SF-PF190 Pump

Non-Pulsatile Microfluidics Pump

INSTRUCTION MANUAL

Serial No._____

070114

World Precision Instruments

CONTENTS

ABOUT THIS MANUAL

The following symbols are used in this guide:

This symbol indicates a CAUTION. Cautions warn against actions that can cause damage to equipment. Please read these carefully.

This symbol indicates a WARNING. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.

Fig. 1—Microfluidic Pressure Pump

INTRODUCTION

The SF-PF pump is a non-mechanical microfluidic pump that provides pulse-free flow over a range of flow rates and can also dispense specific volumes. Pump operation is controlled using the Multi-Function Controller™. The SF-PF pump is compatible with a broad range of solvents, solutions, buffers, and reagents.

The SF-PF pump works by using a pumping fluid (separated from your reagent or solvent by an impermeable barrier, thus eliminating cross-contamination) to act upon an expansion diaphragm to create controlled, pulse-free flow and dispensing. When a voltage is applied to the SF-PF pump, pumping fluid is driven across the selective membrane causing an impermeable diaphragm to expand and deliver solvent to your application (Fig. 2).

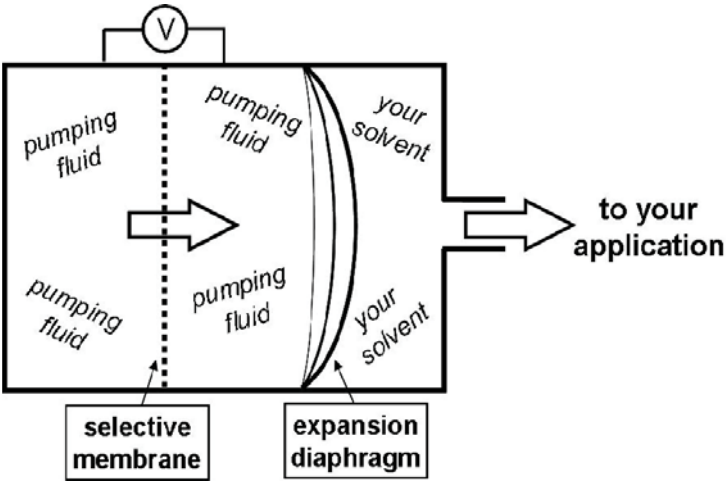

Fig. 2—The solvent pumped never mixes with the pumping fluid.

In operation, the SF-PF pump behaves much like a syringe pump, where your buffer or solvent of interest is loaded into a chamber and then delivered under controlled flow conditions. Likewise, the SF-PF pump has a finite stroke volume, after which it must reset.

Notes and Warnings

CAUTION: Do not remove the SF-PF Pump from the Pump Holder and do not disconnect, or attempt to disconnect, the it from the Multi-Function Controller™, as these actions constitute a safety hazard and may result in permanent damage to the device.

Parts List

After unpacking, verify that there is no visible damage to the sensor. Verify that all items are included:

(1) SF-PF pump shipping and storage case

(1) SF-PF pump with holder

(1) Multi-Function Controller™

(1) 120 VAC to 5 VDC power converter and cord

(1) Certificate of Calibration

(1) Instruction Manual

Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled "Claims and Returns" on page 39 of this manual. Please contact WPI Customer Service if any parts are missing at 941.371.1003 or customerservice@wpiinc.com.

Returns: Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI's Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100mm (four inches) of shock absorbing material. For further details, please read the section entitled "Claims and Returns" on page 39 of this manual.

INSTRUMENT DESCRIPTION

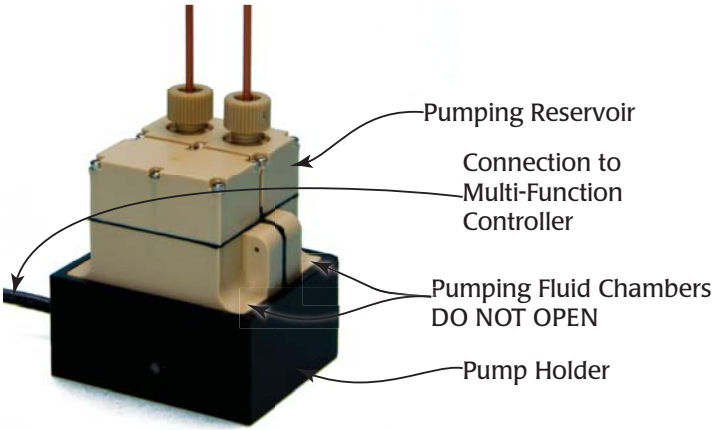

Fig. 3—The SF-PF pump has three chambers, two for the pumping fluid and one for the pumped fluid.

SF-PF Pump Description

The SF-PF pump consists of three chambers and is attached to a Pump Holder. Two of the chambers contain the pumping fluid and are completely sealed off. These chambers require no maintenance, and **the chambers should never be opened**. Opening or tampering with the Pumping Fluid Chambers will incapacitate the SF-PF pump and void any warranty or service agreement. The chamber of primary interest to you is the Pumping Reservoir. An impermeable diaphragm isolates the Pumping Reservoir from the pumping fluid, eliminating cross contamination. Your solvent or buffer of interest is loaded into the Pumping Reservoir and then delivered to the application. The orange PEEK tubing (1/16″ OD X 0.02″ ID) is used for initial filling of the Pumping Reservoir with your solvent/buffer of interest and subsequent solvent/buffer delivery to your application.

SF-PF Multi-Function Controller

The Multi-Function Controller is used to power the SF-PF pump and direct pump operations. Each Multi-Function Controller is carefully calibrated and matched to each SF-PF pump to provide the most accurate flow rate delivery. The Multi-Function Controller allows you to choose between two operational modes:

- Flow Mode, where the pump delivers the user-specified flow rate
- Dispense Mode, where the pump delivers a user-specified volume protocol.

