

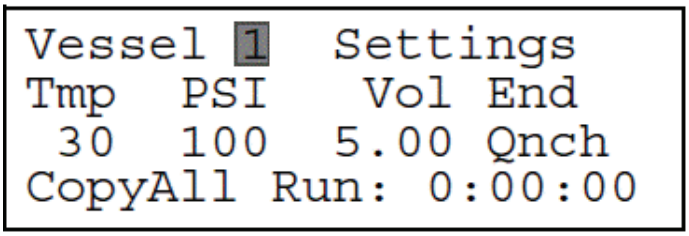

Figure 23. RV Parameter screen.

3. The cursor will be in the RV number field showing RV1. To change to a different RV number, press the +/- arrows.
4. Confirm that the *Settings* field is displayed, not the *Readings* field.
5. Use the left/right arrows to move the blinking cursor to the *Tmp* field. Adjust the temperature value using the +/- arrows.

   Note: The cursor position allows adjustment of values of a particular significant figure, such as units of 1, 10, or 100. The cursor position indicates value adjustment for all fields (Figure 24).

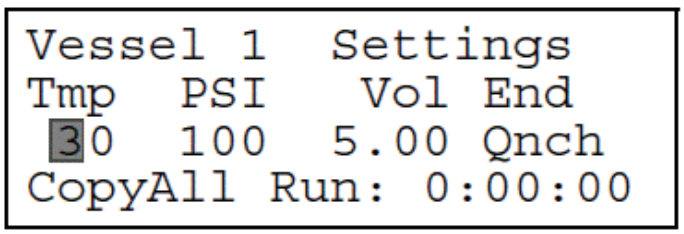

Figure 24. Setting the temperature.

6. To adjust the pressure, use the left/right arrows to move the blinking cursor to the *PSI* field. Use the +/- arrows to toggle between psi and bar. Move the cursor below the *PSI* field and adjust the pressure value using the +/- arrows (Figure 25).

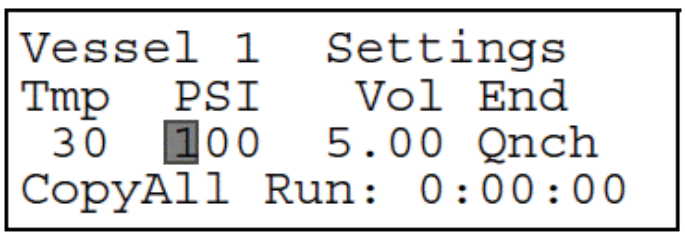

Figure 25. Setting the pressure.

7. Enter the volume of the solution used in the selected RV by moving the cursor to the *Vol* field and adjusting the value with the +/- arrows (Figure 26). This value is used in the gas consumption measurements, and incorrect entries will result in an offset of the gas consumption data and incorrect results.

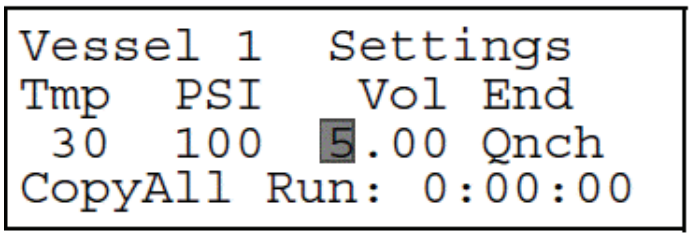

Figure 26. Entering the solution volume.

8. Select the reaction termination step by moving the cursor to the *End* field (Figure 27). The four end choices: Quench, Purge, Vent, and Seal, take effect when the experiment run is complete.
   - » Quench — Introduces the gas from the quench gas line to all designated RVs.
   - » Purge — Introduces the gas from the inert gas line (gas B) to all designated RVs.
   - » Vent — Releases gas from all designated RVs to the vent line.
   - » Seal — Seals the selected RVs and turns off the heat.

   The termination step occurs at the end of the run time.

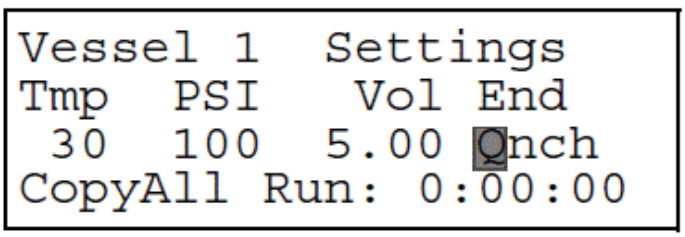

Figure 27. Entering the end type.

Note: The number of purge or quench cycles is set to the fixed value of 10.

Warning

» The use of *Seal* as the end type is recommended when heating the RV during the reaction. this option will minimize the exposure of the gas values to solvent vapor. the use of the Endeavor Advanced Software will allow cooling at the end of the reaction prior to completion of the experiment.

9. Move the cursor to the *Run* field and set the reaction run time. this is input in the hours:minutes:seconds format. For example, a value of *1:22:01* sets the reaction time to one hour, twenty-two minutes and one second (Figure 28).

The Endeavor run time clock begins counting down to zero from the reaction run time value when the run is started.

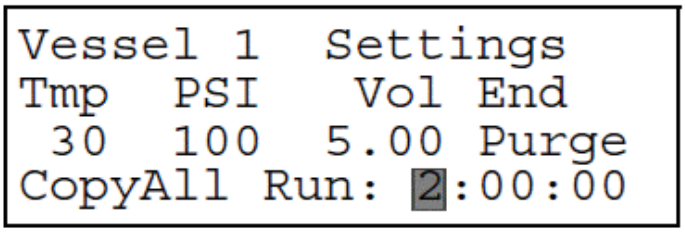

Figure 28. Setting the run time.

Hint: To use identical parameters for all RVs, move the cursor to the *CopyAll* field and press the *MODE* button (Figure 29). The parameters for the current RV will be copied to all other RVs. RV parameters can be individually modified after shared settings are copied to all RVs.

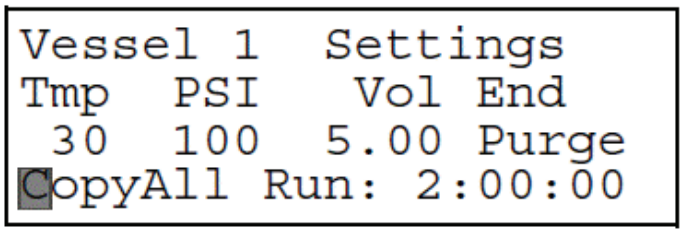

Figure 29. Copying parameters to all RVs.

10. To modify individual RV parameters in turn, select another RV (step 3 above) and repeat steps 4 through 9 for each RV in turn.

    Note: If an RV is not to be used, set the pressure and time parameters to 0 (zero) and the temperature parameter to 10.

11. Press the *MODE* button until the Mixing screen appears. Use the left/right arrows to move the cursor and the +/- arrows to decrease and increase the mixing speed (Figure 30).

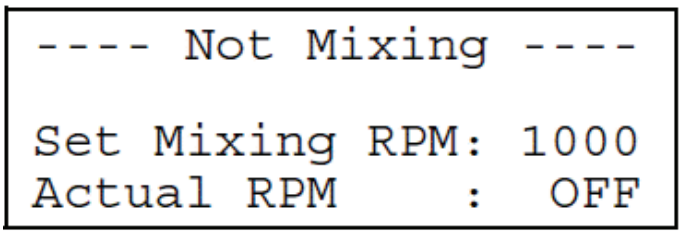

Figure 30. Setting the initial mixing speed.

12. Press the Agitate *ON/OFF* button to start and stop stirring.

    To change the stirring speed at any time, press the +/- arrows on the left side of the control panel. The maximum stirring speed is 1000 rpm.

Starting Data Acquisition (Optional)

Note: This section applies only if a PC is being used for data acquisition.

1. Connect the serial interface cable (9-pin RS232 type) between the serial port of the PC and the data port on the upper right side of the Endeavor system. Start the PC.
2. To open the Endeavor software, double click the Endeavor program icon located on the PC desktop or click the Start menu and choose *Programs* » *endeavor.exe*.
3. When the Endeavor software opens, the Configuration screen will be displayed as shown in Figure 31.

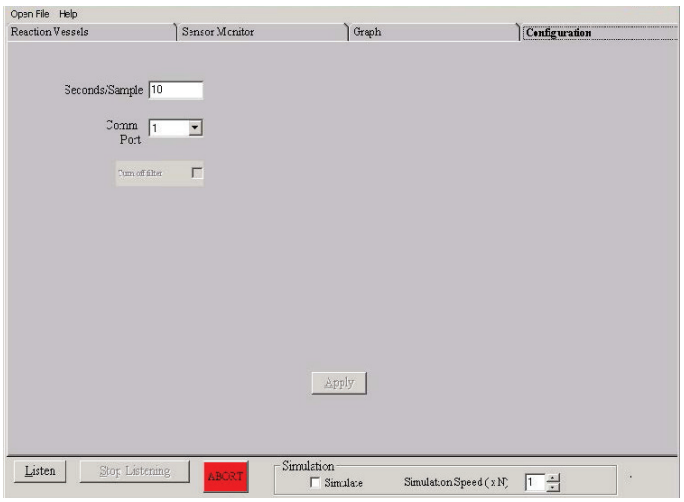

Figure 31. Data acquisition screen.

4. Enter the sampling rate in the *seconds/sample* field. For example, to sample every 5 seconds (0.2 Hz), enter *5* in the field.

   Note: The current version of the firmware (2.7) supports data sampling rates as fast as 3 seconds per sample. While sampling frequencies greater than this can be entered, the actual frequency may vary due to PC processing resource availability. Check the data log for the actual sampling frequency. High sampling frequencies can result in extremely large data log file sizes.

   The table below provides guidelines for adjusting the sampling rate to the length of the experiment while keeping the data file at a reasonable size. Keep the number of data points constant at about 1,200 points to prevent PC delays during large file generation.

Length of Experiment	Sample Rate (sec./sample)	Number of Data Points
1 hour	3	1,200
5 hours	15	1,200
10 hours	30	1,200
20 hours	60	1,200

The sampling rate can be adjusted during the course of the experiment. For example, the sampling rate can be set to 3 sec./sample for the beginning of an experiment and then adjusted to a slower rate as an experiment completes.

5. Ensure that the Comm Port field shows the correct number for the serial port on the PC to which Endeavor is connected.
6. Click on the *Apply* button.
7. To initiate the recording of data, click on the *Listen* button at the bottom of the window.

Note: Clicking on the *ABORT* button will result in the immediate release of gas from all RVs to the vent line, performing the same function as the *Manual Vent* button on the control panel.

Note: If a program is not running, the "Override time stamp" option must be selected before the *Listen* button can be clicked to record data.

Starting the Run

Starting the Run

Press the *START/STOP* button on the Endeavor control panel. The Run screen displays.

Move the cursor to the Run field and press the *START/STOP* button again to start pressurizing and heating (Figure 32).

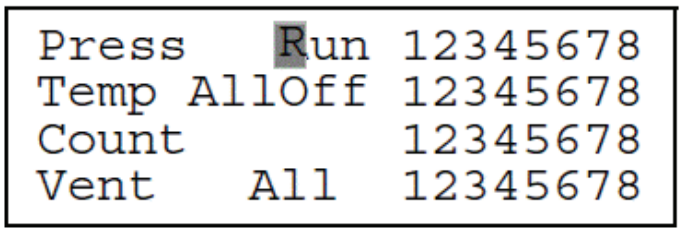

Figure 32. Starting the run.

Purging

When the *START/STOP* button is pressed with the cursor on the Run field, a purge sequence is initiated.

During the purge sequence, each RV will be filled with inert gas and drained ten times to remove residual gas from the RVs. The process will be accompanied by the sound of clicking valves and venting RVs. A countdown indicator on the LCD shows the number of remaining purge cycles (Figure 33).

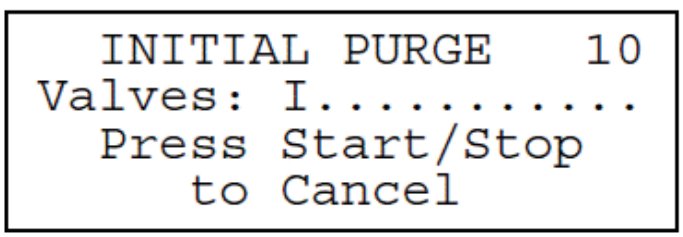

Figure 33. Purge cycle countdown indicator.

Running

When the purge cycle is complete, the RVs will charge to the set pressure with reactive gas (Gas A) and start to heat. Press the *START/STOP* button to display the Run screen.

While the pressure of an RV is changing, a "+" sign replaces the RV number as shown for RV1 in Figure 34.

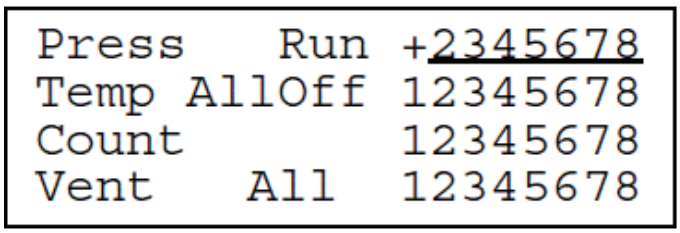

Figure 34. Pressure changing in RV1.

Note: A "+" in place of an RV number shows that a process is currently in progress for the RV.

When the set point pressure is reached for each RV, the RV number will be underscored on the screen as shown in Figure 35.

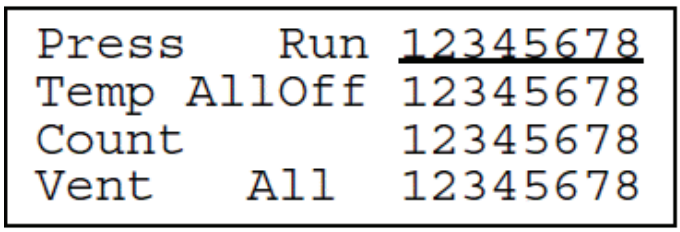

Figure 35. Set point pressure achieved.

When the set point temperature is reached for each RV, the RV number will be underlined on the LCD as shown in Figure 36.

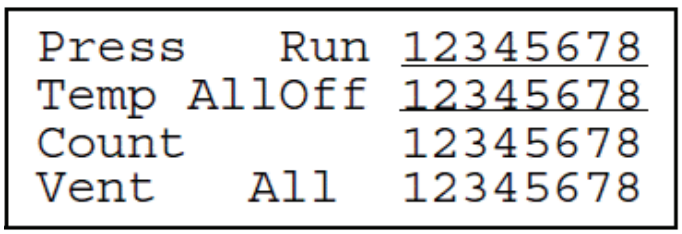

Figure 36. Set point pressure and temperature achieved.

Injecting Reagent and Initiating Mole Consumption Count

When the RVs are charged with gas and heated to the set point values and equilibrium is reached, it may be appropriate to add catalysts and reagents.

Injection (Optional)

There are two types of injections: pure liquids and suspended solids. Pure liquids would typically involve reagents and homogeneous catalysts, while suspended solids includes supported catalysts. Both injections follow the same general procedure; however, for injection of suspended solids, the solvent chase procedure must be followed to prevent clogging of the injector system.

Note: The standard check valve is for liquids only. Optional ball valves are available for liquid and suspended solids (diameter ‹ 100 µm). Refer to “Appendix E: Ball Valves” on page 57 for instructions on ball valve installation and operation.

Equipment

Use the following materials for injecting reagent:

- One 250 µL syringe for delivering reagents, homogeneous catalysts, or suspended solids.
- A 1 mL syringe for delivering a solvent chase to ensure the entire contents of the first syringe are delivered to the RV.
- The two special injection needles supplied with the Endeavor system.

Warning

- Use extreme caution when injecting, particularly under pressure. If the plunger of the syringe is released, RV pressure may result in the forceful ejection of the plunger. Refer to the chapter “Safety” on page 3, for safety information on the use of injection ports.

1. Fill the 250 µL syringe.
2. Place thumb securely on top of the syringe plunger.
3. Inject the solution.

Figure 37. Injecting into a pressurized RV.

4. Wait approximately 20 seconds.
5. Keeping your thumb securely on the syringe plunger, gradually remove the needle from the injection port.
6. Fill the 1 mL syringe with 750 µL of solvent.
7. Insert the needle into the injection port and place thumb securely on top of the syringe plunger.
8. Gradually remove the needle from the injection port.
9. Start the *Count* function (see next section) after injection into each individual RV.

Note: The total volume of reagent and solvent should not exceed 5 mL, and the solvent volume should be at least three times that of the reagent. The solvent chase procedure (following the reagent with solvent) is required to ensure accurate addition of reagents and to prevent clogging of the injection port when injecting particulate suspensions such as supported catalysts.

Gas Consumption Counter

The gas consumption counter must be set in order to start the run¬time clock. This allows the separation of the two factors contributing to gas consumption: gas solubility under pressure and gas consumption through chemistry. If a component is added after pressurization, the counter must be reset.

Setting the Counter

The counter can be set for all RVs simultaneously or set individually for each RV.

To set the counter for all RVs simultaneously:

1. Display the Run screen by pressing the *START/STOP* button.
2. Move the cursor to the *Count* field using the left/right arrows.
3. Move the cursor to the *All* field and press the *START/STOP* button. All RV numbers will be underlined.

To set the counter for each RV separately:

1. Display the Run screen by pressing the *START/STOP* button.
2. Move the cursor to the *Count* field using the left/right arrows.
3. Move the cursor to the desired RV number.
4. Press the *START/STOP* button to reset the counter for the selected RV. The RV number will be underlined (Figure 38).

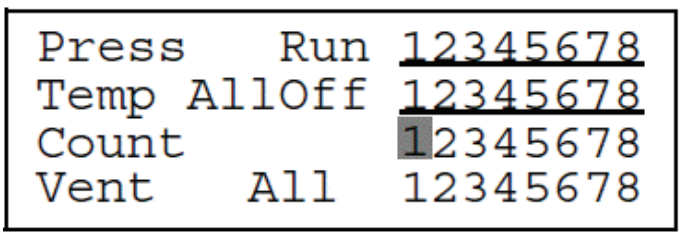

Figure 38. Setting the gas counter.

When the count for a particular RV is started, the run-time clock counts down to zero. When the clock reaches zero, pressurization and heating stop and the programmed end type (Quench, Purge, Vent, or Seal) takes place.

In the case of a reaction missing a component, such as a polymerization reaction without catalyst, the gas counter must be reset after injecting the catalyst (see Step 4 above). Because pressure increase in the RV will be read as the generation of gas, in effect a negative gas consumption, resetting the counter is essential to avoid a negative offset to the gas consumption data.