In Flow Mode, you are able to specify the volume of fluid to be delivered, or simply toggle the pumping action on and off. In Dispense Mode, the pump dispenses fluid

at a factory-defined flow rate which cannot be changed. However, you can dispense the specified volume more than once and specify a delay in between aliquots. The Multi-Function Controller can be coupled to a computer via a USB connection to provide an even more diverse range of flow and dispensing protocols.

Rear Panel

All of the electronic connection ports are located on the rear of the Multi-Function Controller. The rear of the Multi-Function Controller is shown in (Fig. 4) with each port marked.

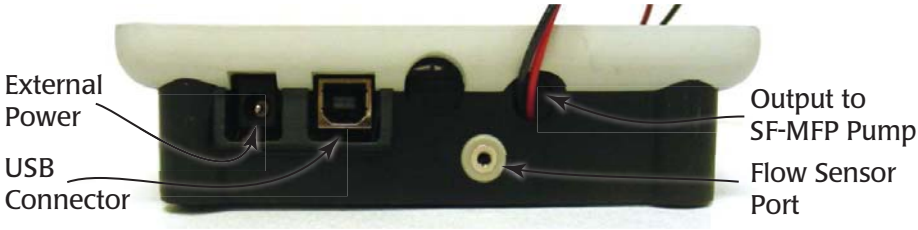

Fig. 4—The rear panel of the controller has all the connections.

External Power: Connects to 5V output AC/DC converter (included).

USB Connector: For remote operation from a PC. See "Appendix A: Remote Operation" on page 28.

Flow Sensor Port: Connection for optional feedback flow sensor. This is used to enhance precision of the pump flow.

Output to SF-PF pump: Permanently connected to SF-PF pump and provides all control signals to the pump. Never disconnect the SF-PF pump from the Multi-Function Controller™.

User Interface Keypad

The user interface keypad (Fig. 5) is located on the top of the Multi-Function Controller. The keypad and the accompanying LCD screen are responsible for all of the communication between you and the Controller. Use the keypad to control all of the functions of the SF-PF pump. You can select the operating mode, program pump operating parameters, adjust display units, turn the pump off and on, refill the pump, and shut down the Controller using these buttons. The Controller lists operating parameters, the current state of the pump, progress of programmed pumping protocols and any errors in the pumping protocol.

Fig. 5—The controller lets you communicate with the pump.

Start/Stop button: The Start/Stop button is used to power on the Controller and to start and stop the pumping action of the pump. When the Controller is off, press and hold the Start/Stop button for at 2 seconds to turn the Controller on. Once the Controller is on and you have configured the pumping parameters to meet your requirements, press the Start/Stop button to initiate the specified pumping sequence. Pressing the Start/Stop button while the pump is running stops the pumping sequence. Anytime the pump is running, the green LED on this button is illuminated. Anytime the Controller is on and the pump is not running, the red LED on this button is illuminated. When the pump is refilling, the green LED is illuminated ("Refill Operation Procedure" on page 19).

Flow button: The Flow button is used to put the Controller in the User-Set Flow Mode. If the Controller is already in User-Set Flow mode, pressing the Flow button will have no effect. The operating mode can only be changed when the pump is stopped and the Main Setup Screen is displayed on the LCD. Operation of the pump in User-Set Flow Mode is described in "User-set Flow Mode Operation Procedure" on page 13.

Dispense button: The Dispense button is used to put the Controller in the User-Set Dispense mode. If the Controller is already in User-Set Dispense mode, press the Dispense button has no effect. The operating mode can only be changed when the pump is stopped and the Main Setup Screen is displayed on the LCD. Operation of the pump in User-Set Dispense mode is described in "User-set Dispense Mode Operation Procedure" on page 16.

Scroll buttons (^, v): The Scroll buttons are used to highlight user-adjustable parameters on the LCD screen. Once a parameter is highlighted, it can be selected using the Enter button. Selecting a flow parameter such as Flow Rate or Dispense Volume allows you to enter the value for that parameter. Selecting a process such as Refill or Shutdown begins that process.

Keypad buttons: The keypad buttons (0-9 and .) are used to enter user-defined flow and dispense protocol parameters to the Controller. The parameters are selected using the Scroll buttons and the Enter button. Then, the keypad buttons are used to change the value of that parameter in the Controller memory. When the correct value is shown in the box on the LCD, press the Enter button again to store the new value in memory.

Backspace Button (<): The backspace button is used to correct errors made while using the keypad to type flow and dispense parameters on the Controller. Pressing this key deletes the character immediately before the cursor on the screen. If this button is pressed when there are no characters on the screen, the Controller returns to the Main Setup Screen and reverts to the previously stored value of the parameter.

Enter button: The Enter button has two different functions. It is used to select a highlighted parameter on the LCD screen, and it is used to store user-defined parameters in memory. As a selection tool, the Enter button can be used to select either a flow or dispense protocol value to be edited, a procedure to initiate, or a choice between Controller generated options. If the entity is a parameter such as flow rate, press Enter once to bring up a screen where you can use the Keypad buttons to input the required value for that parameter. Press Enter again to save the new value in memory and return to the Main Setup Screen.

µ/n button: This button is used to switch the volume units displayed on the LCD between microliters and nanoliters. Pressing this button in no way affects the range of operation of the Controller or the pump. It only changes the units in which the operational parameters are displayed on the LCD. If the Controller is displaying µL or µL/min, then it displays the values to three decimal places. If it is displaying nL or nL/min, then it does not display any decimal places (Fig. 6).

Fig. 6—The Controller operates in two different sets of units. The actual values do not change, only they way that they are represented on the screen. Toggle between the two units using the µ/n button.

^, v –The Scroll buttons allow you to change which parameter is highlighted on the LCD screen. Once the desired parameter is highlighted, it can then be selected by pressing the Enter button.

Start/Stop–Hold this button down for two seconds to turn the Multi-Function Controller™ on. Once the unit is on, this button is used to start and stop the pump. The red LED located on this button is always lit if the pump is not actively pumping.

The green LED illuminates when the pump is actively pumping. One of these two LED's is always on when the Controller is on.

µ/n–This button toggles the units that the Controller displays volume parameters in between µL and nL. It doesn't affect the functionality of the Controller, only the units in which the Controller displays the values on the LCD.

Enter–Used to select highlighted parameters on the LCD screen. It is also used to store user-defined flow and dispense parameters to memory.

<–Backspace key moves the cursor over previously typed numbers. It is used to correct errors made while entering flow and dispense parameters. If all numbers have been deleted, then pressing the Backspace button will return the Controller to the Main Setup Screen and revert to the previously stored value for the parameter.

Flow–Pressing this button when the pump is stopped puts the Controller into Flow Mode. See "User-set Flow Mode Operation Procedure" on page 13.

Dispense–Pressing this button when the pump is stopped puts the Controller into Dispense Mode. See "User-set Dispense Mode Operation Procedure" on page 16.

0-9 and **.**–Used to communicate user-defined flow and dispense parameters to the Controller.

Plumbing Setup

Pumping Reservoir Connections

The pumping reservoir of the SF-PF pump is designed to hold your solvent or buffer of interest. The pumping reservoir has two connecting tubes (1/16" OD, 0.02" ID, PEEK) and either tube can be used as inlet or outlet. Prior to pump operation, fill the pumping reservoir with the solvent/buffer of interest using a syringe. Be sure to eliminate all air bubbles from the reservoir and the connection tubes. This can best be accomplished by holding the SF-PF pump so that one of the tubes is pointing straight up and filling from the bottom while gently tapping the SF-PF pump body to release any trapped gas bubbles. In the event that a small air bubble becomes trapped and will not release, simply pull the solvent out of the reservoir until the bubble bursts and then refill the reservoir according to the above procedure. We recommend that the solvent to be pumped is degassed prior to use in the SF-PF pump. Once the pumping reservoir is filled and all air bubbles have been eliminated, close the shut-off valve and connect the outlet tube to your application.

Connections Accessory Kit

A kit containing the external fluidic connections is available to allow easy filling of the Pumping Reservoir, as well as ready connection to your fluid supply container and your application. The Connections Accessory Kit includes:

- 2-mL glass syringe with luer fitting
- Shut-Off Valve with a luer adapter

- Selection Valve
- 2-foot length of PEEK tubing (1/16″ OD, 0.02″ ID)

This fluidic configuration using the Connections Accessory Kit is illustrated below. All fittings in the Kit are designed to be 'finger tight' and no tools are needed for installation.

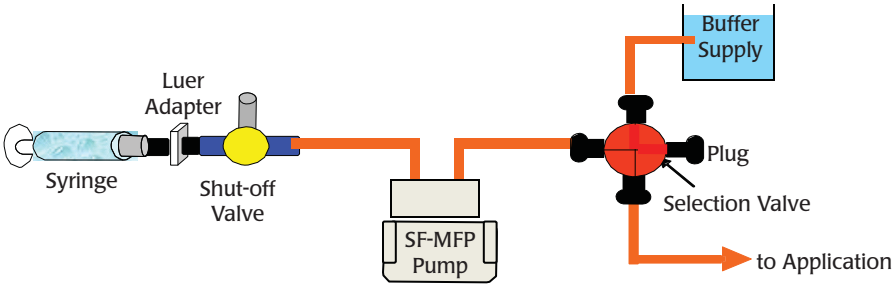

Fig. 7—Configuration of the SF-PF pump with connections accessory kit.

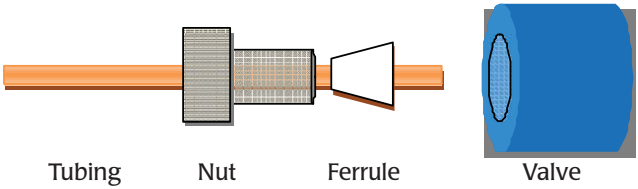

Fig. 8—Connections should be made finger tight.

1. Decide which pumping reservoir tube will be the inlet and which will be the outlet.
2. Attach the shut-off valve to the inlet by first removing the nut and ferrule from the shut-off valve and sliding the nut and ferrule onto the inlet tube. Make sure the flat end of the ferrule is toward the valve.
3. Push the inlet tube completely into the shut-off valve, and finger tighten the nut while holding the inlet tube in place. The fittings are designed to be tightened finger-tight. Never use tools to tighten the fluidic connections.
4. Connect the selection valve to the outlet tube in the same manner. First, remove the nut and ferrule from the selection valve. Slide the nut and ferrule onto the outlet tube. Make sure the flat end of the ferrule is toward the valve.
5. Cut two lengths of PEEK tubing: one to connect the selection valve to your fluid supply container and the other to connect the selection valve to your application. Care must be taken in cutting the PEEK tubing to ensure that the end is flat and burr free.
6. Attach the tube for your fluid supply container to the port on the selection valve

that is next to the outlet tube port using the same finger-tight method as above.

7. Attach the tube for your application to the other port of the selection valve that is next to the outlet port. Attach the plug to the last port on the selection valve. The markings on the top of the selection valve handle indicate which ports are connected.