Ending the Reaction

At the end of the run, make sure the temperature has returned to ambient and that all RVs are depressurized. As an extra precaution, press the *Manual Vent* button before opening the RVs.

Stopping a Reaction in Progress

Press the *Manual Vent* button at any time to terminate the experiment immediately. The gas supply will cease, heating will stop, and the RVs will vent.

Wait until the RVs have reached ambient temperature before opening the Endeavor system.

When using the basic or advanced software, close the program and re-launch the software before beginning another experiment.

Note: Clicking the *ABORT* button in the Endeavor Basic Software will result in the immediate release of gas from all RVs to the vent line, performing the same function as the *Manual Vent* button on the Endeavor control panel.

Caution

» Do not attempt to stop a run by turning off the power while a reaction is in progress. The RVs will remain closed and reactions will continue.

Cleaning the Injector System

To prevent clogging which could impair future experiments, it is essential to clean the injector system after each experimental run is complete. Even if the injection ports are not being used, they should be cleaned on a regular basis (every 100 runs).

Note: It is important that the injection ports be cleaned extremely well after olefin polymerization reactions.

Use the following procedure to clean injection ports.

1. Remove the stirrer assembly and place it on the drip tray (Figure 39).

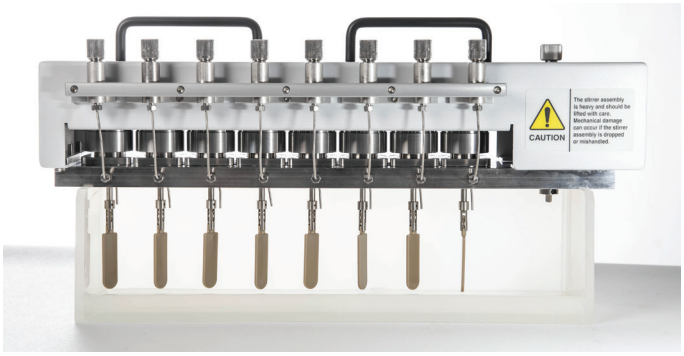

Figure 39. Stirrer assembly on the drip tray.

2. Using a supplied needle, load a 5 mL syringe with the appropriate solvent (working solvent from previous reaction).
3. Insert the needle fully into an injection port.
4. Gradually inject solvent.
5. Using a needle connected to dry nitrogen at 5 psi (≈ 0.4 bar), purge the injection port to dry the injection line.
6. Repeat steps 1 through 5 twice for all eight injection ports.

Viewing Data

The Endeavor system monitors and records three primary data sets as a function of time:

- temperature in Celsius,
- pressure in psi or bar, and
- gas consumption in millimoles.

In addition, certain system functions are recorded for diagnostic purposes.

During an experimental run the primary data can be viewed both on the system LCD and on a PC using the Endeavor Basic Software. In addition, with a PC, the data can be viewed and analyzed after an experiment using either the Endeavor software or a user-provided numerical analysis and graphing software package such as Microsoft Excel.

Viewing Primary Data

LCD

To view data on the LCD, press the *MODE* button repeatedly from any screen until the Monitor Temperature screen appears (Figure 40).

Press *MODE* again to display the Monitor Pressure screen (Figure 41).

Press *MODE* once again to display the Monitor Gas Usage screen (Figure 42).

Press the *MODE* button to continue cycling through the screens.

Temperature is shown in degrees Celsius, rounded to the nearest integer. Figure 40 shows an example with all eight RVs at room temperature.

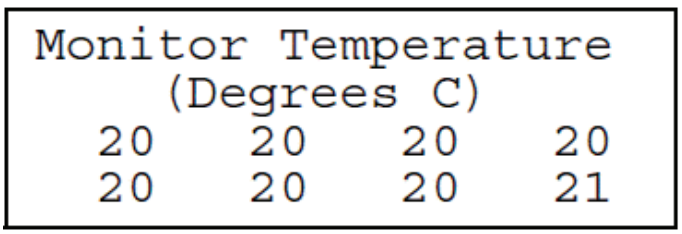

Figure 40. Temperature Data screen.

Pressure can be shown in psi or bar, rounded to the nearest integer. Refer to “Setting the Reaction Parameters” on page 17 for instructions on changing the units for pressure. Figure 41 shows an example with all eight RVs at zero psi, i.e., at atmospheric pressure.

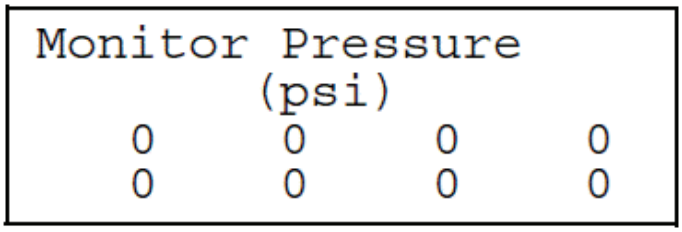

Figure 41. Monitor Pressure screen.

Warning

- If the LCD display shows "***" for any of the RVs, but the PC software shows no pressure change, the pressure inside the RV is ≥ 510 psi (≈ 35 bar).
  In this situation, the experiment must be aborted immediately by pressing the *Manual Vent* button at the lower right of the control panel, as described on page 3.

Gas Consumption is shown in millimoles (mmol) of gas, rounded to the third decimal place. Figure 42 shows an example with zero values for RVs 1 through 4.

When viewing the Gas Usage monitor screen, use the *left/right* arrows to bring the values for all RVs into view on the LCD as shown in Figure 43.

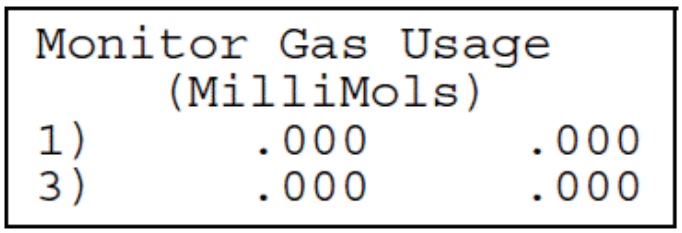

Figure 42. Monitoring gas usage—screen 1.

The values for RVs are displayed sequentially from left to right, starting with RV1 in the upper left and ending with RV8 in the lower right.

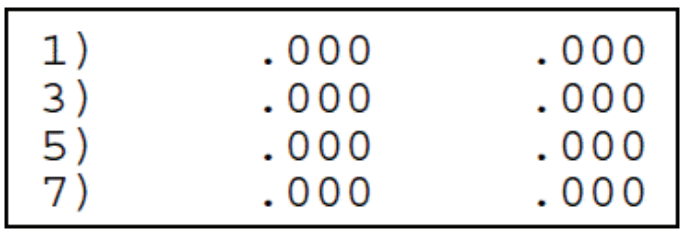

Figure 43. Monitoring gas usage—screen 2.

The displayed data is updated approximately every second to give snapshots of the progress of the experiment. After the experimental run is complete, the gas consumption values display the overall gas consumptions for each of the RVs.

Although this data is useful for monitoring the progress of a reaction and the final amount of gas consumed, the Endeavor PC software should be used to capture each data point and allow evaluation of the kinetics of a reaction.

Personal Computer

The experimental data can be plotted and recorded with the Endeavor Basic Software on a PC connected to the Endeavor with a serial cable. The procedures in the "Preparation for Experiment" chapter, particularly the items under "Starting Data Acquisition (Optional)" on page 18, describe the steps necessary to set up the software for collecting the data using a PC. Data is recorded continuously and can be displayed in real-time in several formats.

When ready to begin the experimental run, activate the Endeavor Basic Software. Click on the *Configuration* tab to display the Configuration screen shown in Figure 44.

Configuration Tab

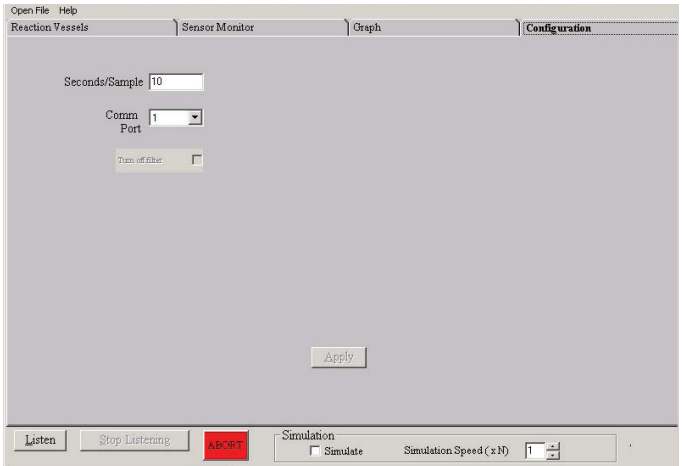

Figure 44. PC Software—Configuration screen.

Set the value in the Seconds/Sample box to the desired data sampling frequency. Select a value giving consideration to the duration of the experiment; too much data will be unmanageable whereas too little data will reduce the value of the experiment (see the table on page 18).

Note: The data sampling frequency can be adjusted during the course of the experiment.

Ensure that the Simulate box is unchecked as shown in Figure 44, start the experiment run, and click on the *Listen* button.

Stop the collection of data by clicking the *Stop Listening* button in any screen. To restart data collection, click the *Listen* button.

The Endeavor software will generate a separate file for each *Listen* period. Data collection can be started and stopped during the course of the experiment without affecting the chemistry run.

Graph Tab

Click on the *Graph* tab to display the primary data, and then click on the *All* button at the upper-left corner. The default data display of the temperature is plotted as a function of time.

Select the type of data to be displayed by checking the appropriate boxes in the *Include* panel to the right of the graph area. In Figure 45, only Temperature is checked, and the display shows a curve for each RV. Each curve is identified by the RV number and by the color indicated at the top of the window.

Above the graph, select which RV data is to be displayed. The *All* button displays data for RVs 1 through 8. The *Off* button prevents the display of all data. Click on a particular RV number button to toggle the display of the data for the selected RV.

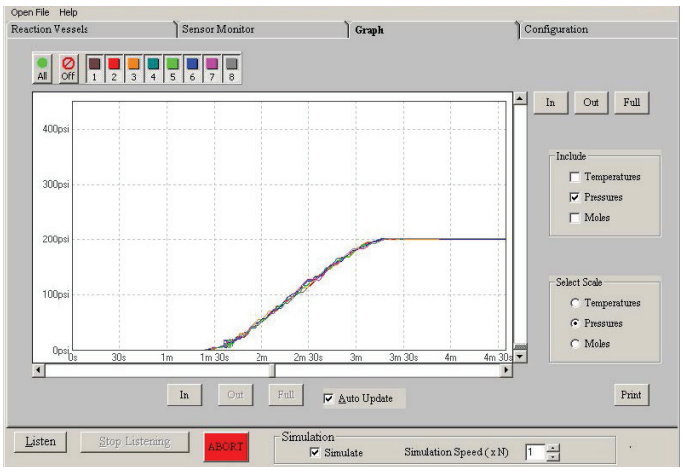

Figure 45. Selecting data for display.

Data Display can be adjusted by selecting and adjusting a data set:

- Checking a data set (temperature, pressure, or gas mmols) in the Include box toggles the display of the data.
- The data set which determines the y axis scale is chosen in the select scale box.
- Clicking the *In* or *Out* buttons zooms in or out on the appropriate axis. Click the lower buttons for the x axis and the upper right buttons for the y axis.
- Clicking *Full* scales the axis to encompass the entire data set.

» Clicking *Auto Range* adjusts the scale of the y axis to display all data points selected. For example, if Pressure is selected for the scale of the y axis, then only the pressure data will be adjusted when the *Auto Range* option is selected.

» The *x* or *y* position of the graph can be moved by clicking and dragging the scroll icons located on the bottom (*x* scale) and right (*y* scale) of the graph.

Tips for data display to provide further options for viewing data:

» Sometimes it can be difficult to determine which data set in the graph belongs to a particular RV. When in doubt, toggle the RV number button on and off. The data set for the selected RV will blink on and off.

» For large data sets, updating the entire display is time consuming. It is easier to adjust the x and y scale by first turning off all data display (*Off* button) and then selecting and displaying the desired data.

» To display data continuously as it is generated, check the Auto Update box. If unchecked, data is collected but the display is not updated until the box is checked again.

» Click the *Print* button near the lower right corner of the window to print the graph as it is displayed on the screen.

Sensor Monitor Tab

To display numerical data, select the *Sensor Monitor* tab. The values are displayed in a spreadsheet format as shown in Figure 46. Scroll through the data values using the scroll bars at the bottom and right edges of the window.

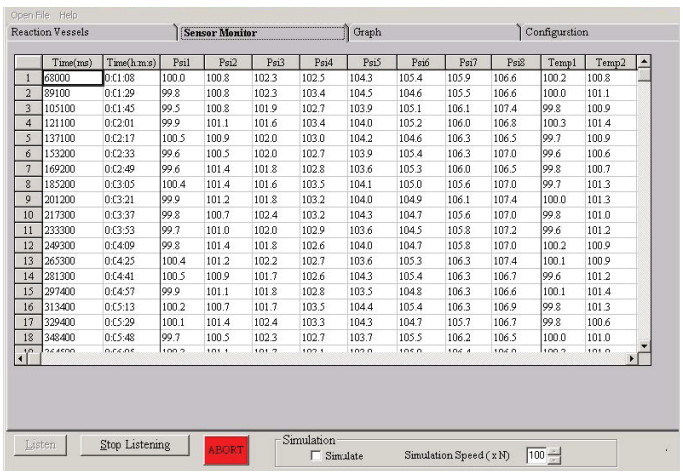

Figure 46. Sensor Monitor—time; pressure; temperature.

Figure 46 shows the time and the pressure columns for all eight RVs and the temperature column for RV1 and RV2.

Moving the bottom scroll bar to the right displays additional columns of data. Figure 47 shows the temperatures for RVs 6 through 8 and the mole count for RVs 1 through 7. Scrolling further shows additional columns containing diagnostic data that assists the service engineer in troubleshooting.

To resize a column, place the cursor over the right margin of the heading and drag it to the left or right.

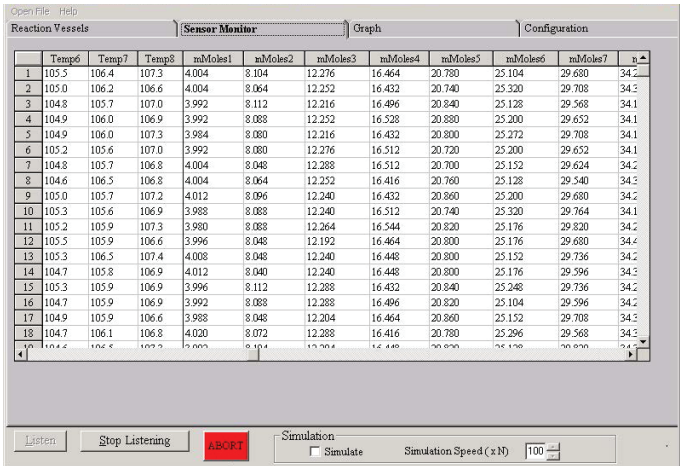

Figure 47. Sensor Monitor—temperature and moles.

Reaction Vessels Tab

The *Reaction Vessels* tab displays a schematic of the Endeavor hardware. Valves can be manually opened and closed from this tab, and the stirrer rate can be manually set.

During the experiment, the table displays the pressure and temperature for each RV.

Figure 48 shows the plumbing diagram with RVs 1 through 8 from left to right.

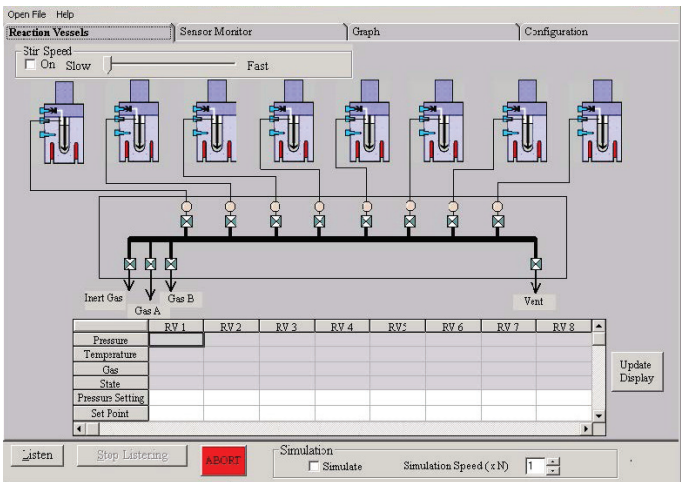

Figure 48. Plumbing diagram.

Valves can be manually opened by clicking the desired valve until the valve symbol changes to a yellow box (Figure 49).

To close the valve, click the valve again.

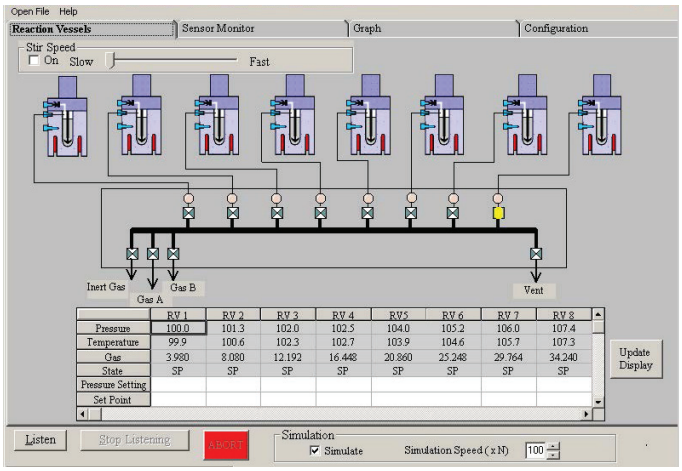

Figure 49. Valve 8 in the open position.

Analyzing Data

Data from an experiment is saved in the computer as a tab-delimited text file. The data file is automatically given a name in the format:

EndeavorLog_year_month_day_hour_minute_second.txt

For example, the file name: *EndeavorLog_2000_02_27_16_29_00.txt* corresponds to an experiment run on the 27 February 2000 starting at 16:29 (4:29 pm).

Note: Log file name extensions are *.txt* when using the Endeavor Basic Software and *.ear* when using the Endeavor Advanced Software.

If the data recording is stopped and restarted later (see “Configuration Tab” on page 23), a separate data file is generated for each ‘Listening’ period.

Biotage® Endeavor™ Software

To view data from previous experiments, start the Endeavor Basic Software and select *Open File* on the menu bar to display the *File Selection* box. Double click on the appropriate file and view the data as described in the previous section.