SF-PF Pump Installation

1. When shipped, the SF-PF pump is ready to be filled with your solvent. Any residual liquid in the Pumping Reservoir is distilled, deionized water left over from initial testing. The SF-PF pump is permanently electrically connected to the Multi-Function Controller. The SF-PF pump and Controller are matched at the factory. Do not disconnect the Multi-Function Controller from the SF-PF pump at any time.
2. Make the fluidic connections to couple the filling syringe to the pumping reservoir of the SF-PF pump according to the directions given on the previous page.
3. Fill the pumping reservoir with your degassed solvent or buffer using a syringe, as described above. It is important to ensure that all air bubbles have been eliminated from the pumping reservoir.
4. Make remaining fluidic connections and push more solvent/buffer through the tubing to fully purge the pumping reservoir and tubing, eliminating all air bubbles from the system.
5. Once all air bubbles have been eliminated from the pumping reservoir and tubing, close the inlet tube and make the fluidic connections to your application.
6. We recommend that you wait for 5-10 minutes after making fluidic connections before operating your SF-PF pump to ensure that all residual fluid motion has subsided.
7. Plug the power adapter into the back of the Multi-Function Controller™ and connect to the 120 VAC outlet.
8. Press the Start/Stop button and hold it for 2 seconds to turn on the Multi-Function Controller, the red LED on the Start/Stop button should be illuminated.
9. You are now ready to define the operating parameters and begin pumping.

OPERATING INSTRUCTIONS

Changing your Solvent/Buffer

1. In preparation for changing the solvent/buffer to be pumped, the SF-PF pump first needs to be at the initial starting position. If the pump is not in the initial starting position, a Refill must be executed first. See "Refill Operation Procedure" on page 19.
2. Once the Refill is complete, the SF-PF pump is ready to fill with your new solvent/buffer.
3. Use the syringe to empty the SF-PF pump pumping reservoir and all connecting tubing.
4. Use the syringe to flush the pumping reservoir and all tubing with your new solvent/buffer. We recommend that you fill and empty the pumping reservoir and tubing several times to minimize cross contamination.
5. Fill pumping reservoir and tubing as described in "SF-PF Pump Installation" on page 10.
6. You are ready to begin pumping with your new solvent.

Operating the Unit

Once the pumping reservoir and tubing have been filled with the solvent/buffer to be pumped, the SF-PF pump behaves similar to a syringe pump. That is, the SF-PF pump has a finite stroke volume, the volume of solvent/buffer that can be delivered before refilling.

After initial filling of the pumping reservoir and tubing (see "Changing your Solvent/Buffer" on page 11), when the Start/Stop button is pushed the SF-PF pump delivers the solvent/buffer according to the operating mode and user-defined flow parameters until either:

- the Start/Stop button is pushed again
- the prescribed fluid delivery program is completed
- the SF-PF pump's maximum stroke volume has been reached. When the maximum stroke volume is reached, the Controller displays the Main Setup Menu on the LCD and the available volume will be 0. Under this condition, the Controller only allows the pump to execute a Refill.

Connect the SF-PF pump outlet tube to the solvent container and execute a Refill cycle. (See "Refill Operation Procedure" on page 19.) This caused the SF-PF pump to operate in reverse, pulling solvent from the container and refilling the pumping reservoir of the SF-PF pump. Once the Refill process is completed (<10 min.), switch the outlet tube to your application, set the parameters to the required flow program

and begin pumping again. When the pump is pumping, it can be stopped at any time by pushing the Start/Stop button. This process can continue until the maximum stroke volume is reached. You can initiate a Refill at any point in the SF-PF pump stroke cycle, but once the Refill mode is initiated it will continue to completion.

Operational Modes

The SF-PF pump with the Multi-Function Controller operates in either the User-set Flow Mode or the User-set Dispense Mode. Anytime the pump is not actively pumping, you can switch between these modes by pressing the Flow or Dispense button located below the LCD screen on the Controller.

- **User-set Flow**: In the User-Set Flow Mode, you define the Flow Rate and have the option to define a single Set Volume to dispense. If you don't define a dispense volume, or defines a dispense volume of 0, then the Set Vol value on the display reads OFF. Pressing the Start/Stop button causes the SF-PF pump to flow continuously at the user-defined flow rate until either the Start/Stop button is pressed again or until the available stroke volume is exhausted. If you define a volume to dispense, the unit pumps at the user-set flow rate until either the Start/Stop button is pressed again or until the user-defined volume has been delivered. You are not allowed to enter a dispense volume that is greater than the remaining available volume in the stroke cycle. You can change the flow rate at any time by selecting Flow Rate and entering a new value. The Main Setup menu of the User-Set Flow Mode is shown in Fig. 9.

Fig. 9—Main Setup Menu for the User-Set Flow Mode and User-Set Dispense Mode.

- **User-set Dispense**: In User-Set Dispense Mode, you can define the Dispense Volume, the Number of Doses to dispense and the Delay between the doses. The fluid will be pumped at the factory-defined flow rate stated on the certificate of calibration. In this mode, you do not control the flow rate. The Controller will not allow you to define a dispense program that requires more volume than is remaining in the available stroke cycle. The Main Setup menu of the User-Set Dispense mode is shown in Fig. 9.

Operating Procedures

Pump Operation Procedure

Once the pumping reservoir and inlet/outlet tubes are filled with the solvent/buffer to be pumped and all air bubbles have been removed, you are ready to pump. We recommends that you wait 5-10 minutes after filling the reservoir and tubing before

you operate the SF-PF pump to ensure that all residual fluid motion has subsided. Press and hold the Start/Stop button for 2 seconds to power-up the Controller. The red LED next to the Stop indicator should illuminate, and the LCD screen shows the startup screen for 3 seconds and then display the Main Setup Menu for the mode that was last used (default is User-Set Flow Mode). The Controller saves all previous flow and dispense parameters before shutting down, so be careful to verify all parameters before beginning to pump.

Determine which mode, (Flow or Dispense) you wish to operate in and press the corresponding button below the LCD. If the Controller was already in the desired mode, then nothing happens, otherwise the LCD changes to the default menu for the chosen mode.

User-set Flow Mode Operation Procedure

The default main setup screen for the User-Set Flow mode is shown in Fig. 9. It shows the current operating parameters for the pump: the Flow Rate and the Volume to dispense (OFF designates continuous flow). The LCD also displays the Available volume left in pump, which is not an adjustable parameter, and the Shutdown procedural option. After the pump has been run for some amount of time, the Shutdown option is replaced by the Refill option, since the Controller requires that the pump be refilled prior to shutting down. (See “Refill Operation Procedure” on page 19 and “Shut-Down Procedure” on page 21.)

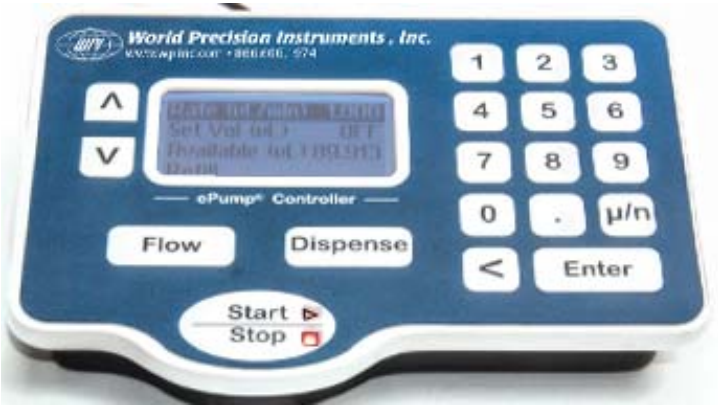

Fig. 10—The setup menu of the User-Set Flow Mode. Notice the red LED is on because the pump is stopped. The Flow Rate parameter is highlighted.

To select an option, press the up and down scroll keys until the item you wish to select is highlighted, and then press the Enter button. Selecting one of the two adjustable operating parameters, Flow Rate or Set Volume, displays a screen stating the name of the operating parameter and the current value of that parameter (Fig. 11). To change the value of the parameter, simply use the keypad to type the desired value. Use the backspace (<) key to correct any mistakes. When the correct

value has been correctly typed in, press Enter to replace the old value with the new value and return to the main setup screen. If you get to parameter input screen and wish to restore the previously stored value, simply press the backspace key until all numbers are deleted and then press it again. The Controller returns to the Main Setup Screen and reverts to the previously stored value of the parameter.

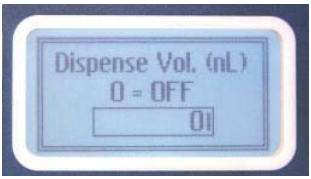

Fig. 11—Shows the screen where the Dispense Volume is edited. Use the keypad to enter the desired flow rate and then press Enter to save it to memory and return to the main setup menu. Entering 0 turns the set volume OFF. In this mode the Start/Stop button is used to toggle the pumping action on and off.

Once all of the flow parameters have been set to the desired values. Pressing the Start/Stop button starts the pumping action. The LCD will show that the pump is pumping (Fig. 12). It also shows the set flow rate and, if a dispense volume was chosen, the volume remaining. If the Set Volume is OFF, then the display shows that the remaining volume is OFF. While the pump is pumping the green LED on the Start/Stop button is illuminated.

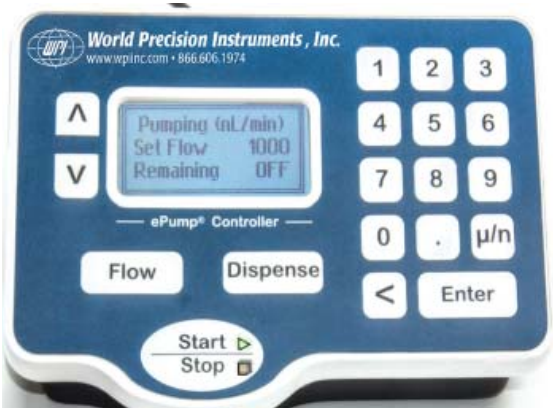

Fig. 12—Shows the Controller while the pump is pumping in User-Set Flow mode. The green LED is illuminated and the screen shows the Set Flow Rate and Volume Remaining. This Controller shows the Remaining Volume is OFF because a user-defined dispense volume was not programmed into the Controller.

Pressing the Start/Stop button again stops the pump.

- If a dispense volume has been programmed into the Controller, pressing the Start/Stop button pauses the protocol. The Controller gives the option to

Continue the protocol, resume at the point where the pump was stopped, or to Stop the protocol completely and return to the Main Setup Menu. Make your decision by using the Scroll buttons to highlight the appropriate choice and press Enter.

- If the pump is being run with the Set Vol = OFF, then pressing the Start/Stop button simply stops the pump and returns the Controller to the Main Setup Menu.

Pressing the Enter button allows for the flow rate to be changed without stopping the pump. Just press Enter, then type in the desired flow rate and press Enter again. The pump changes flow rates instantly.

Once the pump is running, if the Start/Stop button is not pressed again, then the pump runs at the user-defined flow rate until either the user-defined dispense volume has been delivered or the available stroke volume has been exhausted. The Controller will not allow you to define a dispense volume greater than the available stroke volume of the SF-PF pump.

When the pump is stopped, selecting one of the procedural options, either Shutdown or Refill, changes the LCD to a screen displaying the option to Allow the procedure or Cancel and return to the main setup screen (Fig. 13). Use the Scroll keys and the Enter button to select and execute the desired option.

Fig. 13—The conformation screen for execution of procedures. Determine procedure by using the Scroll buttons to highlight the desired choice and press Enter. A similar screen is presented when Shutdown is selected from the Main Setup Menu.

Example: Using the pump in User-Set Flow mode to dispense 500nL at 1000nL/min.

1. Fill the SF-PF pump reservoir and attach tubing to your experiment and a refill reservoir (“SF-PF Pump Installation” on page 10).
2. Press and hold the Start/Stop button for two seconds. This will turn the Controller on.
3. When the SFC Fluidics screen is no longer showing, press the Flow button.
4. Press the µ/n button, if necessary, so that the Controller displays flow parameters in nL units.
5. Use the up and down Scroll buttons to highlight the Rate (nL/min) line and press Enter. This takes you to the Rate (nL/min) screen.
6. Press 1 followed by three 0’s on the keypad so that the number 1000 shows

in the box. Press Enter. Now the Main Setup Screen shows the Rate (nL/min) as 1000 nL/min.