Third-Party Software

To facilitate analysis, processing, and presentation of data in other software, the data is stored in a tab-delimited text file. To view data in another software program, first run the program, then use the File » Open or File » Import command.

Set the File Type ‘text’ (**.txt* or **.ear*) or ‘all file types’ (**.**) to ensure the data file appears. Typically, the first two rows in an Excel file contain standard header information and can be disregarded.

The procedure applicable to Microsoft Excel is given below. Importing data into other applications functions in a similar fashion.

Importing into Microsoft Excel

Importing data from Endeavor software to Microsoft Excel is as follows.

1. Start Excel.
2. Select File » Open.
3. Choose text Files or All File types as the type of file to open.
4. Select the appropriate data file under *C:\Program Files\Endeavor*.
5. Click *Finish* in the text import window.

All data is imported into Microsoft Excel, along with the Endeavor header information.

A quick way to import a data file into Microsoft Excel is as follows:

1. Open Microsoft Excel.
2. A new spreadsheet is opened automatically.
3. Open Windows Explorer and navigate to the location of the data file.
4. Click and drag the data file into the new spreadsheet.

Care and Maintenance

Follow the procedures below to ensure safe and problem-free operation of Endeavor.

1. Clean the injector system after each experiment when it has been used.
2. Inspect the entire reactor visually before and after each use.
3. Replace and regenerate the sealing O-rings when needed.
4. Lubricate stirrer assembly gears as needed.
5. Check for leaks before every run on Endeavor.
6. Purge the gas lines and manifold of solvent as needed.
7. Clean the stirrer assembly before and after use.

Biotage® Endeavor™ User Maintenance

Follow the Endeavor user maintenance plan below to troubleshoot problems and ensure safe operation.

Biotage® Endeavor™ Reactor

- Clean and wipe down the system.
- Check source gas inlet pressure < 520 psi (≈ 36 bar).

Reaction Chamber

- Replace face seal O-rings and gland seal O-rings as needed (see “Replacing the O-Rings” on page 29). Compressed or flattened O-rings can be re-used after soaking in hot water for approximately 10 minutes. Replace O-rings if they do not return to the original shape.
- Replace glass liner gripper tubing.
- Clean RV reaction chambers with a suitable solvent.
- The inlet pressure of the source gases can be adjusted. However, the firmware has been optimized for source gas settings of 520 psi (≈ 36 bar). If the source gas inlet pressure cannot be set to 520 psi, then the source gas should be at least 30 psi (≈ 2 bar) greater than the RV set pressure.

Stirrer Assembly

- Flush and clean RV injection ports.
- Check injection ports for leaks. See the back of this document or visit our website www.biotage.com for information on contacting Biotage 1-Point Support for ordering and replacing parts.
- Inspect screws on clamps. Verify that they move freely and apply lubricant (Krytox™ LVP grease) as needed.

System Performance Test

- Perform a system self test.

Cleaning the Injector System

Clean the injector system fully after each use. Follow the procedures given in the chapter “Preparation for Experiment” on page 12. Cleaning materials include:

- a 5 mL syringe,
- the two needles supplied with the system,
- solvent appropriate for dissolving residual chemical solids from the previous runs, and
- a low pressure (5 psi or 0.4 bar) supply of dry nitrogen.

Inspecting the Injector Tubes

At a minimum, check the injector tubes after every 10 runs. Residual chemicals or injected solids can clog the injector tubes. Look for particulates or chemical residues at the end of the injector tubes where they enter the RVs. Blockage will make injection difficult or impossible.

Inspecting the Injector Valves

Figure 50 shows the two types of injector valves available. The valve on the right has a manual control lever (shown open); the valves on the left are the standard check valve.

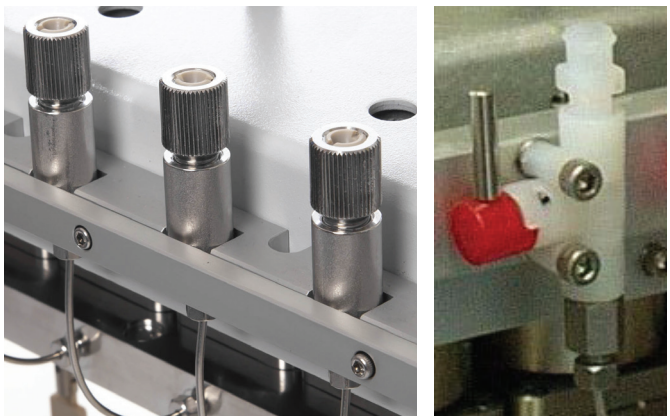

Figure 50. Injector valves.

Cleaning Injection Ports

The Endeavor solution injection port seal mechanism has three components inside: a wave spring, a disk, and a check-valve O-ring. In addition, a small O-ring inside the needle guide port is used for sealing the needle during liquid injection.

The injection port could leak due to damage or solids depositing on the surfaces of these components. Routine cleaning and inspection of these parts can prevent leaks, as described below.

Injection Port Maintenance Procedure

The following tools and materials are needed for injection port maintenance:

Tools and Materials

- 7/16" open-end wrench
- 3/32" hex key
- 1/4" open-end wrench
- Vise grip locking
- Flat screw driver
- Lint-free cloth
- Lint-free swab

Chemicals

- Ethanol or appropriate solvent
- House N_2 gas or air

Kit Contents (P/N 900810)

- Eight wave spring washers
- Eight large injection port O-rings
- Eight small injection port O-rings

Disassembling Injection Ports

1. Vent all eight RVs to 0 psi.
2. Unscrew the eight injection port nuts (Figure 51) by turning counter-clockwise with the 1/4" open-end wrench. Do not bend the injection tubes to pull them out of the injection ports. Once they are loose enough to remove by hand, proceed to the next step.

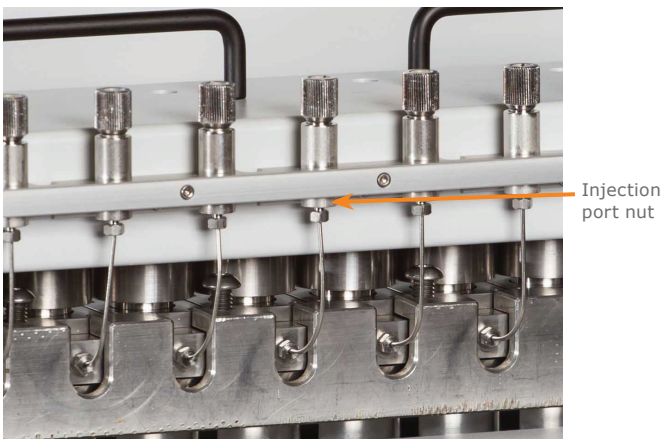

Figure 51. Injection ports.

3. Unscrew the four hex screws on the injection port clamp bar (Figure 52) using a 3/32" hex key.

Figure 52. Injection port clamp bar.

4. Carefully unscrew each injection port by hand. Do not bend or twist the injection tubes.
5. While keeping the injection port upright so that internal parts are kept inside, unscrew the injection port's needle guide (Figure 53) from the check-valve housing assembling by hand. If the needle guide cannot be removed by hand, use a 7/16" open-end wrench on the flat notch on the bottom housing. Loosen the needle guide with a vise grip.

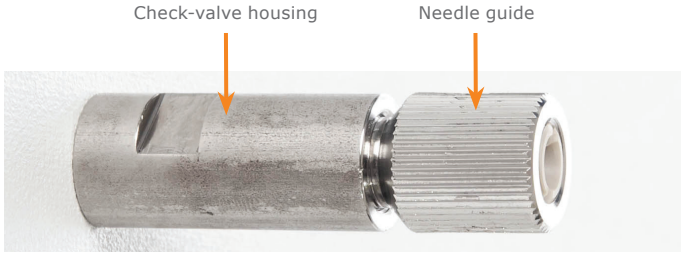

Figure 53. Injection port assembly.

6. Remove the internal parts from the housing and place them on a lint-free cloth. If the parts are difficult to remove from the bottom housing, invert the housing and gently tap it against the lint-free cloth until the parts drop loose.

Cleaning Injection Ports

Always wear solvent-resistant gloves and protective eye equipment when handling cleaning solvents. The cleaning procedure for injection ports is as follows:

1. Clean inside the housing and the needle guide surface using ethanol-soaked lint-free swabs.

   Note: It is highly recommended that all solvent-based cleaning be done inside a well-ventilated work area. If available, use an appropriate fume hood.

2. Clean the wave spring, the disk, and the large o-ring using an ethanol-soaked lint-free cloth.
3. Inject ethanol through the needle guide and into the housing several times to ensure the liquid path is clean.
4. Using N_2 gas or compressed air, dry the cleaned surface of the needle guide.

Reassembling Injection Ports

Wear clean gloves when handling the cleaned parts.
The assembly procedures for injection ports are as follows:

1. Inspect the wave spring. If the wave spring looks flat, it should be replaced.
2. Drop the wave spring into the housing. The concave side of the spring should face the bottom end of the housing.
3. Drop the disk into the housing with the end with the smaller outside diameter (OD) facing down.
4. Make sure the disk is seated at the bottom of the housing by pressing the disk with the bare end of a swab. If the disk springs back, the disk is seated properly; otherwise, continue pressing the disk gently until it touches the spring.
5. Inspect the check-valve O-ring for damage, replacing it if necessary.

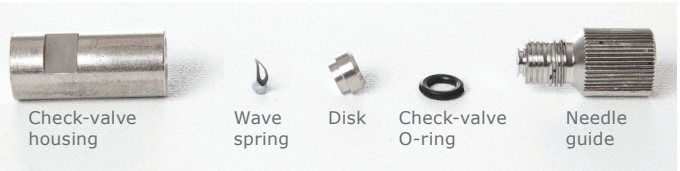

Figure 54. Reassembling an injection port.

6. Insert the check-valve O-ring on the needle guide by gently pressing on the O-ring until it is fully set in the groove (Figure 55).

Figure 55. Check-valve O-ring.

7. Gently push the needle guide into the housing until the O-ring is past the first few threads, then screw in the needle guide carefully by hand. Avoid applying excessive force, which may damage the O-ring. If you encounter resistance, push the O-ring farther down before continuing to screw in the needle guide.
8. When the needle guide is screwed tightly by hand, hold the housing flat with a 7/16" open-end wrench and hold the needle guide with a locking vise grip to gently tighten the needle guide. Do not apply excessive force.
9. Screw the injection port tubing nut into the injection port by hand. Make sure one of the flat sides on the housing faces out and the tube is not bent or twisted.
10. After tightening the tubing nut by hand, hold the injection port housing flat with a 7/16" open-end wrench and carefully tighten the injection port nut with a 1/4" open-end wrench (Figure 56).

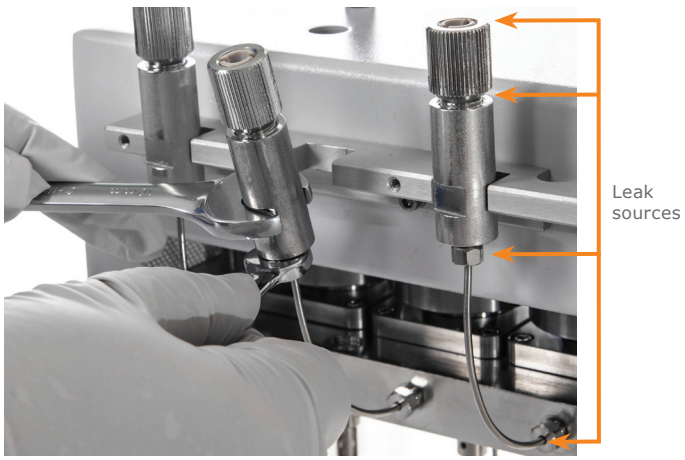

Figure 56. Leak sources.

Checking for Leaks

1. Manually pressurize the RV to 500 psi (≈ 34 bar) N_2 (or to the tank regulator setting). Place a paper towel below the injection port tubing to prevent water from dripping onto the heater block fuses or ground wires.
2. Carefully snoop the leak sources shown in Figure 56 with soapy water.
3. Watch for any bubbles. If a leak is detected, tighten and inspect injection parts again and make necessary changes before testing.

Once all eight injection ports have been assembled and checked, mount the injection port clamp bar (Figure 53).

Mounting the Clamp Bar and Stir-Plate

1. Make sure the bottom end of the injection port tubings is not touching the stirrer assembly. If necessary, gently move the tubing away from the stirrer using your hand.

Caution

» When adjusting tubing, avoid using pliers, using excessive force, or twisting the tube since this may damage the tubing.

2. Insert a glass liner into each RV chamber and mount the stir-plate on the RV chamber.

Checking for Injection Problems

1. Manually pressurize all eight RVs to approximately 350 psi (≈ 24 bar) and then inject 1 mL water into each RV using the Endeavor needle (P/N 900463) connected to a 1 mL syringe.
2. While injecting, watch for any of the following problems:
   - » Excessive resistance during injection.
   - » Bubbling during injection.
   - » Spit-back as the needle is removed.

Resistance and spit-back indicate poor sealing at the check-valve O-ring assembly in the housing, while bubbling indicates poor needle sealing in the needle guide assembly O-ring (Figure 57).

Figure 57. Check-valve housing parts.

To fix problems related to excessive resistance and spit-back, disassemble the housing and inspect the parts. Replace damaged parts and follow the installation procedure above.

Replacing the Needle Guide O-ring

To fix problems related to bubbling, unscrew the needle guide from the housing while the housing is clamped in place and disassemble the needle guide as follows:

1. Unscrew the O-ring retainer screw using a flat screwdriver. Care should be used when unscrewing the O-ring retainer, as the plastic retainer can be damaged.
2. Replace the needle seal O-ring with a new O-ring (P/N 900663).
3. When the needle guide is assembled, mount it on the housing and repeat the water injection test again.
4. When the injection test is completed, run the Endeavor automatic leak check program. Refer to the “Leak Test Procedure” on page 16 for details. Fix any leak source greater than 2 psi/hr. (≈ 0.14 bar/hr.).

Replacing the O-Rings

If the system does not pass a leak test (see “Checking the System for Leaks” on page 16, changing the O-rings of the leaking RVs can help the problem. Two of the principle sealing O-rings are located at the top sealing surface of the RV. Over time, these O-rings may become mechanically damaged—worn, nicked, broken, or appear deformed from the original annular geometry—a condition known as “compression set”.

This section describes the procedure for replacing the top sealing O-rings and a procedure for restoring compression set O-rings to return their shape as close as possible to their original geometry.

Note: Compression setting of the O-rings is common after long experiments.

Removing and Replacing the O-Rings

The O-rings that seal the top of the RV are consumable items that need to be replaced periodically. The system is supplied with AllChem chemically-resistant O-rings; however, depending on the application, either Viton or AllChem O-rings can be used. See “Appendix C: Technical Details” on page 44 for suggested use and ordering information. Figure 58 shows the two O-rings, the glass liner gripper tubing required for each RV, and their respective locations in the reactor module.

The face seal O-ring is more likely to need replacement than the gland seal O-ring. After replacing the face seal O-ring, test the system for leaks to avoid unnecessarily replacing the gland seal O-ring.

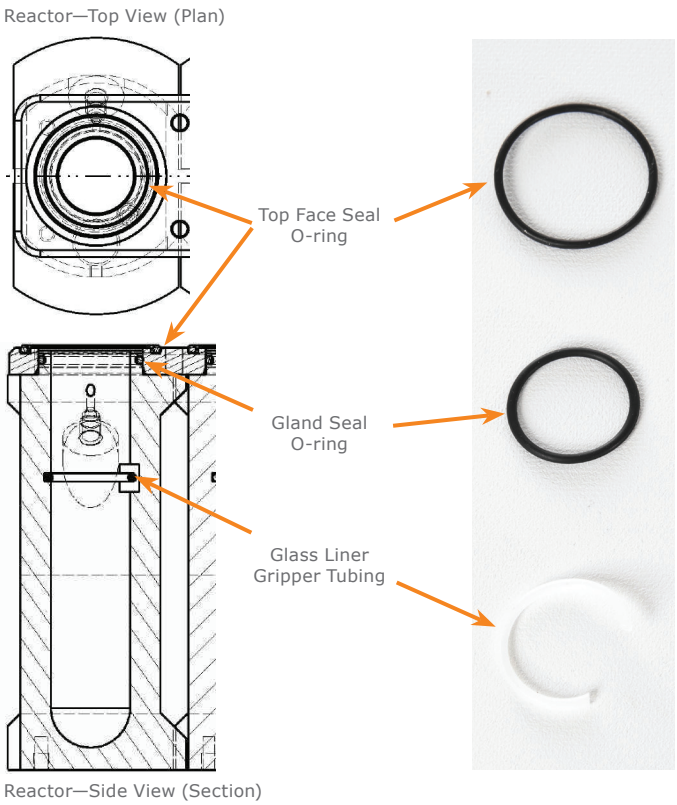

Figure 58. O-rings and glass liner gripper tubing.

Removing the Face Seal O-ring

1. Remove the stirrer assembly from the system. The face seal O-rings will be visible (Figure 59).
2. Remove the O-ring(s) in question.

Caution

» Nothing sharp or abrasive should be used to remove the O-ring. The pointed end of a tie wrap or similar tool is useful in prying the O-ring out of its groove without damaging the O-ring or groove. Avoid using anything metallic such as a needle or spatula.

3. Clean the O-ring groove on the RVs with an ethanol-soaked lint-free cloth. Remove any residual lint using compressed gas.
4. Replace O-rings with new or reconditioned parts.
5. Make sure the mating sealing surface of the stirrer assembly is also clean. A small amount of vacuum grease can be used to hold the O-ring in place if the grease will not adversely effect the chemistry.

Biotage cannot guarantee that any grease or other material used on the O-rings will not contaminate reactions.

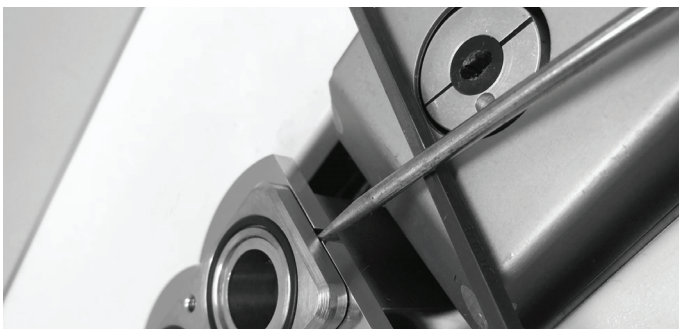

Figure 59. Leveraging the screwdriver.

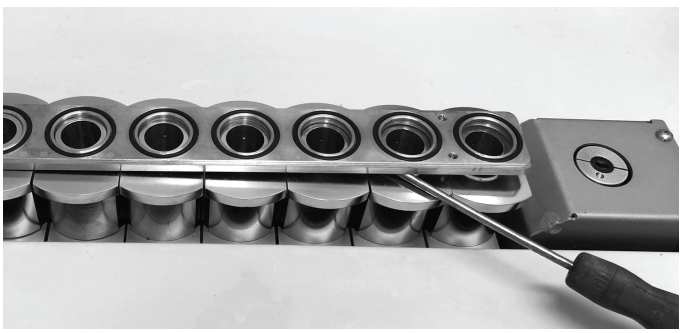

Figure 60 Removing the faceplate.

Removing the Gland Seal O-ring

The O-ring which provides the gland seal will require occasional replacement. To access the gland O-ring, the faceplate that provides the gland seal must be removed so that the gland O-rings are visible (Figure 61). Insert the tip of a screwdriver into the recess available at one end of the face plate (Figure 59), and lever it against another screwdriver or bar. When the face plate is lifted, move the screwdriver along the open edge of the face plate (Figure 60). Put the face plate on a level surface to make sure that it is flat. If it has become curved, push the face plate over a cantilevered point to reshape it.

Caution

» If the O-rings are worn, extra leverage may be required. Do not peel the face plate from the reacors. Lift it carefully.

Figure 61. Faceplate removed.

To remove the gland seal O-ring:

1. Grasp around the outside of the O-ring with thumb and forefinger at opposite points.
2. Squeeze and push inward. The forward portion of the O-ring will come out of the groove so that it can be “hooked” out with the end of the a wrap or similar non-abrasive item (Figure 62).

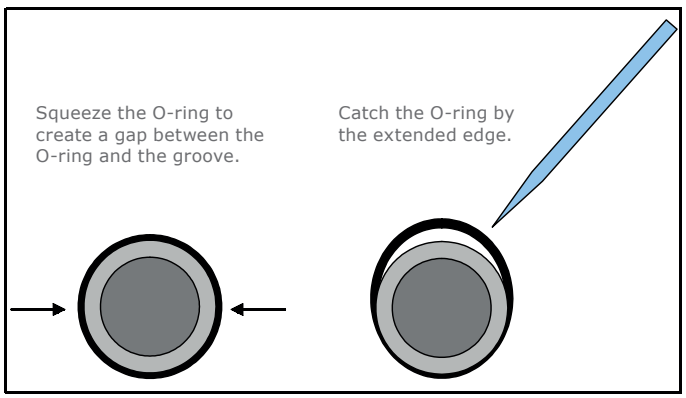

Figure 62. Removal of Gland Seal O-rings.

3. Clean the O-ring groove on the RVs with an ethanol-soaked lint-free cloth. Remove any residual lint using compressed gas.
4. Replace with new or reconditioned O-rings. See “Reconditioning Previously Used O-Rings” below.
5. Remove the four screws from the plate.
6. Clean and replace the faceplate, pushing it until it lies flush against the reactor. When the stir assembly clamps down, the plate will properly seat itself on the reactor. Ensure that the mating sealing surface of the stirrer assembly is also clean.

Caution

» Because any scratch in the retaining grove will prevent proper sealing of the RV and require replacement of the entire RV, never use a sharp object to remove an old O-ring.

Reconditioning Previously Used O-Rings

If removed O-rings are not shredded, cut, or otherwise mechanically damaged but appear flattened or squared due to compression set, the O-rings can be reconditioned to closely match the original shape.

1. Soak the O-rings in boiling deionized water. Be sure to use a Pyrex glass beaker or equivalent and bring the water to a rolling boil before adding the O-rings.
2. Allow the O-rings to swell completely (approximately 10 minutes) in the boiling water and then let the water cool.
3. Remove the O-rings while wearing a powder-free glove and dry them completely with compressed gas.

Removing the Glass Liner Gripper

The glass liner gripper tubing holds the liner in place but does not provide a seal. Replace the tubing as necessary. For example, if the glass liner can drop into the RV past the internal gripper tubing without resistance, the gripper tubing should be replaced.

1. Remove the glass liner gripper using tweezers or a dental pick (Figure 63).

Figure 63. Removal of the glass liner gripper.

2. Discard the used glass liner gripper.
3. Using alcohol and lint-free swabs, clean the groove.
4. Insert the new gripper by pinching the gripper and inserting it into the RV (Figure 64).

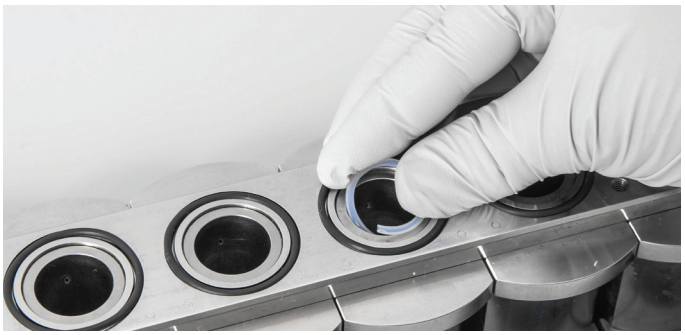

Figure 64. Insertion of the glass liner gripper.

5. To ensure the gripper is seated properly in the groove, insert and remove a glass liner half way, several times. Initially, the glass liner may be somewhat difficult to insert.

Lubricating Moving Parts

The Endeavor gear train should be lubricated every 350 hours of usage, or if the gear train appears to be laboring or making excessive noise.

Tracking the Stirrer History

Endeavor maintains a usage log for the stirrer, each of the eight heaters, and the 12 valves. The OTHER FUNCTIONS menu on the Endeavor LCD lists three options: Set Impeller Type, Perform Self Test, and Show Usage Logs.

The usage logs for the stirrer, heaters, and valves store and display the number of hours the stirrer, heaters, and valves have been on since the Endeavor system was manufactured or the system usage log was reset. The usage logs can be reset by a Biotage service engineer or may be reset when a new firmware version is installed.

To access the stirrer usage log, perform the following steps:

1. On the Endeavor control panel, scroll down to the OTHER FUNCTIONS menu and select option 7, *Show Usage Logs* (Figure 65).

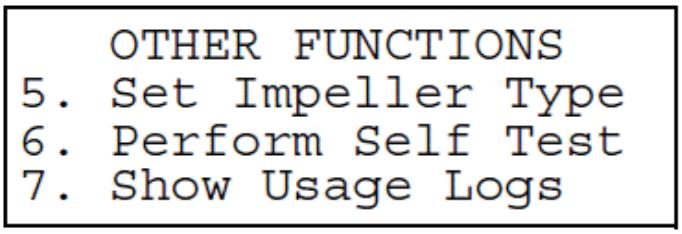

Figure 65. OHTER FUNCTIONS menu.

2. In the Show Usage Logs screen, select option 2, *Mixing Usage* (Figure 66).

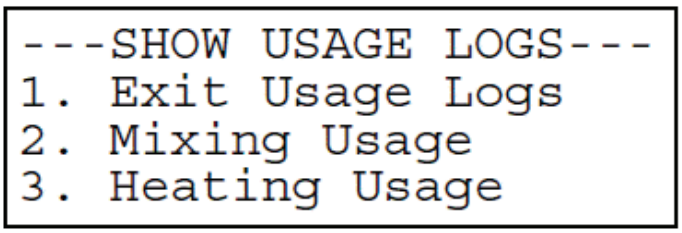

Figure 66. Selecting mixing usage log.

3. Note the agitation time currently on the system (Figure 67). Record the agitation time and the current date in the logbook.

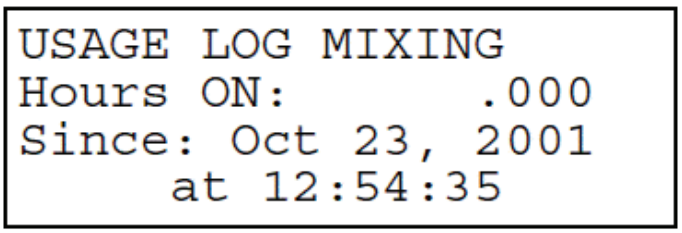

Figure 67. Usage Log Mixing screen.

4. The logbook should be routinely compared to the stirrer usage log on the Endeavor system.

Equipment and Tools

The following tools are needed to lubricate the gear train:

- A 1 mL disposable syringe.
- A 2 oz. tube of Krytox LVP grease.
- Logbook.

Perform the following steps to lubricate the gear train:

1. Remove the syringe plunger completely from the barrel.
2. Fill the syringe barrel with approximately 1 mL of Krytox LVP grease.
3. Gently replace the syringe plunger without ejecting any of the grease from the syringe.
4. If the Endeavor stir plate is in a dry box, remove the stir plate from the glove box.
5. Place the Endeavor stir plate on its side on a flat surface with the injector tubes facing up.
6. Locate the gear train under the gear cover (Figure 68). Eight 1.50" diameter gears and one 3.50" diameter gear are lined up above the stir-plate. Turn the knob for the large gear. All gears should rotate smoothly.
7. Using the syringe, apply two small spots of grease onto the teeth of each gear (Figure 68). This application should use about 20 percent of the grease in the syringe.

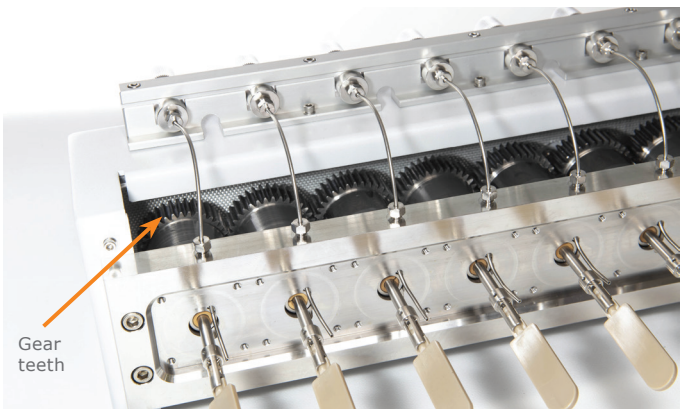

Figure 68. Greasing the gear train.

8. Rotate the knob on the large gear and lubricate the newly-exposed gear teeth. Continue rotating the gears and applying grease until the gears are completely lubricated.
9. Store the syringe and tube of grease for later use.
10. Install impellers on the eight stir shafts and replace the Endeavor stir plate. Clamp the stir plate in place.
11. Set the agitation speed to the lowest possible setting and agitate for 10 minutes at this speed. The system is now ready to use.
12. Routinely compare the logbook to the Endeavor mixing usage record.
13. At a minimum, the Endeavor gear train should be lubricated every 250 hours of usage if run at 500 rpm, and every 125 hours at 1000 rpm.

Checking for Leaks

Each Endeavor system is fully leak-tested prior to shipping and upon installation (maximum acceptable leak rate is 2 psi/hour). The system should be rechecked for leaks after it is reinstalled or moved, after any modifications to the gas lines, or whenever a leak is suspected. See “Leak Test Procedure” on page 16. RV leaks can develop due to dirty, damaged, deformed, or flattened (due to “compression set”) O-rings, injection ports contaminated with solid particles, loose compression fittings, or other disruptions to a seal.

Warning

- A leaking RV may result in complete solvent loss from the RV during an Endeavor run. Take appropriate safety precautions against possible reactions of dry catalysts or reagents in the event of complete solvent loss.

Purging the Gas Lines

If the Endeavor system is vented at higher temperatures, the high vapor pressure of the solvent may cause solvent to condense in the gas lines to the RVs, as well as in the manifold. Solvent can be removed from the gas lines and manifold by purging with inert gas. Use the *Reaction Vessel* tab in the Endeavor PC software to manually open and close the appropriate valves. Flushing the gas lines and manifold with inert gas can remove residual solvent. The gas lines should be flushed after each experiment.

Warning

- Do not stand directly in front of the system while purging gas lines. The gas inlet to the reactors is angled forward and can eject trapped solvent out in the absence of the stirrer assembly.

Cleaning the Stirrer Assembly

Warning

» Solvents could be trapped under the O-rings around the paddles. Personnel working with or near the Endeavor system must wear protective clothing, safety gear, and eye protection that have been approved by applicable local and national safety regulations

If the Endeavor system is operated at temperatures near or above the boiling point of the solvent (at reflux temperatures), solids can deposit on the stirrer assembly. These deposits can be removed by rinsing the stirrer assembly with solvent.

Troubleshooting

Proper routine maintenance of the Endeavor system will minimize the need for service. This chapter lists some common problems along with probable causes and solutions.

Common System Problems

Impeller Stirring Interference

The impeller may cause stirring problems if:

- Impellers are not inserted fully or correctly.
- Glass liners are not fully inserted.
- Injection tubes are touching impellers.
- Glass liners can be broken due to loose-fitting liners, poor gripper tubes, or the presence of glass shards from a previously-broken liner in the RV chamber.

To resolve impeller problems, refer to “Removing Liners” on page 12 and “Changing Impellers” on page 14.

Glass Liner Residue

Although some residue is expected during certain chemical reactions, residue not related to the chemistry run may deposit in the glass liners if:

- Impeller assembly shaft is worn.
- Glass liners are not fully inserted.
- Impellers are loose.
- Injection port tubes are bent.
- Unfiltered gas and unclean gas liner tubes are being used.

For information on removing and cleaning liners and impellers, refer to “Removing Liners” on page 12 and “Changing Impellers” on page 14.

Biotage® Endeavor™ System Leaks

Refer to “Checking the System for Leaks” on page 16 for information on identifying leak sources.

- Damage to the sealing O-rings.

  Replace the O-rings. Refer to “Replacing the O-Rings” on page 29.

- Uneven sealing of the stirrer assembly.

  Be sure to tighten the stirrer assembly clamps symmetrically and gradually. Refer to “Tightening the Clamps” on page 15.

- Accumulation of material at the sealing edge of the stirrer assembly.

  Clean the recessed portion of the stirrer assembly thoroughly. Refer to “Cleaning the Stirrer Assembly” on page 33.

- Worn seals.

  Use ‘snoop’ or soapy water to see if bubbles are generated at any seals in the pressure system.

  If injection ports leak, follow the “Leak Test Procedure” on page 16.

  Note: If working in a glove box, use the working solvent instead of ‘Snoop’ or soapy water to see if bubbles are generated in the pressure system seals.

- No heat transfer fluid.

  Add approximately 1 mL of transfer fluid to the space between the glass liner and the reactor. Either reaction solvent or oil can be used as a heat transfer fluid.

- Consumption too high.

  Gas consumption counter not set (re-nulled) subsequent to addition of catalyst.

  RV run without impeller. The calculation is based on head space volume, which includes an impeller.

- Negative mole consumption.

  Thermal equilibrium was not achieved. Use an extended Wait For or Wait command.

- RV temperature drops.

  Check the heater or thermocouple error type and notify Biotage 1-Point Support immediately. To check the error type, press and hold *Mode* on the Endeavor control panel until the Temperature screen appears on the LCD display.

  If **Htr* or ***** appears on the screen, open the general user interface terminal box and enter “herr,1” (substitute the appropriate RV number for 1) and click the *Send Cmd* button.

- Wrong impeller type.

  Change the impeller type before running the experiment. To change the impeller type, press and hold *Mode* until the OTHER FUNCTIONS screen appears.

  Press and hold the right arrow to scroll down to the Set Impeller Type step, then press *Mode* again. Press the + or - keys to toggle between the Anchor and Paddle type impellers. When the correct impeller type is displayed, press *Mode* again to set the selected impeller type.

- Total gas consumption comparatively high in one RV, and the gas consumption curve does not flatten out, but continues with a positive slope after the reaction is complete.

  Possible injection port leak. Check the O-rings and the gas line connections.

» Injection port leaking.

Check the injection line to see that there is a slight downward slope into the Reactor. This will ensure that residual material does not remain in the injection line, preventing the formation of polymeric material specific to polyethylene chemistry.

» Leaking RV system.

Follow the “Leak Test Procedure” on page 16 to identify and fix the leak source.

» Inaccurate quantity

The Qty calculation is based on ideal gas, but the gas used may not be the ideal. Two possible methods for checking quantities are as follows:

a. Use pressure data points and calculate using the ideal gas law, the van der Waals equation, or another model appropriate to the gas used. Turn pressure regulation off to perform this calculation.

b. Use an HPLC or other means of measurement to quantify the final product.

Verify the operation by comparing the analysis of the product, such as the millimoles used or the percentage of the conversion, with the results of a standard hydrogenation reaction. Some gas will dissolve in the reaction liquid.

» Excessive stirrer assembly vibration.

Install an impeller on every RV, regardless of whether the RV is used in the chemistry run.

Pressure Reading Fluctuation

» Pressure reading exhibits gradual fluctuations over several hours.

The lab temperature is unstable and is causing pressure fluctuations in the RVs.

Pressure Parameter Adjustments

For background information on the firmware algorithm used by the Endeavor system to attain and regulate pressure, see “Appendix C: Technical Details” on page 44. The pressure algorithm for the Endeavor system has been optimized at Biotage using nitrogen and helium with a regulated input tank pressure of 520 psi (≈ 36 bar). The optimization attempts to balance three key constraints in the pressure system: uniform pressure ramping, minimized set point overshoot, and time to pressure.

For some Endeavor systems, a 520 psi tank pressure is not possible, and a lower tank pressure must be used. Other systems may utilize a gas other than hydrogen or helium. In these cases, the pressurization algorithm may not perform optimally with the factory default parameters installed. For instance, if the ramp time to set point is longer, the system may start pressurizing correctly but fail to reach the set point, or an unwanted amount of overshoot may occur.

When the pre-set pressure ramp algorithm does not meet the requirements for unique experiment conditions or a specific facility setup, the pressure parameter adjustment procedure can be used to adjust two of the pressurization algorithm parameters: maxpulse and pboost.

The pressurization algorithm on the Endeavor system controls pressurization by pulsing the manifold inlet and RV control valves for brief time periods. The *maxpulse* parameter relates to the pulse durations the RV valves use during ramping and pressure maintenance. The *pboost* parameter relates to how the algorithm adjusts pulse durations during pressure maintenance and as the system approaches the set point.

Both commands have an array of several parameter values. Only certain values of the parameters typically need to be adjusted, and each RV valve may have different values for sending a serial command from the Endeavor software to the Endeavor instrument.

Caution

» Adjusting the parameters of the Endeavor system should be done with caution and only within the guidelines of this document. Incorrect adjustment of these parameters may result in poor pressurization performance.

All adjustments should be recorded in a record or log book.

Preparing for Parameter Adjustments

Prior to adjusting parameters, complete the following actions:

» Perform three or more pressure ramp cycles successively to check for system variability. This is especially important if the system has been idle for an extended period.