7. Use the up and down Scroll buttons to highlight the Set Vol (nL) line and press Enter. This takes you to the Dispense Volume (nL) screen.

8. Press 5 followed by 0 two times on the keypad so that the number 500 shows in the box. Press Enter. Now the Main Setup Screen shows the Set Vol (nL) as 500 nL.

9. Press the Start/Stop button on the Controller to start the pumping. The pump will run at 1000 nL/min, dispense 500 nL, and then stop automatically.

10. Adjust your valves so that the SF-PF pump is connected to Your Fluid Supply Container (Fig. 7).

    Use the Scroll buttons to highlight Refill and press Enter.

    Use the Scroll buttons to highlight Allow and press Enter.

    Wait for the refill to complete (The red LED will illuminate and the LCD will return to the main setup menu). You are now ready to use the SF-PF pump in User-set Flow Mode.

User-set Dispense Mode Operation Procedure

The default Main Setup Screen for the User-set Dispense Mode is shown in Fig. 9. It shows the current operating parameters for the pump: the Volume to dispense, the # of Doses and the Delay(s) between doses. The LCD also displays the Shutdown procedural option. After the pump has been run for some amount of time, the Shutdown option is replaced by the Refill option, since the Controller requires the pump be refilled prior to shutting down.

To select an option, press the up and down Scroll keys until the item you wish to select is highlighted and then press Enter. Selecting one of the three adjustable operating parameters displays a screen stating which parameter is being adjusted and its current value (Fig. 14). To change the value, simply use the keypad to type the desired value. Use the backspace (<) key to correct any mistakes. When the correct value has been typed in, press Enter to change the parameter to the new value and return to the Main Setup Screen. To return to the Main Setup Screen and keep the previously stored parameter, simply press the backspace key until all the digits have been deleted and then press it one more time.

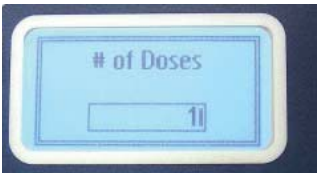

Fig. 14—The screen that allows you to define the number of doses for the pump to deliver.

Use the keypad to type the number of doses desired and press Enter to write that number to memory.

Selecting one of the procedural options, either Shutdown or Refill, changes the LCD to a screen where you will be given the option to Allow the procedure or Cancel and return to the Main Setup Screen (Fig. 15). Use the Scroll keys and the Enter button to select and execute the desired option.

Fig. 15—The confirmation screen for execution of procedures. Use the Scroll buttons to highlight the desired option and press Enter. A similar screen is presented when Shutdown is selected from the Main Setup Menu.

Once the parameters are set to the correct values. Pressing the Start/Stop button will start the pumping action. The LCD indicates whether the pump is Dispensing or Delaying and the current cycle number. While the pump is pumping, the green LED on the Start/Stop button is illuminated, and while the pump is delaying, the red LED will be illuminated (Fig. 16).

Fig. 16—Shows the Controller executing a dispense/delay cycle. While the pump is dispensing, the green LED is on and while it is delaying the red LED is illuminated.

Pressing the Start/Stop button while the pump is executing the user-defined dispense/delay cycle pauses the pump immediately. The Controller gives the option to Continue the pumping protocol, resuming at the beginning of the next complete dispense/delay cycle, or to Stop the cycle completely and return to the Main Setup Screen. Make the decision by using the Scroll buttons to highlight the desired procedure and then press Enter (Fig. 17).

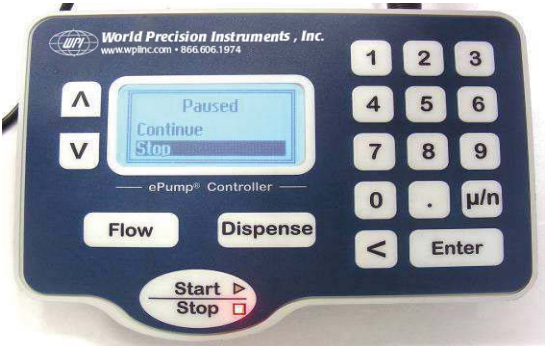

Fig. 17—The Controller gives the option to Continue or Stop if a dispensing protocol is Paused. Selecting Continue will continue the protocol at the beginning of the next complete dispense/delay cycle. Selecting Stop exits the protocol entirely.

If the Start/Stop button is not pressed again after the initial starting of the pump, then the pump runs at the Factory-set Flow Rate until the user-defined dispense protocol is complete. The Controller will not allow you to define a protocol that requires more volume than the available stroke volume of the SF-PF pump. Similarly the Controller will not begin a previously defined protocol if it requires more volume than the available stroke volume of the pump.

Example: Using the pump in Dispense Mode to dispense 500nL at the Factory-set Flow Rate 3 times with a 10 second delay between each one.

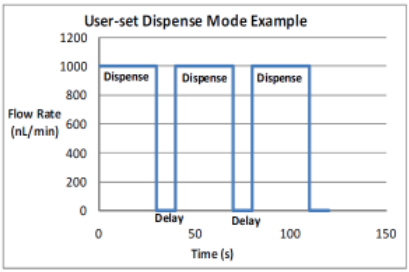

Fig. 18—The dispensing protocol for this example.

1. Fill the SF-PF pump reservoir and attach tubing to your experiment and a refill reservoir (“SF-PF Pump Installation” on page 10).
2. Press and hold the Start/Stop button for two seconds. This turns the Controller on. When the splash screen is no longer showing, press the Dispense button.
3. Press the µ/n button, if necessary, so that the Controller displays flow parameters in nL units.
4. Use the up and down Scroll buttons to highlight the Vol (nL) line and press Enter.

This takes you to the Dispense Volume (nL) screen.