» Perform a leak check according to the specifications (see “Leak Test Procedure” on page 16 and verify that the leak rate is < 2 psi/hr. for RVs 1 through 8 and 3 standard cubic centimeters per minute for valves 9 through 12.

» Verify that the external tank pressure is set to 520 psi (≈ 36 bar). For situations where the tank pressure cannot be set to 520 psi (because that pressure level is not available), be sure to set the pressure to at least 50 psi (≈ 3.4 bar) over the highest pressure set point of the chemistry run.

Accessing the Terminal Console

Pressure parameters are adjusted through the *Terminal Control* screen. To access this screen, click once on the word 'Simulation' located at the bottom of the main screen of the Endeavor software (Figure 69).

Note: If using the Endeavor Basic Software, click twice on the word 'Simulation'.

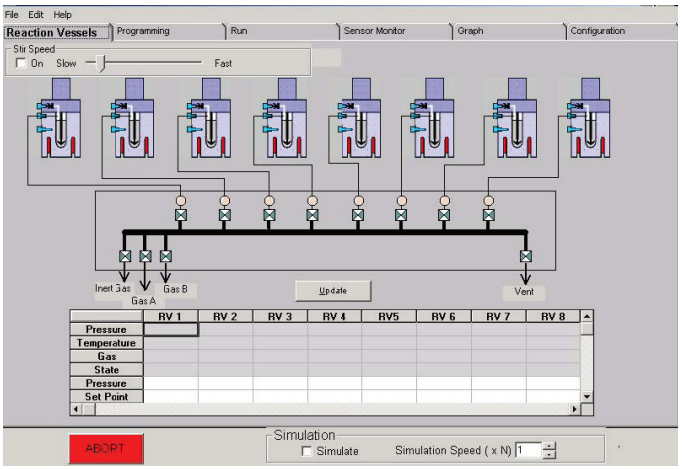

Figure 69. Main screen of Advanced Software.

The *Terminal* button appears next to the *Abort* button (Figure 70).

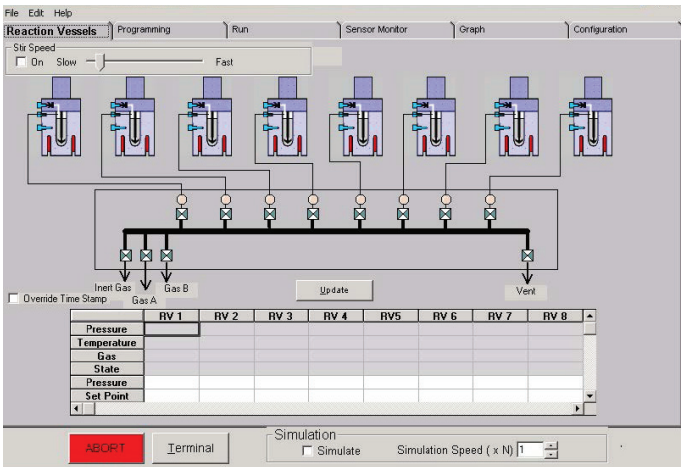

Figure 70. Terminal and Abort buttons in Endeavor main screen.

Click on the *Terminal* button to open the *Terminal Console* screen (Figure 71).

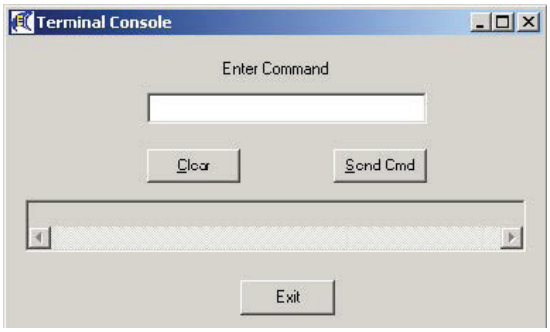

Figure 71. Terminal Console in the Advanced Software.

Pressure Parameter Adjustment Troubleshooting

The adjustment of the *maxpulse* and *pboost* parameters depends on how the algorithm is to be adjusted. Follow the troubleshooting steps below based on the aspect of the ramping algorithm that needs to be adjusted.

Pressurization Step Is too Slow

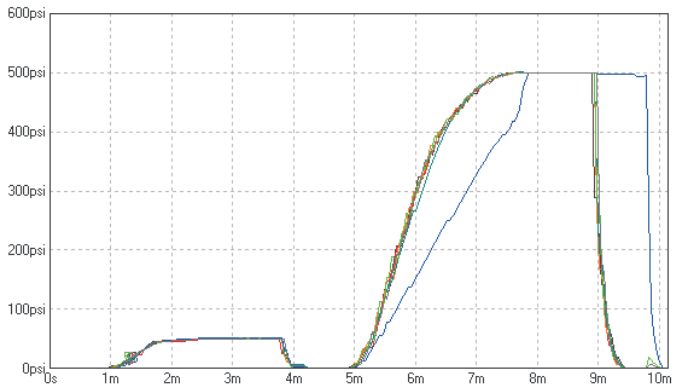

Figure 72. Slow ramp up on one RV.

If the pressurization is too slow for a specific RV (Figure 72), adjust the *maxpulse* parameter as follows:

1. Open the Terminal Console in the Endeavor software and type *maxpulse,n* (where n is the valve number 1 through 8); then click on the *Send Cmd* tab. The software reads the current values on the Endeavor system for the selected RV. Copy the response line back into the Send Command window. Remove the "G" and edit the values as necessary.

   Note: Valve numbers match RV numbers. For example, RV 3 uses control valve number 3.

2. The default *maxpulse* values for all RVs are: 3,15,15,1.6.
3. Increase the second and third *maxpulse* parameters (e.g., *maxpulse*,n,3,*18*,*18*,1.6) and click on the *Send Cmd* tab. Do not adjust any of the other values on the screen. Increasing the second and third values increases the maximum pulse width allowed during ramp up. In effect, this increases the maximum gain allowed during the ramp.

Note: Typically, values for the second and third maxpulse parameter are in the range of 3 to 10. Some gases may require larger increases. The second and third parameter can be increased up to 1000; however, the maximum value should be less than 35. Check for overshoot at lower pressures. Overshoot is often most visible at low-pressure settings, such as 50 psi (≈ 3.5 bar). See Figure 73 below.

4. Re-check the pressurization ramp.
5. Repeat the *maxpulse* adjustment as necessary.

If adjusting the maxpulse parameters still does not improve the top end of the pressure ramp, and the slow ramp is inside the region within 14.5 psi of the set point, then adjustment of the pboost parameters may be helpful.

Pressurization Ramp too Slow at the Beginning of the Pressurization Step

The most obvious symptom would be a gradual increase in pressure at the beginning of a pressure ramp. Alternatively, excessively large initial pressure pulses on one or more RVs may be observed. See Figure 73.

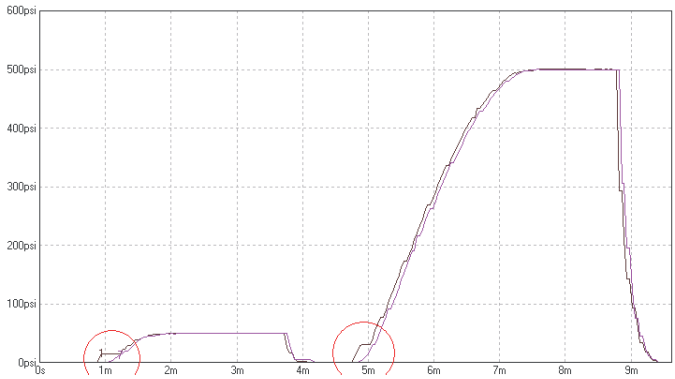

Figure 73. Large initial pressure pulse.

Increasing or decreasing the first *maxpulse* parameter can correct this problem. The first parameter is the initial pulse width used by the algorithm.

Adjust the *maxpulse* parameter as follows:

1. Open the Terminal Console in the Endeavor Software and type *maxpulse,n* (where n is the valve number 1 through 8); then click on the *Send Cmd* tab.
2. Increase the first parameter (e.g., *maxpulse*,n,*5*,15,15,1.6) and click on the *Send Cmd* tab. Do not adjust any other values on the screen.
3. Re-check the pressurization ramp and repeat the maxpulse adjustment as necessary.

It is possible to combine adjustments to the first, second, and third *maxpulse* parameters to affect an overall ramp time increase. Check performance throughout the desired pressure range and with each gas that is used.

Caution

» Excessive *maxpulse* parameter increases leads to overshoot and poor pressure control. See Figure 74 below for an example of excessive overshoot at 50 psi (≈ 35 bar) with high *maxpulse* parameters.

Pressurization Ramp Overshoots the Set Point

Adjustments to both the *maxpulse* and *pboost* parameters may be needed.

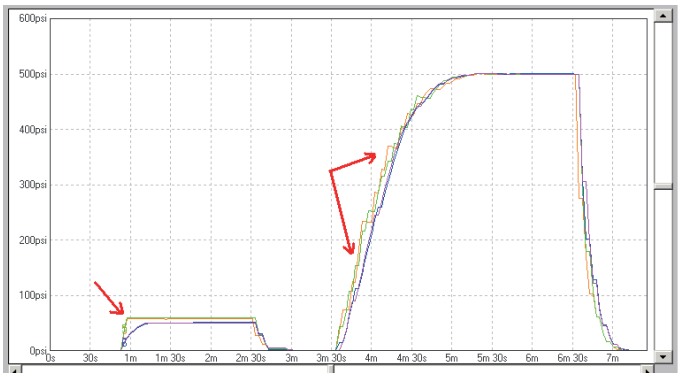

Figure 74. Poor control and overshoot.

Adjust the *maxpulse* parameters first:

1. Open the Terminal Console in the Endeavor Software and type *maxpulse,n* (where n is the valve number 1 through 8); then click on the *Send Cmd* tab.
2. Reduce the second and third *maxpulse* parameter values (*e.g.*, maxpulse,n,3,10,10,1.6).
3. Re-check the pressurization ramp.

If pressure overshoot is still high, reduction of the second *pboost* parameter value may be required. Refer to “Pboost Parameter Adjustments” below.

Pboost Parameter Adjustments

The *pboost* parameter controls a set of five parameters that are only active inside a 14.5 psi band around the pressure set point. These parameters can be broken into two separate groups:

» The first group of three parameters assists in the prevention of pressure spikes due to a plunger that is momentarily “stuck” to the valve seat because of friction or adhesion, which can be part of normal valve operation.

» The second group of two parameters is used to regulate pressure at the set point. These parameters adjust the pulse width for the next valve actuation depending on the performance of the previous valve actuation.

Note: Adjustment of the *pboost* parameters is uncommon. Prior to adjustment, carefully read the pressurization algorithm description provided in “Appendix C: Technical Details” on page 44.

Pressure "Spikes" Prior to Regulation

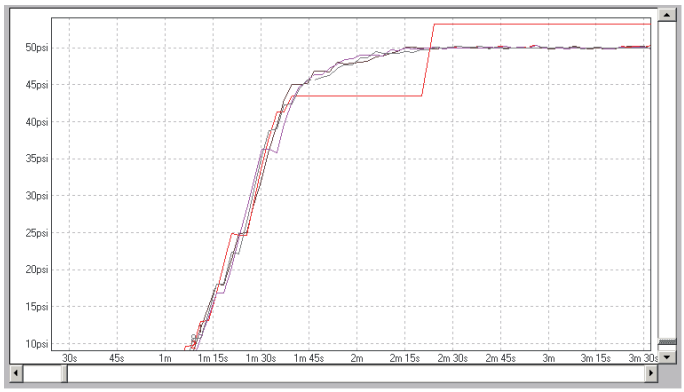

Figure 75. Pressure spikes.

Reduction of the second *pboost* parameter may be needed.

Adjust the *pboost* parameter as follows:

1. Open the Terminal Console in the Endeavor Software and type *pboost,n* (where n is the valve number 1 through 8); then click on the *Send Cmd* tab.
2. The default *pboost* values for all RVs are: 7,20,0.050,0.040,0.065.
3. Reduce the second *pboost* parameter (e.g., *pboost*,n,7,*18*, 0.050,0.040,0.065) and click on the *Send Cmd* tab.

Pressure Set Point Not Reached for One or More Set Points

This problem may be caused by high first or third *pboost* parameters, or the second *pboost* parameter may be low.

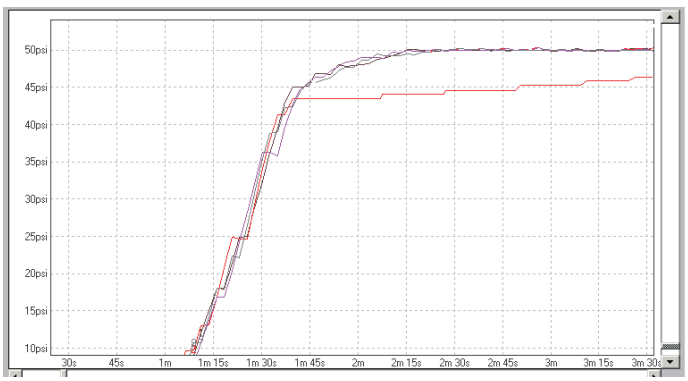

Figure 76. Unmeet set points goals.

Adjust the first three *pboost* parameters as follows:

1. Type *pboost*, n in the Terminal Console box and click on the *Send Cmd* tab.
2. To increase the second parameter value, edit the value (e.g., *pboost*,n,7,*25*,0.050,0.040,0.065); then click on the *Send Cmd* tab. This will increase the number of addition cycles performed prior to resetting the algorithm.
3. If the pressure overshoot is too high, reduction of the second parameter value in the pboost may be required (e.g. *pboost*,n,7,*18*,0.050,0.040,0.065.
4. If pressure overshoot still too high, increase the third parameter value of *pboost* (e.g. *pboost*,n,7,18,*0.065*, 0.040,0.065).
5. Repeat the *pboost* adjustment as necessary.
6. If the ramp is too slow, decrease the third *pboost* parameter value (e.g. *pboost*,n,7,25,*0.040*,0.040,0.065) and test pressurization again.

Poor Regulation at Set Point

Adjustment of the second group of parameters in the *pboost* parameter may be required. Regulation problems at set point are typically seen during gas consumption when the pressure is actively being regulated to the set point.

Parameters 4 and 5 of the *pboost* parameter are percentages that are used to add or subtract milliseconds from the current and subsequent valve pulse width:

- Increasing parameter 4 causes larger increases to the pulse width when a pulse has not succeeded to reach 1 psi (≈ 0.07 bar) over the set point.
- Increasing parameter 5 decreases the pulse width during the next pressure maintenance step if a pulse results in a pressure rise greater that 1 psi (≈ 0.07 bar) over the set point.

Adjustments are performed as above; however, testing can only be performed while a system is regulating.

Software Not Communicating

- No data is recorded.
- Error message "method ~ of object ~ failed" appears when starting the Endeavor Basic Software.

  This problem occurs when multiple programs claim the use of the same communications (com) port on the computer. To troubleshoot this communication conflict:

  - If using the Windows NT operating system, check the com port configuration of any programs included in the Windows startup directory.
  - Check to see if external devices such as handheld computers, modems, scanners, or other external hardware devices are connected to a com port.
  - Communication programs such as Terminal and Hyperterminal may claim the com port is in use although no connection is actually active.
  - Some laboratory equipment software drivers may claim the com port, even when the application itself is not running.
  - Switch to a different com port under the *Configuration* tab in the Endeavor software to ensure that no port conflicts exist. After changing com port software settings, switch the cable to the newly-selected com port.

Improving Reproducibility

This section lists several operational aspects for Endeavor that can improve the reproducibility of the system.

Reagent Measurements

Accurate and precise measurement techniques while preparing reagents for a reaction will help improve system reproducibility.

Liquid Volume Measurements

- Use a gas-tight glass syringe with a luer-lock connection and a PTFE plunger to increase the consistency of results.
- A 15 gauge non-disposable needle is recommended.
- Check delivery gravimetrically.

Catalyst Variations

Variations in the amount of catalyst added to the RV can impact the reaction rate, depending on the particular reaction.

- Use an analytical balance with a precision of at least 0.1 mg.
- Keep the target range for the measurement tight, and record the exact amount of catalyst added.
- If weighing paper is used, tare the paper, accurately weigh the catalyst required, add catalyst to the RV, and re-weigh the weighing paper. Subtract any residual catalyst.

Programming the Reaction

The order of the Endeavor programming steps is important to ensure consistent results.

Agitation Settings

Rapid gas transfer into the reaction solvent occurs when agitation is turned on. With agitation turned off, gas transfer is much slower. Therefore, when performing a "purge" cycle with the reactant gas prior to initiating a run, agitation should be turned off.

Additionally, it is recommended that agitation is turned on after the RVs reach the programmed temperature and pressure set points. This minimizes the amount of reaction occurring prior to the start of the mole count recorder. In cases where the reaction gas is used to purge the RVs while temperature ramping is in progress, it is strongly recommended that the amount of gas consumed during this time be determined.

Temperature Set Points

When specifying a temperature set point, it is recommended to program a "Wait For" temperature that will occur prior to the pressurization step of the run. Then program a 10 to 30 minute WAIT time to allow the RV temperature to reach equilibrium.

The WAIT time depends on the temperature set point:

- Use a 10 to 15 minute WAIT time for set temperatures less than 40°C.
- Use a 20 to 25 minute WAIT time for set temperatures between 40 and 100°C.
- Use a 30 minute WAIT time for set temperatures greater than 100°C.

When pressurizing, a "Wait for Pressure" step should be used to ensure that all RVs are at the set pressure prior to agitation and the initiation of the mole counter.

Note: Prior to starting the run, reset both the software and the instrument. To reset the instrument, turn the main power switch off and then back on. To reset the software, close the Endeavor software application and then restart the program.

Analyzing Data

A spreadsheet can be created to calculate the average and standard deviation of the mole consumption and reaction rate data. The following Microsoft Excel functions are referred to in this section:

AVERAGE()	Average
STDEV()	Standard Deviation
*100 *(rsd)/(average)*	% Relative Standard Deviation (rsd)

Typically, the precision for the eight RVs for a run will be less than or equal to 10 percent rsd. Other considerations for data analysis include the following:

- The average mole consumption may not match the theoretical value based on stoichiometry due to non-ideal gas behavior or absorption of gas into the solvent and reaction products.
- Accuracy is dependent on several factors: temperature, pressure, solvent type, gas type, mixing speed, catalyst amount, and reagent concentration.

Adjusting the Mole Scale Factor

In some situations, it may be desirable to "scale" the mole consumption results from one or more RVs to bring the RVs in question into closer agreement with the other RVs in the Endeavor system.