5. Press 5 followed by 0 two times on the keypad so that the number 500 shows in the box. Press Enter. Now the Main Setup Screen shows the Vol (nL) as 500 nL.
6. Use the up and down Scroll buttons to highlight the # of Doses line and press Enter. This takes you to the # of Doses screen.
7. Press 3 on the keypad so that the number 3 shows in the box. Press Enter. Now the main setup screen shows the # of Doses as 3.
8. Use the up and down Scroll buttons to highlight the Delay (s) line and press Enter. This takes you to the Delay (s) screen.
9. Press 1 then 0 on the keypad so that the number 10 shows in the box. Press Enter. Now the main setup screen shows the Delay(s) as 10.
10. Press the Start/Stop button on the Controller to start the pumping. The pump dispenses 500nL three times with a 10 second delay between each dose. The fluid will be pumped at the factory-set rate indicated on the certificate of calibration that was delivered with your SF-PF pump. The example graph above shows the resulting flow rate from a pump with a factory-set flow rate of 1000 nL/min.
11. Adjust your valves so that the SF-PF pump is connected to your fluid supply container (Fig. 7).

    Use the Scroll buttons to highlight Refill and press Enter.

    Use the Scroll buttons to highlight Allow and press Enter.

    Wait for the refill to complete (The red LED will illuminate and the LCD will return to the main setup menu). You are now ready to use the SF-PF pump.

The Controller is designed with a USB port to connect to a computer. You will be able to define a wide variety of flow and dispense programs when this functionality is completed. Please see "Appendix A: Remote Operation" on page 28 for an overview of hardware and software configurations for Remote Operation.

Refill Operation Procedure

NOTE: For good pump operation, the SF-PF pump must be refilled at the following times.

- At the end of the day, before turning the Controller power off.
- When the maximum stroke volume has been reached.
- Before changing the pumping solvent/buffer ("Plumbing Setup" on page 8).
- Any time the SF-PF pump will be in Stop mode for more than 3 hours. The SF-PF pump automatically refills after 3 hours in Stop mode, so make sure your fluidic connections are correct.
- The controller requires a refill before allowing a complete power off.

Description of Refill Mode

The SF-PF pump is similar to a syringe pump in that it has a finite stroke volume. Much like a syringe pump, if the SF-PF pump is driven past its maximum stroke volume, it causes irreparable damage to the pump. The controller is specifically designed to prevent this from happening. Unlike a syringe pump, the SF-PF pump must be returned to its initial state before it is left idle for a lengthy amount of time (maximum idle time is 3 hours). The process of returning the pump to its initial state is called the refill procedure. In the refill mode, the SF-PF pump operates in reverse, pulling fluid into the pumping reservoir. With proper use of external valves (Fig. 7), the reservoir can be refilled with the correct fluid, so that the pump can be used again immediately after the refill is complete.

- Before refilling, be sure to stop the pump and switch the pumping reservoir outlet tube connection to your solvent/buffer supply container (Fig. 7).
- Once the pump is stopped, use the scroll keys to highlight the refill line on the LCD display and press Enter. You will be given an option to Allow or Cancel the refill. If you are ready to refill, use the scroll buttons to highlight Allow and press Enter. Using the scroll buttons to highlight Cancel and pressing Enter will return the controller to the Main Setup screen.
- The refill mode can be initiated at any point in the stroke cycle. It is not necessary to wait until the maximum stroke volume has been reached. Once the maximum stroke volume has been reached, the only function the controller will allow is the initiation of a refill procedure.
- Once a user-initiated refill is complete, you are free to pump again or shut down the controller.

NOTE: Once the refill mode is initiated, it runs until completion.

- There is no option to stop the refill mode once it has begun.

In addition to a user-initiated refill, the controller will automatically initiate a refill if any of the following conditions are met:

- The maximum stroke volume has been reached and 3 hours has elapsed. When the maximum stroke volume has been reached, the controller automatically stops the pump. The controller only gives you the option to allow a refill of the pump. If you do not conduct the refill procedure within 3 hours, the refill procedure is automatically executed. In this case, the system automatically powers off at the end of the refill.
- The SF-PF pump is idle for 3 hours. Whenever the SF-PF pump has been stopped for three hours, the refill procedure is automatically executed. Upon completion of the refill, the system powers off.
- Power is lost to the controller for 3 hours (for example, a power outage or when the unit is unplugged. In this event, the backup battery takes over,

the backlight for the LCD goes out, the controller stops the pump, and the controller only gives you the option to allow a refill. If you don't initiate a refill, the controller automatically executes a refill after three hours. If no external power is connected, the pump shuts down upon completion of the refill, regardless of whether it was user-initiated or controller-initiated. The backup battery is continually recharged when the pump is plugged in, so it requires no maintenance.

Shut-Down Procedure

It is important that the SF-PF pump be stored in its initial state. For this reason, the Multi-Function Controller is designed to always refill the SF-PF pump before powering off. To power off the SF-PF pump and controller:

1. If necessary, execute a refill process. See "Description of Refill Mode" on page 20.
2. Once the refill is complete, use the scroll buttons to highlight "Shutdown" on the LCD screen, and press Enter. You are given the choice to Allow or Cancel the procedure. If you wish to shutdown, use the scroll buttons to highlight Allow and press Enter. If you highlight Cancel and press Enter, the controller returns to the main setup menu.
3. The controller shuts down automatically if it has been idle for three hours.
4. For prolonged storage, see "Storing the SF-PF System" on page 22.

There is no option for shut down of the SF-PF pump without executing a refill cycle. The controller can only be shut down if the pump is in its initial state.

MAINTENANCE

The SF-PF pump and Multi-Function Controller™ have been carefully designed to minimize the amount of maintenance necessary to keep the SF-PF pump in top working condition. This section describes how to maintain your SF-PF pump. Do not attempt to repair or service your SF-PF pump. If you think your SF-PF pump needs repair or if you have questions concerning its operation, contact WPI.

Before Each Use

Inspect the tubing and pump body for signs of wear or cracks.