The Endeavor firmware (version 2.3 or higher) has scale parameters for each RV that can be set to values ranging from 0.5 to 1.5. The default value, 1, has no scaling. For example, entering a scale factor of 1.4 for a particular RV would cause the reported mole consumption to increase by 50 percent. Likewise, a scale factor of 0.5 would result in a 50 percent decrease in the reported mole consumption.

Required Equipment and Tools

A PC with either the Endeavor Basic Software or Endeavor Advanced Software installed must be connected to the Endeavor system for scale factor adjustments.

Procedure for Entering Scale Factors

1. Scale factors are adjusted through the *Terminal Control* screen. To access this screen, click the word "Simulation" located at the bottom of the main screen (Figure 77).

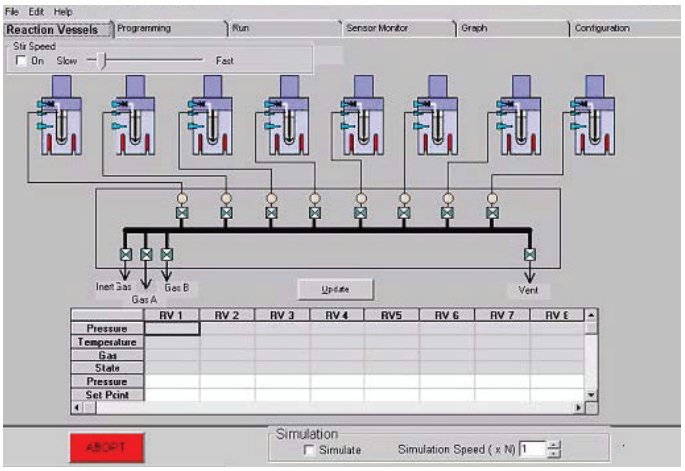

Figure 77. Click "Simulation" from the main screen.

Note: If using the Endeavor Basic Software, click twice on the word "Simulation".

2. The *Terminal* button appears next to the *Abort* button (Figure 78).

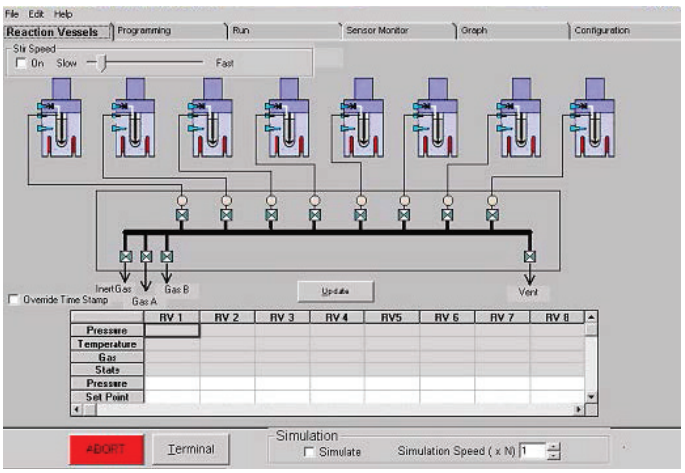

Figure 78. Abort and Terminal buttons.

3. Click the *Terminal* button to open the *Terminal Console* screen (Figure 79).

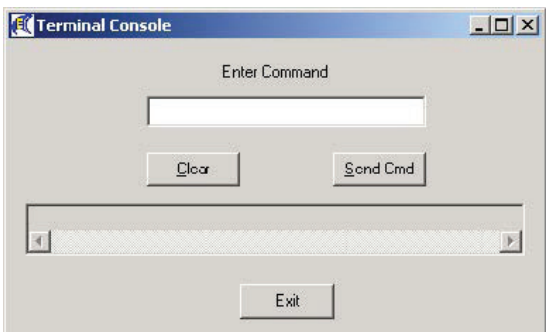

Figure 79. Terminal Console screen.

4. To enter an RV mole consumption scale factor, type *molescale,RV#,scalefactor* in the *Terminal Console* screen and click the *Send Cmd* button.

   Example: For a 1.2 scale factor on RV5, type *molescale,5,1.2* and click the *Send Cmd* button.

5. The default value is 1. Repeat for other RVs if necessary.

Appendix A: Glossary

Anchor Impeller	Mixing impellers shaped similar to a boat anchor; ideal for solutions containing solids.
Blade Impeller	Mixing impellers with a long flat blade.
cP	Centipoise, units of viscosity.
Firmware	Programmed code resident in read-only memory circuit chips within the Endeavor system. This code controls Endeavor components such as valves and the stirrer motor. Abbreviated *F/W*.
GUI	Graphical User Interface.
Glass Liners	The glass tubes, sealed inside the RVs, in which reactions take place.
LCD	Liquid Crystal Display.
PEEK	Polyetheretherketone.
Precision	The degree of mutual agreement among a series of measurements or results.
Purge	To remove or replace one gaseous environment with another.
Quench	To end a reaction with the introduction of a reaction-stopping gaseous or liquid reagent.
rpm	Rotations per minute.
rsd	Relative standard deviation, given in a percentage; the rsd is calculated as: (sd/(Avg) * 100.
RV	See *Reaction Vessel*.
Reaction Vessel	The eight pressure vessels machined into a solid block of 316 stainless steel precisely sized to hold glass liners. Abbreviated *RV*.
Reactor Block	The reactor block has eight reaction vessels for parallel pressure reactions. Heating, stirring, and solvent additions are performed on the reactor block.
Reagent	General: A chemical reactant dissolved in a solvent.
Rinse Solvent	A solvent which is effective in rinsing its associated reagent. Usually the solvent in which the associated reagent is dissolved.
Solvent	General: A liquid with the ability to dissolve a material and form a homogeneous mixture or solution.
Standard Deviation	A statistical measure of precision. Abbreviated *sd*.
Stirrer Unit	Provides stirring via magnetically coupled removable impellers; also has injection ports for the manual addition of reagents to individual reaction vessels.

Appendix B: Checklists

Installation Checklist

The Endeavor system installation checklist should be completed prior to installation. For questions regarding installation, please contact Biotage 1-Point Support (see contact information on the back of this document or visit our website www.biotage.com).

Biotage® Endeavor™ Installation Checklist

Facility Name:_____

Primary User Name:_____

Phone:_____

Lab Phone: _____

E-mail:_____

System Information and Configuration

System Serial Number:_____

Computer Serial Number:_____
(If supplied by Biotage)

Missing or Damaged Items

- Check for missing items from the shipment. Check the ship list versus the actual items shipped. Notify Biotage 1-Point Support immediately if any items are missing or defective.

Lab Readiness

Prior to installation, make sure the lab facility meets the following requirements:

- 100 to 120 VAC or 200 to 240 VAC, 50 to 60 Hz circuit, 15 Amp, stable electrical power.
- Up to three gas sources for inert, reactive gas 1, reactive gas 2, or quench gas. High pressure gas is regulated to 520 psi maximum, with stainless steel tubing to connect to 1/8" male flare fittings.
- Enough space in the fume hood for the instrument, with sufficient ventilation to meet applicable requirements as stated in the Facility Requirements form.
- Computer (optional) that meets the hardware and software specifications stated in the Facility Requirements form.

System Setup

To ensure the system is set up correctly, complete the following items:

- Open all boxes and crates and configure the instrument on the bench.
- Make all necessary pneumatic and electronic connections. Make sure all connections are sound and secure and that there are no leaks.
- Verify that the latest firmware version is loaded on the controller.
- Verify that the proper instrument parameters are set and a copy is saved.

Performance Verification

Complete the following items to ensure the instrument performs properly:

- Check for agitation and stirring at various rates and speeds without stalling.
- Perform a leak test on all manifold valves. Pressurize using nitrogen to 500 psi; then close valves at 500 psi and ensure there is no drop below 498 psi in two hours.
- Perform a heater test. Run a temperature reaction to 200°C in each chamber and verify that the instrument can achieve and maintain the temperature regulation for 30 minutes.
- Perform a gas uptake test. Using equal volumes of water in each RV, run a pressure/temperature reaction and verify that the pressure, temperature, and gas uptake data are within the specifications.

Basic Training

In order to properly run a reaction and work with the instrument, operators should become familiar with the following items and tasks:

- Overview of Endeavor instrument, accessories and terms and definitions.
- Overview of flow diagram and description of flow paths.
- Hardware operation.
- Installation and removal of impellers, glass liners, and stirrer assembly.
- Front panel control.
- Software operation and use (basic and/or advanced software, as appropriate).
- Manual control.
- Post-reaction cleaning of reactor stage area and chambers.
- Cleaning of upper reactor area on stirrer assembly plate.
- Flushing and cleaning of injector ports and lines.
- Glass liner internal resistance ring replacement and removal.
- Pressure sensor calibration.
- Impeller clamp mechanism cleaning.
- O-ring inspection and replacement.
- Leak testing.
- Describe and identify consumables; determine typical quantities.
- Biotage support structure and support contact information

Installation Acceptance

Following the installation, the installation technician will request the customer to sign a completed copy of the following Endeavor Installation Acceptance form. A copy of the form is sent to Biotage.

Biotage® Endeavor™ Installation Acceptance Form

The following checklist is used to verify that the operation and functionality of the Endeavor system meets the specifications of Biotage. This acceptance form helps ensure customer satisfaction with the installation and provides a guideline for the installation technician.

- Facility lab readiness verification.
- Packing list inventory.
- System installation.
- System performance verification.
- System overview.
- Basic user maintenance.
- Consumable and spare parts re-ordering.
- Warranty and Service Contracts.
- Technical Service and Support Hotline.

Comments:_____

_____

By signing below, the customer acknowledges acceptance of the instrument as installed per Biotage specifications.

_____

Customer Name (Printed)

_____

Customer Authorized Signature

_____

Date

_____

Biotage Representative Name (Printed)

_____

Biotage Representative Signature

_____

Date

Appendix C: Technical Details

This chapter discusses details of calculation assumptions and chemical compatibility related to the Endeavor system.

Gas Consumption

The gas consumption calculation is based on measuring the pressure drop, knowing the head space volume and gas temperature, and applying the ideal gas law (PV = nRT). As a default, the head space volume assumes the standard impeller geometry (the blade-type impeller).

The impeller type can be modified via the Endeavor control panel. The headspace is 20.56 mL when using the anchor-type impeller and 20.09 mL when using the blade-type impeller. The blade-type impeller is referred to as Type 1, and the anchor-type impeller is referred to as Type 2.

Note: The default impeller is Type 1; however, the default can be changed from the Set Impeller Type screen found in the OTHER FUNCTIONS menu on the Endeavor control panel.

Stirring Speed

The maximum stirring speed is 1000 rpm. It can take up to 50 seconds for a change in stirring speed to take effect.

Chemical Compatibility

Part	Environment	Material	Not Acceptable
Glass Liner	liquid	borosilicate	HF, concentrated HCl, NH_4F
Impeller	liquid and gas	PEEK	Aqua regia concentrated acid HCl HBr HF Phosphoric acid > 40% Sulfuric acid Nitric acid < 15%
Impeller Shaft	gas	316 stainless steel	
Reaction Vessels	gas	316 stainless steel	
Gas Manifold	gas	316 stainless steel	
Gas Valves	gas	316 stainless steel	
Pressure Transducer	gas	316 stainless steel	
Injector	liquid and gas	316 stainless steel, PEEK, AllChem	

Table 1. Chemical compatibility.

Caution

» 316 stainless steel can corrode in the presence of acids and chlorine gas. The Endeavor system should be stored in a non-corrosive environment.

Various Chemical Resistances

This section should be used as a guide for chemical resistivity of common laboratory chemicals toward materials utilized in the Endeavor instrument.

A = Resistant
B = Moderately resistant
C = Not suitable

Resistance at 20°C	PEEK	Polyethylene	Polypropylene	PTFE	Tefzel	FKM
Acetaldehyde	A					C
Acetic acid (20%)	A	A	A	A	A	C
Acetic acid (80%)	A	A	A	A		
Acetic acid (glacial)	A	A	A	A	A	C
Acetone	A	B	A	A	A	C
Acetonitrile	A			A	A	
Acrylic acid	A					
Ammonia, anhydrous	A					C
Ammonia (10%)	A	B	A	A	A	
Ammonia (liquid)	B					
Ammonium hydroxide	A	A	A	A	A	A
Aqua regia	C					
Aromatic hydrocarbons	A	B	C			
Benzene	A	B	C	A	A	A
Benzoic acid	A					
Benzaldehyde	A					C
Bromine/dibromoethane	C					
Bromine (dry)	C					
Bromine (wet)	C					
Boric acid	A					
Butanol	A	A	A	A	A	
Calcium hydroxide	A					A
Carbon tetrachloride	A					
Chlorine (gas)	A					
Chorine (liquid)	C					
Chloroacetic acid	A	B	B	A	A	C
Chlorobenzane	A					A
Chloroform	A	B	B	A	A	A
Cyclohexane	A	B	C	A	A	A
Cyclohexanone	A	C	C	A	A	
Diethylamine	A	C	A	A	A	
Diethylether	A					
Diethylformamide	A	A	A	A	A	
Dioxane	A				A	
Ethanol	A	B	A	A	A	A
Ether	A	B	C	A	A	
Ethylacetate	A	B	A	A	A	C
Ethylene chloride		B	B	A	A	
Ethylene glycol	A	A	A	A	A	A
Heptane	A	B	B	A	A	
Hexane	A	B	B	A	A	

Resistance at 20°C	PEEK	Polyethylene	Polypropylene	PTFE	Tefzel	FKM
Hydrobromic acid (100%)	C	B	B	A		
Hydrobromic acid (20%)	C	B	A	A	A	
Hydrochloric acid (100%)	A		B	A	A	
Hydrochloric acid (20%)	A	A	B	A	A	A
Hydrofluoric acid (100%)	C		B	A	A	A
Hydrofluoric acid (20%)		A	A	A	A	
Hydrogen peroxide (100%)	A	B	B	A		
Hydrogen peroxide (50%)	A	B	B	A	A	
Hydrogen peroxide (10%)	A	A	A	A	A	
Iso-octane	A		A	A		
Isopropanol	A	A	A	A		
lsopropyl ether		A	B	A		C
Ketones	A	B	B	B		
Methanol	A	A	A	A	A	B
Methyl dichloride			C			
Methyl ethyl ketone	A	B	B	A	A	
Methylene chlorlde	A	B	B	A	A	B
Nitric acid (100%)	C	B	C	A	A	
Nltric acid (20%)	A	B	A	A	A	
Pentane	A	C	C	A		
Perchloric acid	A	B	B	A		
Phenol (dilute)	A					
Phenol (conc,)	C					
Phosphoric acld(100%)	A	B	A	A	A	
Phosphoric acid(40%)	A	A	A	A	A	
Potassium hydroxide (dilute)	A					A
Potassium hydroxide (70%)	A					
Propanol	A					
Pyridine	A	B	A	A	A	C
Sodium hydroxide (80%)	A	B	A	A		
Sodium hydroxide (20%)	A	A	A	A	A	A
Sulphuric acid (100%)	C	B	B	A	A	
Sulphuric acid (75%)	C	A	A	A	A	
Sulphuric acid (40%)	A	A	A	A	A	
Tetrahydrofuren	A	B	B	A	A	
Toluene	A	B	B	A	A	
Trichloro acetic acid	A	A	A	A	A	
Trichloroethane	A		B	A		
Trichloroethylene	A					A
Triethylamine			C	A	A	
Water	A	A	A	A	A	A
Water (distilled)	A	A	A	A	A	
Xylene	A					

Table 2. Chemical resistance to solvents.

Pressurization Algorithm Functional Description

The algorithm used by the Endeavor system to attain and regulate pressure is based on a proprietary algorithm. The major consideration is driven by the manner in which the valves must be opened. The valves leading to the RVs are not allowed to fully open during pressure ramp up and regulation.

The valves are prevented from fully opening because the pressure inside the source manifold is assumed to be well above the desired regulation point and the time that the valve plunger requires to cycle from fully closed to fully open and back would produce unacceptable performance. Instead, the plunger inside the valve is gently lifted off the valve seat for a few thousandths of a second. This provides a small "leak" of pressure across the valve seat.

This calculated pressure release is further complicated by statistics and by natural friction and adhesion. Unlike conventional control loops, a pulse of a known duration does not always produce the same response. Valve plungers may stick to the valve seat until sufficient energy is introduced to "pop" the plunger free. All the while, the algorithm must strive to prevent pressure spikes generated when a valve is popped open.

Pressurization Algorithm Functional Description

The algorithm works as follows:

At the beginning of a pressure ramp up the software calculates a table of pressure regions starting at ambient pressure and ending at the set pressure. Each region is assigned incremental pressure per valve pulse goals.

When the ramp is initiated, the algorithm uses an initial pulse width (PWi). After the first actuation, a pressure reading is performed and compared to the goal for that pulse. The pulse width PWi is incremented proportional to the goal. The pulse width (PW) may continue to increase up to a maximum limit (PWmax).

Each valve for all RVs is sequenced in order. Valves may be skipped during this sequence in order for lagging RVs to catch up (added at version 2.3). This procedure is followed until the pressures are within a 14.5 psi (≈ 1 bar) range of the set point. Inside this region, additional control is added to the algorithm because statistics, friction, and adhesion may cause a single pulse to produce excessive overshoot as the set point is approached.

The additional control loop adds a distance factor (Unmet Goal Boost) to the proportional component of the loop with a boundary condition that limits the number of cycles (Unmet Goal Limit) the Goal Boost can add before the algorithm backs off by the (Unmet Goal Drop Pct) and attempts a fresh pass at a pulse width calculation.

Statistically, under normal conditions, this extra portion of the loop is not required. Once the pressure set point is attained, the algorithm has calculated a pulse width that typically produces a response that allows regulation within specification.

At this point, the algorithm enters a band regulation mode and issues pulses to maintain the set point. The pressure is allowed to fall 1 psi below the set point and then an attempt is made to adjust the pressure up to 1 psi over the set point. The increase in pressure for each pulse is monitored, and the pulse width for the next valve cycle is adjusted slightly up or down by a percentage (Regulation Boost Pct and Regulation Drop Pct) depending on the delta between pulse goal and measured pressure.

Maxpulse and Pboost Parameters

The following table lists the definition and limits for the *maxpulse* and *pboost* parameters.

Maxpulse	Default	Minimum	Maximum
PWi (initial Pulse Width mS)	3	2.5	1000
PWr (not Used; Set Same as PWmax)	15	2.5	2000
PWmax (Maximum PUlse Width mS)	15	3	2000

Pboost	Default	Minimum	Maximum
Unmet Goal Boost (1/24 Psi)	7	1	100
Unmet Goal Limit (count Number)	20	1	100
Unmet Goal Drop Pct (percentage)	0.05	0.01	1.0
Regulation Boost Pct	0.04	0.01	1.0
Regulation Drop Pct	0.065	0.01	1.0

Table 3. Maxpulse and pboost limits.

See "Pressure Parameter Adjustments" on page 35.

Gas Types: Time to Pressure

The following table includes some typical results as measured on Endeavor for the "time to pressure set point" for various gases at 50 and 500 psi or 3.5 and 34 bar (individual results may vary).

	Time to Pressure	
Gas Type	**50 Psi (≈ 3.5 Bar)**	**500 Psi (≈ 34 Bar)**
Hydrogen	~ 1 min	~ 2 min
Helium	~ 1 min	~ 2 min
Nitrogen	~ 1 min	~ 4 min
Argon	~ 1 min	~ 5 min

Table 4. Time to pressure table with different gas types.

Appendix D: Advanced Software

The Endeavor Advanced Software (EAS) increases the flexibility of experimentation and expands the capabilities of the Endeavor instrument. Specifically, the EAS allows greater flexibility in the sequence of operation events than the basic firmware provides. In addition, the EAS allows special operations, such as ending the experiment on the basis of gas consumption instead of time.

Introduction

Prerequisites

Before reading this chapter or using the EAS, install and become familiar with using the Endeavor Basic Software for data acquisition.

Requirements

The EAS requires that firmware version 1.5 or higher must be installed, and a controller board with a minimum of 1 MB memory must be installed and enabled.

Support

If any problems are encountered while using the EAS, contact Biotage 1-Point Support directly. Be prepared to report in detail the circumstances involved with the problem. This detailed problem description assists the support group in reproducing the problem and enables Biotage to quickly remedy any issues. It is also recommended that you e-mail a detailed problem description and any supporting run files related to the problem directly to Biotage 1-Point Support. See contact information on the back of this document or visit our website www.biotage.com.

Operational Sequence

1. Prepare the instrument components (chemicals, sealing, and other items for the run). See “Preparation for Experiment” on page 12.
2. Open the EAS.
3. Click on the *Programming* tab.
4. Drag and drop the desired sequence of experimental steps.
5. Enter the appropriate parameters.
6. Click on the *Run* tab.
7. Click on the *Start* button.
8. The software verifies that the parameters are valid and prompts the user to save the data file.
9. The instrument performs the experiment and collects data.

Data and Program Files

Files generated by the EAS have the extension **.ear* and are in a tab- delimited text format. The first section of the data includes experimental steps and parameters; the second section contains the experimental data. Data in an **.ear* file is automatically placed into separate rows and columns when imported into a spreadsheet program such as Microsoft Excel.

The files can be loaded by selecting File » Open from the drop-down menu in the EAS. The software displays, “Do you wish to load sensor monitor data?”:

- Select *Yes* to load the data and experimental parameters for that particular experiment.
- Select *No* to load only the experimental parameters.

Loaded experimental parameters can be used to perform an experiment under identical conditions.

The EAS can open data files generated previously using the basic software. To display the basic software **.txt* files, select File » Open and choose All file types *.* in the File Type drop-down menu. EAS automatically reads these correctly.

The two file types (**.txt* and **.ear*) differ in significant ways:

- **.txt* files do not contain experimental parameters.
- In **.txt* files, the sequence of columns is: time, pressure, temperature, mmols, etc.
- In **.ear* files, the sequence of columns is: time, mmols, pressure, temperature, etc.

In both files the units for gas consumption are mmols.

Macros

A convenient *Make Macro* button in the *Programming* tab allows the selected experimental steps and parameters to be saved under a user-defined name. These macros can then be used in the same way functions are used when designing experiments; they can be dragged and dropped into the desired sequence of experimental steps. See “Operational Sequence” on page 48.

Stop and Abort Buttons

There is one *Stop* button and one *ABORT* button in the EAS.

- The large red *ABORT* button performs the same function as the *Manual Vent* button on the Endeavor control panel.
- The small rectangular *Stop* button, which appears only in the *Run* tab section after starting an experiment, seals when clicked.

Main Functions

The main functions are listed in the Main Functions pane in the general order in which they are to be used. The following functions have no control panel equivalent:

- *Wait*
- *Wait For*
- *Note*

The main functions are explained in detail in this section.

Synchronization

Some functions can be applied to individual RVs; other functions can be applied to all RVs simultaneously. The EAS will wait until all RVs complete certain commands before proceeding. Specifically, all RVs must complete previous steps before the following functions can be performed:

- *Purge*
- *Stir*
- *FillManifold*

Details of Functions

Stir

Control Panel Equivalent	*Agitate*
Values	Off; 250 to 1000
Units	rpm
Description	This function sets the speed of stirring to the value entered and applies to all RVs simultaneously.
Notes on Use	The change in stirring speed is not instantaneous; it can take up to 50 seconds to reach 1000 RPM.

Purge

Control Panel Equivalent	*Purge*, cycle options
Values	Gas (Inert, Gas A, Gas B)
Units	Number of cycles
Description	This function determines how many times the entire RV block is purged, and with which gas.
Notes on Use	Purging can be done only at times when pressure regulation is not being used. A *purge* cycle always leaves the RVs with the purge gas present. To avoid diluting the reaction atmosphere, a final purge must be done with the reactive gas prior to pressurization. For glove box operation, purging after a reaction helps prevent contamination of the glove box atmosphere when removing the stirrer assembly.

ExtendedPurge

Control Panel Equivalent	None
Effect	Purges the system with two different gases, each successively for the specified number of cycles.
Values	Gas (Inert, Gas A, Gas B)
Units	Number of Cycles (blank, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
Description	This function allows for two successive purge cycles, determining how many times the entire reactor block is purged, and with which gases.
Notes on Use	This function combines two purges to allow purging of two different gases.

Heat

Control Panel Equivalent	*Temp*, temperature
Values	10 to 200
Units	Temperature in Celsius
Description	This function turns on the heater, ramps the temperature to the entered set point value, and maintains that value for the individual RVs.
Notes on Use	This function is used to raise the temperature above the current value. To lower the temperature below the current value, use the *Cool* function to reduce the temperature setting. The program proceeds to the next function after initiating the *Heat* function. To make the program wait until the heating is complete and the set point has been reached, use the *Wait For* function.

Pressurize

Control Panel Equivalent	*PSI*, pressure
Values	Inert, Gas A, Gas B; On (default value), Off; 0 to 500 psi (0 to 33 bar)
Units	psi or bar
Description	This function fills the manifold with the selected gas, ramps the pressure to the given set point value, and maintains that value for the individual RVs.
Notes on Use	This function is actually three functions grouped together for convenience: » *FillManifold* selects the gas used to pressurize the RVs. This is a system parameter, and the RVs can only be pressurized with one gas type at a time. » *Gas Pressurize* specifies the set point for the RV. A value of 0 (zero) prevents an RV from being pressurized. » *Pressure Regulate* controls whether or not the pressure is maintained once the system reaches the set point. Pressure Regulate ON means that as the reactor consumes gas, the system will replenish the gas to keep the pressure constant. Pressure Regulate OFF allows the pressure to decay within the RVs as the gas is consumed.

Note: In reactions with low levels of gas consumption, running with *Pressure Regulate* set to OFF can yield a lower rsd on millimole uptake data due to the noise generated by valve events.

Start Run

Control Panel Equivalent	*Count*
Values	Individual, AllTogether, OnKeyPress
Units	None
Description	This function sets the gas consumption counter to zero and starts the reaction clock.
Notes on Use	This function must be followed by the *Run Until* and *Stop Run* functions. *Individual* This option starts each RV as soon as the RV has reached its set temperature and pressure. This is equivalent to starting the count on individual RVs. *AllTogether* This option starts all RVs simultaneously when all RVs have reached their set temperatures and pressures. This is equivalent to the *Count All* operation on the control panel. *OnKeyPress* This option is used when the *Count* function is initiated from the control panel. This is useful for operations that require user intervention, such as manual injection.

Run Until

Control Panel Equivalent	*Run*
Values	Up to 99 hours, 59 minutes, 59 seconds; 0.01 to 100 mmol
Units	Gas consumed in millimole or time in [hms] format
Description	This function determines how long an RV remains at the set conditions. The first specified condition stops the RV.
Notes on Use	To allow the run to continue when the specified mmol consumption is reached, enter a zero or leave the cell blank. A Timeout value must be entered even if the intent is to stop on a particular gas usage (0 and blank are not allowed). If there is no value in the Timeout cell, and the Gas Usage value is not reached, the RV will run indefinitely until stopped manually. This function must be preceded by *Start Run* and followed by *Stop Run*.

Seal Vessel

Control Panel Equivalent	No direct equivalent
Values	None
Units	None
Description	This function stops pressure regulation and keeps the RV sealed until all RVs reach the *Stop Run* step.
Notes on Use	This command is performed for each RV when it is ready. *Stop Run* with the Seal option performs the identical command, but only when all RVs are ready. This function allows user to seal the RV, cool the RV, and purge.

Note: The basic difference between the *Seal Vessel* and *Stop Run* functions is as follows:

- The *Stop Run* with the Seal option seals RVs and turns off the RV heater indefinitely, but no regulation of pressure occurs. The operator can break the seal by either removing the stirrer assembly or manually venting the system.
- The *Seal Vessel* function seals the RV and turns off the heater for the RV that reaches the set point first until the remaining RVs are completed. Once all RVs reach the *Stop Run* step, the program proceeds to the next step and can either seal or vent.

Stop Run

Control Panel Equivalent	*End Type*
Values	Seal, Purge, Quench, Vent
Units	None
Description	This function determines RV events after completion of the reaction. The selected action is applied to all RVs when the last RV is finished. This step automatically turns off the heater and pressure regulation.
Notes on Use	This function applies to all RVs. For reactions at elevated temperatures, the reactor block atmosphere will contain a large amount of solvent.

Caution

- The Seal function must be used to keep the RVs sealed until the temperature drops. Purge, Quench, or Vent opens the RV immediately at reaction completion, resulting in the venting of reactor gases into the manifold. Venting in the manifold can cause vapors to condense throughout the gas lines and manifold, resulting in clogging or contamination of the gas lines.

Cool

Control Panel Equivalent	*Temp*, temperature, new value during a run
Values	10 to 200
Units	Temperature in Celsius
Description	This function turns off the duty cycle to allow the RVs to cool to the set point value and maintains that value for individual RVs. This function does not turn the heater off, but is used when lowering the temperature of an RV while maintaining thermal control by regulating the heater duty cycle.
Notes on Use	The program proceeds to the next function after initiating the *Cool* function. To make the program proceed to the next function after reaching the set point value, use the *Wait For* function. Because Endeavor does not have a cooling system, the time value should be long enough to allow the temperature to ramp down. The rate at which it cools depends on ambient conditions. Generally, the setting for the timeout should allow 1 minute for every degree of temperature differentiated for the RV. For example, when cooling from 100 to 25°C, set the timeout for 75 minutes. Because the Endeavor instrument waits only as long as needed to reduce the temperature, it is better to overestimate the timeout. This function is used to lower the temperature below the current value. To raise the temperature above the current value, use the *Heat* function.

Wait

Control Panel Equivalent	None
Values	Up to 99 hours, 59 minutes, 59 seconds
Units	Time in [hms] format
Description	This function provides a hold period in the program which must be completed before proceeding to the next step.
Notes on Use	This function can be used to ensure equilibration at any step in the program before *Start Run*. For example, *Wait* can be used to ensure that a solid has completely dissolved by allowing the system to stir and heat for a desired time. It can also be used to allow the reactor temperature to reach a steady state.

Wait For

Control Panel Equivalent	None
Values	0 to 200°C; 0 to 500 psi or 0 to 34.5 bar; up to 99 hours, 59 minutes, 59 seconds
Units	Temperature in Celsius, or psi or bar, or time in [hms] format
Description	This function makes the program wait until a desired temperature or pressure is reached before proceeding to the next step. Because the instrument waits only the minimum amount necessary before proceeding to the next step, it is better to overestimate the timeout than to underestimate the wait.
Notes on Use	A reasonable timeout value must be entered in case the desired temperature or pressure is not reached.

Note

Control Panel Equivalent	None
Values	256 characters
Units	Text and numeric
Description	This provides a way to insert comments into the program.
Notes on Use	This can be used to explain why certain experimental steps were taken, or to note when a manual procedure such as an injection must be performed.

Hidden Features

Because the EAS is designed to be easy to use, many features are hidden from view. The display clearly presents commonly used features and provides an overall picture of the software without the clutter of many small details. However, these hidden features can be accessed by selecting Show Hidden Functions in the *Programming* tab.

RV Volume

Effect	Shows the volume in an individual RV.
Units	mL
Description	The volume tab is a notebook feature to aid in calculations of mole consumption and is mandatory.

Regulate

Effect	Maintains set pressure for individual RVs.
Units	On/Off
Description	This feature determines whether the pressure of the RV is maintained at the set pressure for the duration of the experiment.
Notes on Use	*Regulate* with the on option maintains a set pressure for the duration of the experiment. However, in a gas consumption experiment, entering off for the *Regulate* option causes the pressure to drop as gas is consumed.

FillManifold

Effect	Fills the system with gas.
Units	Inert, Gas A, Gas B
Description	Prepares the system for the next gas control step.

GasPressurize

Effect	Pressurizes individual RVs to set value.
Units	psi or bar
Description	This feature ramps the pressure to the given set value for individual RVs.

Include Vessel

Effect	Allows one or more RVs to be activated or included during an experiment and deactivates other RVs.
Units	On/Off
Description	This feature can be used to exclude an RV or a group of RVs from an experiment. When less than eight RVs are used in a run, the *Include Vessel* function must be used to specify which RVs should be used and which RVs should remain inactive.

Valves 1-8

Effect	Allows individual On/Off control for valves 1 through 8.
Units	On/Off
Notes on Use	Valves 1 through 8 are controlled using the *Valves 1-8* command. To open the valve, set the parameter to On. To close the valve, set the parameter to Off.

Note:
Valve 9 = inert gas
Valve 10 = Gas A
Valve 11 = Gas B
Valve 12 = Vent

Valves 9-12

Effect	Allows individual on/off control for valves 9 through 12.
Units	On/Off
Notes on Use	Valves 9 through 12 are controlled using the *Valves 9-12* command. Specify *RV1* for valve 9, *RV2* for valve 10, *RV3* for valve 11, and *RV4* for valve 12. RVs 5 through 8 should be set to *Off* in the *Valves 9-12* command. Valve 9 is controlled through the parameters in the column labeled RV1. Valve 10 is controlled by the column labeled RV2. Valve 11 is controlled by the RV3 column, and Valve 12 is controlled by the RV4 column.

Note: The *Valve* control function should not be used during the pressurization step.

Hidden Feature

To activate multiple EAS applications, follow the steps below:

1. From the Start menu, launch the EAS. Drag the application window to the left side of the screen. Launch another new window of the EAS.
2. (Optional) Create a shortcut to the EAS on the desktop. Double click the icon to launch another instance of the application.
3. In the second application, open the *EAS Configuration* tab. If the second application's RS232 communication port is not the intended com port (or is in use), change it and click on the *Apply* button.
4. Exit the second application and start it again.

Note: If an RS232 communication port error appears, follow the instructions in step 3 to select another port.

Viewing Data in the EAS

Viewing data in the EAS is similar to viewing data in the Endeavor Basic Software (see "Viewing Data" on page 22).

The EAS provides added features and functionality as follows.

Viewing Real Time Data

During the course of the experiment, real-time data can be viewed in the *Reaction Vessel* tab. Pressure, Temperature and Gas (consumption) are displayed. The State refers to the line of the program currently in use.

Recording Valve Events

The *Sensor Monitor* tab, in addition to recording the pressure, temperature and millimole consumption, records the number of valve events (opening and closing of the valve) and the step of the program being run when the data is collected, referred to as the State. The Sample columns are for the use of service engineers and to contain data related to the status of the instrument during the experiment.

Entering and Editing Data

Notes on data entry and editing are as follows:

- Entire rows or columns cannot be copied or deleted.
- To remove macros or functions, highlight the top cell of the macro in the operations column and use the delete key on the keyboard.
- The contents of a cell are not automatically over-written and must be deleted first prior to re-entering data.
- The delete key on the keyboard should be used to clear contents from a cell.

Example Experiment

This example illustrates how to program a simple experiment in which:

- The RVs are purged with inert gas.
- The RVs are purged with reactive gas.
- The RVs are brought to temperature and pressure.
- The mmols count is reset, signaling the start of the reaction.
- Stirring is started.
- The system is allowed to run until the specified moles are consumed.

For brevity, the operational steps of loading and sealing the Endeavor instrument are omitted here. These steps are described fully in the chapter “Preparation for Experiment” on page 12.

Step 1. Start the EAS, click on the *Programming* tab, and fill in the Notebook section for records (optional).

In the RV Volume row, enter the volume of the solution (1 to 5 mL) to be used in each RV (mandatory) in the appropriate columns for each RV (Figure 80).

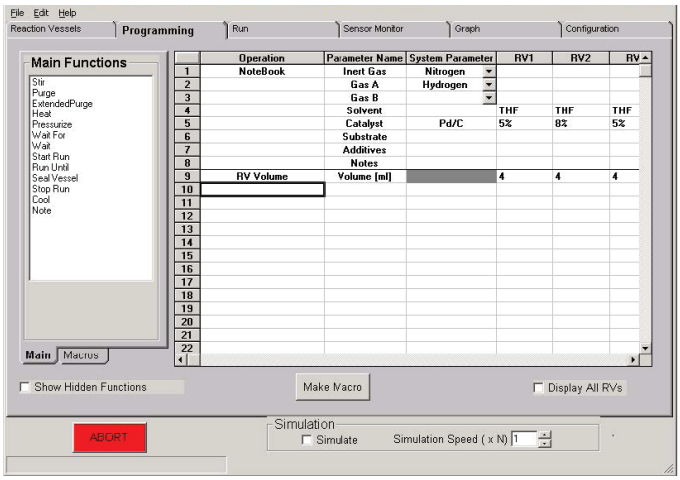

Figure 80. Programming—solution volumes.

Step 2. Drag the appropriate commands from the Main Functions pane on the left and drop them into the Operation column on the right. The program runs the functions in the sequence in which they are entered.

Figure 81 shows an example in which the logical sequence of the experimental steps are dragged and dropped from the Main Functions pane: *Purge*, *Purge*, *Heat*, *Wait for*, *Pressurize*, *Wait for*, *Start Run*, *Stir*, *Run Until*, and *Stop Run*.

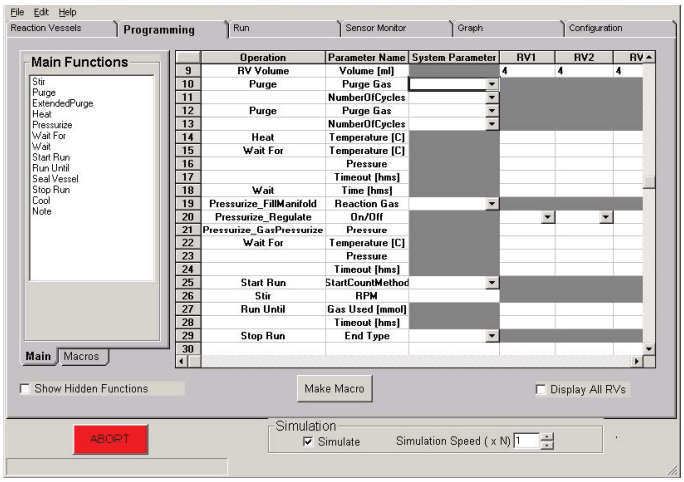

Figure 81. Programming—operations.

Note: Commands placed after the *Stop Run* command are not executed.

Step 3. Enter the appropriate parameters.

Some parameters, such as purging, stirring, gas used on a single step, and the end type, are set at the system level and apply to all RVs. Other parameters, such as temperature, pressure, and run time, are set at the individual RV level and a value can be entered for each RV.

For parameters with discrete choices, a drop-down menu is provided, but other parameters must be entered directly.

The program shown in Figure 82 has been set with two purge cycles, five times each. One cycle uses the nitrogen gas connected to the Inert Gas inlet and the second cycle uses the reactive gas, Gas A.

The purge cycles are followed by a Heat to 50°C and Wait For temperature with a Timeout at 50 minutes. The mole counting is initiated by the Start Run function, followed by starting the stirring to run at 500 rpm until otherwise instructed.

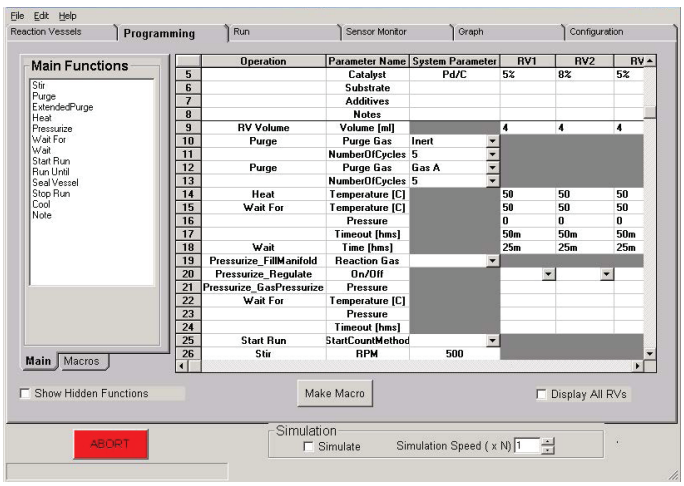

Figure 82. Programming—purging.

Note: Run Time and Wait Time parameters must be specified in [hms] format. In this format, hours, minutes, and seconds are separated by the letters 'h', 'm', and 's' respectively. For example, "5h29m2s" indicates 5 hours, 29 minutes, and 2 seconds. A component that is not present can be omitted. For example, '5h' and '30m' are accepted time formats. *Do not specify more than 59m or 59s; use 1h or 1m instead.* Only specify time in whole units. Time is the only parameter that requires units to be specified.

Step 4. The desired temperature and pressure values for each RV are entered into the individual cells at the intersection of the row and RV column as shown in Figure 83. Choose the reaction gas from the drop-down menu; in this example it is Gas A.

Note: The limits on operating parameters are 0 to 200°C, and 0 to 500 psi (≈ 34 bar). Any values which exceed these limits are rejected during the option verification stage, prior to the actual experimental run.

In the example in Figure 83, the temperature ramp-up starts first and holds for 25 minutes at the set temperature before the pressure ramp- up begins.

Step 5. Similar to control panel operation, the EAS requires the reaction countdown clock to be started. The *Start Run* function determines how this occurs. There are three possible options: Individual, AllTogether, and OnKeyPress.

Individual	This option starts the countdown clock automatically for an individual RV as soon as it has reached its set temperature and pressure.
AllTogether	This option starts the countdown clock automatically for all RVs once all of the RVs have reached their set temperature and pressure.
OnKeyPress	This option makes the system wait for manual user intervention from the Endeavor control panel, using the *Count* function on the LCD. This option should be used in cases where reagents and catalysts are manually injected into the RVs to start the chemical reaction.

The *Run Until* function determines how long each RV runs, based either on gas consumption or elapsed time:

Gas Used	Enter a value in mmol in the row labeled Gas Used.
Timeout	Enter a value in the [hms] format. For example 1h20m15s = one hour, twenty minutes and fifteen seconds.

Figure 83 shows an example showing all RVs heating to 50°C, pressurizing to 50 psi (≈ 4.4 bar) with Gas A, starting AllTogether, and running for 3 hours or until 5 mmols of gas are consumed.

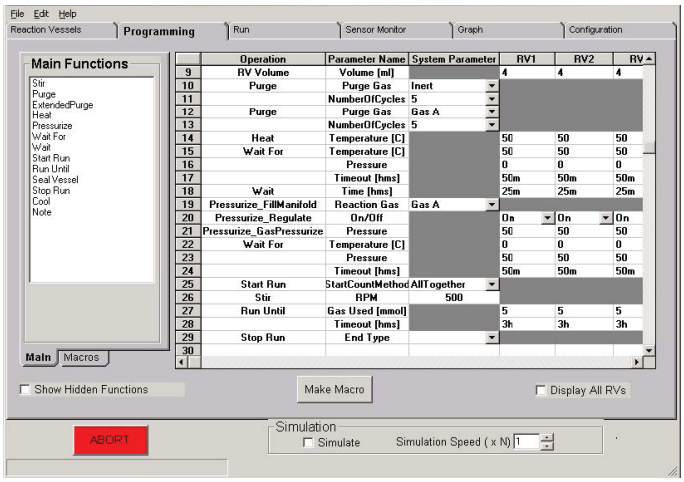

Figure 83. Programming—heating, pressurizing, and running the reaction.

Step 6. Figure 84 shows that when the *Run Until* function is completed for an RV, the program proceeds to the Stop Run function and seals the RV.

Sealing the RV triggers the heater to be shut off and triggers pressure regulation to be turned off for that RV. The RV remains sealed until the other RVs have reached the end point and are sealed off.

Once all RVs have reached the end points, all RVs remain sealed when the end type is set to Seal.

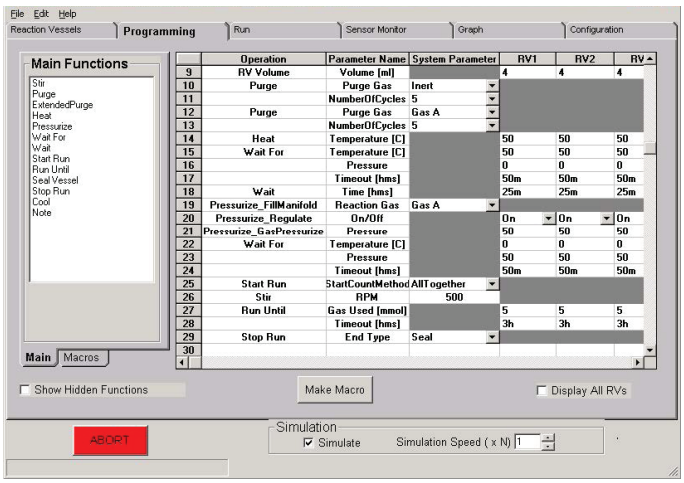

Figure 84. Programming—run until, sealing, and stopping the reaction.

Step 7. At this point, the experimental steps and parameters entered can be carried out. Click on the *Run* tab and click on the *Start* button at the bottom of the screen. The EAS and the instrument communicate with each other and verify the steps and parameters given.

After this is completed, the EAS will prompt to save the data. The data name suggested includes a date and time stamp, saving experiments as *samplename date time.ear*. This is shown in Figure 85.

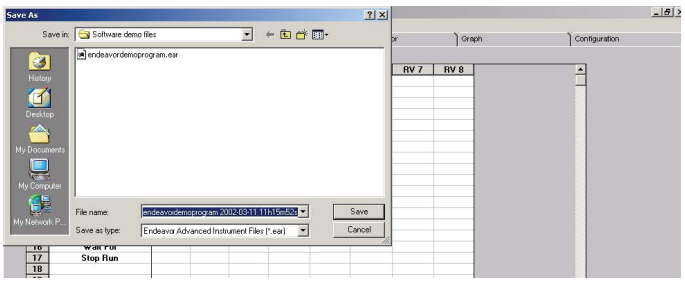

Figure 85. Saving the data.

Note: The EAS is limited to 200 lines of command.

Errors are detected when a program is downloaded from the PC to the Endeavor instrument firmware. If a problem is detected, the PC references the program that contains the error.

Additional Example

Additional pre-programmed examples can be found in the directory where the EAS resides (*C:\Program Files\Adv Soft Endeavor*). These files can be opened to illustrate how the following experiments can be programmed.

Coupling Reaction

For a coupling reaction using a transition metal catalyst, there is no reactant gas, and the solution is heated to boiling point under an inert atmosphere.

There is a choice of blanket gas, control of the temperature, time, and stirring. At the end of reaction, the heater is turned off and the RVs cool to a set temperature with the valve shut.

At the set temperature, the RVs vent. An inert atmosphere is reintroduced with a short purge cycle. See the file *coupling reaction.ear* located on the EAS CD.

Pre-Running a Leak Test

An RV leak test should be run prior to running reactions on the Endeavor instrument.

For Endeavor users running the instrument via the EAS, a standard leak test “ear” file is provided in an electronic format on the Endeavor Basic Software CD. The name of the file is: Endeavor_Pre_Run_Leak_Test.ear.

1. Load the leak test program file: Endeavor_Pre_Run_Leak_Test.ear. This program pressurizes the RVs with nitrogen up to the pressure setting of the nitrogen inlet gas source regulator.
2. The program runs for 40 minutes; the first 10 minutes allow the pressure readings to equilibrate and the final 30 minutes are the duration of the leak test.
3. Upon completion of the test, open the graphing utility of the EAS and check the RV pressure plots. From time = 10 minutes to time = 40 minutes, the drop in pressure should not exceed 2 psi (≈ 0.14 bar).

Important Notes

Error checking in the EAS is currently design to be basic. Care must be taken to program the instrument correctly. The overall programming sequence must be identical to the sequence run by the firmware. In addition, the following items are important:

The Following actions are allowed:

- Adding or removing *Purge* steps at the beginning or end of the experiment.
- Heating first, or pressurizing first.
- Waiting for a particular temperature or pressure before proceeding to the next step.
- Varying the stirring speed at particular points in the experiment.
- Selecting the gas to be used for a particular step.
- Waiting for a fixed time before proceeding to the next step.

The Following actions are *Not* allowed:

- Failing to use the *Start Run*, *Run Until*, and *Stop Run* functions. These are required functions.
- Using the *Start Run*, *Run Until*, and *Stop Run* functions in a different order than given here.
- Using the *Purge* function while the system is regulating the pressure.
- Programming conflicting commands, such as waiting for higher temperatures than the set point temperature.
- Partially deleting a macro on the programming spreadsheet. The entire macro must be deleted.
- Functions used after the *Stop Run* function, as any commands after *Stop Run* are not executed.
- Blank lines.

Appendix E: Ball Valves

This chapter contains instructions for using and maintaining the Endeavor ball valve injectors.

Caution

» For systems equipped with ball valves, always make sure that the valve is in the horizontal closed position before using the instrument, and when the Endeavor instrument is not in use. Always close the ball valve before removing the needle when performing an injection, otherwise gas leakage from the RV's will occur.

Injecting Slurries

Ball Valve with Luer Lock

The procedure for injecting a slurry through the ball valve with luer lock is as follows:

1. Prepare the mixture of solid and solution. To avoid clogging, a maximum solid to liquid ratio of 50 mg/mL is recommended for injected slurries.
2. Withdraw the slurry solution using a gas tight syringe with a stainless steel needle. The Endeavor 3" injection needle (P/N 900463) or the Endeavor 10" injection needle (P/N 900464) is recommended.

   Note: Mix well while drawing the mixture into the syringe to prevent the slurries from settling to the bottom of the container.
3. Remove the stainless steel needle (and connect the syringe to the luer lock adapter (Figure 86).

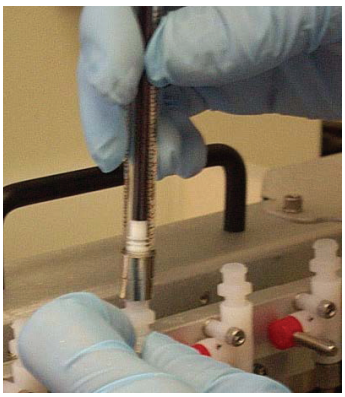

Figure 86. Ball valve Luer lock adapter.

4. Keeping thumb securely on the syringe plunger, open the ball valve until the handle is aligned vertically (Figure 87).

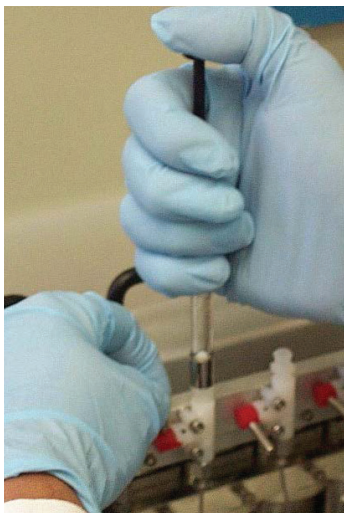

Figure 87. Aligning the handle.

Warning

» It is important to maintain a firm grip on the plunger of the syringe when injecting through the ball valves, as they have a straight path into the injection tubing. Failure to maintain control of the plunger can result in injury.

5. Carefully inject solution.

Warning

» Use extreme caution when injecting, particularly under pressure. If the plunger of the syringe is released, reactor pressure may result in the forceful ejection of the plunger. Refer to the chapter "Safety" on page 3 for important safety information on the use of injection ports.

6. After injecting solution, turn the valve to the closed position so the handle is aligned horizontally. Keep thumb securely on the syringe plunger.
7. Carefully remove the syringe from the injection port.
8. Repeat steps 1 through 7 for addition of a chase solvent, using at least 200 mL of solvent to flush the line. One (1) mL is recommended.

Ball Valve with Needle Guide Adapter

1. Prepare the mixture of solid and solution. Fifty (50) mg/mL is recommended.
2. Withdraw the slurry solution using a gas tight syringe with a stainless steel needle. The Endeavor 3" injection needle (P/N 900463) or the Endeavor 10" injection needle (P/N 900464) is recommended.
3. Carefully insert the needle into the needle guide adapter until resistance is encountered. Continue inserting the needle until the needle cannot extend further at approximately 0.8" (20.5 mm) from the tip of the needle (Figure 88).

Figure 88. Inserting the needle into the guide adapter.

4. Keeping thumb securely on the syringe plunger, open the ball valve so that the handle is aligned vertically (Figure 89).

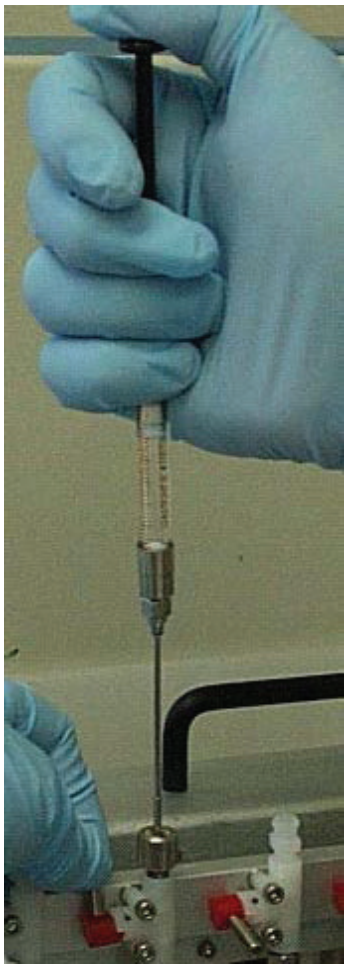

Figure 89. Opening the ball valve.

5. Carefully inject the solution.

Warning

» Use extreme caution when injecting, particularly under pressure. If the plunger of the syringe is released, reactor pressure may result in the forceful ejection of the plunger. Refer to the chapter "Safety" on page 3 for important safety information on the use of injection ports.

6. After injecting solution, turn the valve to the closed position so that the handle is aligned horizontally (Figure 90). Be sure to keep your thumb securely on the syringe plunger.

Figure 90. Closing the valve.

7. Gradually remove the needle from the injection port.
8. Repeat steps 3 through 7 for addition of a chase solvent. Use at least 200 microliters of solvent to flush the line. One (1) mL is recommended.

Cleaning and Maintaining Ball Valve Adapters

To ensure the ball valve adapters work optimally, the following routine maintenance should be completed:

- Flush solvent through the injection line multiple times after each use (when the instrument run is complete).
- The injection port tubing lines can be dried by flushing with compressed gas after the solvent flush step.

Appendix F: Ordering Information

Parts for the Endeavor system should be ordered from a local Biotage representative. See contact information on the back of this document or visit our website www.biotage.com.

Consumables

Part No.	Description	Qty
900409	Glass Reactor Liners	304
900543	Blade-type Impeller	40
900411	AllChem Gland Seal O-ring	8
900412	Viton Gland Seal O-ring	24
900451	AllChem Top Face Seal O-ring	8
900663	AllChem Check Valve Small O-ring	8
900676	Glass Liner Gripper Tube	16

AllChem O-rings are suitable for all operating temperatures (RT to 200°C). Check reagent and solvent compatibility.

Viton O-rings are suitable for lower operating temperatures (RT to 150°C). Check reagent and solvent compatibility.

Accessories

Part No.	Description	Qty
900463	Injection Needle, 3"	1
900464	Injection Needle, 10"	1
900466	Ball Valve Injector Luer Kit	1
900812	Needle Injection Adapter for Ball Valve	1

Parts

Part No.	Description	Qty
900404	User Manual	1
900408	Glass Reactor Liner Extractor Tool	1
900657	Endeavor Drip Tray	1
900810	Endeavor Check Valve Maintenance Kit	1
105799	Endeavor Filter, Hight pressure inlet, 5-micron	1
900849	Endeavor RV Push Tool	1
900813	Endeavor Basic Software	1

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