Inspect the electrical wires connecting the SF-PF pump and the Multi-Function Controller™. The wires should be completely coated in insulation with no signs of wear.

Flush the tubing with a small amount of the solvent that you are going to pump to ensure that the lines are not clogged or contaminated.

Make sure all fluidic connections are properly tightened. The fittings provided with the Connections Accessory Kit should be finger-tight, no tools are required to make these fittings. If you are using your own connections, make sure that they are properly connected.

After filling the pumping reservoir and making all connections, check all fitting to ensure that there are no leaks.

Cleaning the Pumping Reservoir

Care should be used to avoid contamination of the pumping reservoir. If the pumping reservoir should become contaminated, empty and then purge the reservoir with a miscible solvent. If using aqueous-based solvents, then extensively rinse the pumping reservoir and associated tubing with high-purity water. Empty the system and then purge with high-purity methanol. Again, empty the pumping reservoir and tubing and repeat purging with high-purity water.

External Cleaning of SF-PF Pump

If the external surfaces of your SF-PF pump require cleaning, carefully wipe the surface clean with a soft cloth (e.g. Kimwipe). If further cleaning is needed, apply a small amount of water or methanol to the cloth before wiping and dry all surfaces thoroughly. NEVER remove the SF-PF pump from its holder, doing so will expose sensitive electronics and cause irreparable damage to the pumping system.

Storing the SF-PF System

If your SF-PF pump system will not be used for an extended period of time, it should be stored properly to minimize the risk of permanent damage. Complete the following steps to properly prepare your pump for storage.

1. Follow the shut down procedure. See “Shut-Down Procedure” on page 21.
2. Wait until the shutdown procedure is complete and the power is off. The LCD will be blank and both LEDs will be off.
3. Using a syringe, remove all of your solvent/buffer solution from the pumping reservoir and all associated tubing. If you have been pumping aqueous-based fluids, flush the system with water, and then methanol, to ensure that the pump is clean when it is used again. Empty all remaining fluid out of the pumping reservoir and associated tubing. This will help to minimize contamination from previous uses and may discourage the growth of biological contaminants during storage.
4. Cap the inlet and outlet tubing on the pumping reservoir to minimize contamination during storage.
5. Return the SF-PF pump, Multi-Function Controller, DC power converter and all accessories to the SF-PF case.
6. The case should be stored in ambient conditions between 40-100 °F (4-38°C), with relative humidity between 5-85%, and at atmospheric pressure.

Multi-Function Controller Maintenance

The Multi-Function Controller requires little maintenance. The back-up battery for the SF-PF pump is continuously recharged, as long as the Multi- Function Controller is connected to a 120 VAC power source. If the Multi- Function Controller is disconnected from external power for an extended time, the battery may have to be recharged prior to using the controller. To recharge the battery, simply plug the controller into a 120 VAC outlet for 24 hours. If the battery needs to be replaced, call WPI and arrange for replacement.

Disposing of the SF-PF Pump

If, for some reason, disposal of the SF-PF pump and/or Multi-Function Controller is required, please return the device to WPI for proper handling and disposal.

TROUBLESHOOTING

The SF-PF pump is designed for simple, trouble-free operation. This section allows you to troubleshoot any operational difficulties.

Issue	Possible Cause	Solution
Unit doesn't power on when Start/Stop button is pressed		Press and hold the Start/Stop button for at 2 seconds
	Pump disconnected from power for a lengthy time, and backup battery needs to be charged	Make sure that the external power plug is connected to a functional 120V outlet for 24 hours. The backup battery loses charge very slowly when the Controller is disconnected from an external power source. If the voltage gets low enough, the Multi-Function Controller does not respond and the battery must be recharged before use.
Pressing the Start/Stop button doesn't initiate pumping AND the Green LED does NOT come on	Controller not connected to 120V power source	Make sure that the Multi-Function Controller is connected to an operational 120 VAC external power source through the supplied DC converter.
	Multi-Function Controller is powered OFF	If it is on, the LCD backlight will be on, and it will display some information. If not, press the Start/Stop button and hold for two seconds.
	Multi-Function Controller is in Refill mode	If it is in Refill mode, the LCD indicates that it is refilling and shows how much time is remaining. The refill process will continue until the refill cycle has completed. No buttons are active during this time. Once the refill cycle is completed, pressing Start/Stop starts the pump and the Green LED illuminates.
	SF-PF pump has already pumped its maximum allowed volume	If this is the case, pressing the Start/Stop button should generate an error message on the LCD screen. The controller will only allow you to execute a refill cycle (“Refill Operation Procedure” on page 19).
	Flow rate is set to 0 nL/min or 0.000 µ L/min.	Set a flow rate

Power is lost to the Multi-Function Controller during operation	Power is lost during refill mode	The controller remains in refill mode and the refill cycle continues. There is nothing that can be done to stop the refill mode once it is initiated! Once the refill cycle completes, the pump won't allow you to begin pumping until external power has been restored. If the power hasn't been restored three hours after the power loss occurred, the controller automatically powers off. Under no condition will the unit pump without external power.
	Power is lost while the pump is stopped	The controller will not allow you to begin a pumping protocol. You will only be able to initiate a refill (if necessary) and shut down. If power has not been restored within 3 hours, the controller automatically initiates refill (if necessary), and shuts down. During the time that the controller is without external power (and before 3 hours has passed), a refill may be initiated at any time by using the Scroll buttons to select refill and pressing Enter. If you must leave the SF-PF pump without external power for more than 3 hours, we recommend that you initiate the refill cycle yourself. Remember to switch valves so that the pump reservoir is connected to your solvent/buffer supply.
	Power lost while the pump is actively pumping	The pump automatically stops. As long as external power is not present, you only have the option to initiate a refill and then shut down.
Pressing the Start/Stop button doesn't initiate pumping AND the Green LED DOES come on	Shut-off valve is open or the selection valve is improperly connected	Check that your shut-off valve is closed and that the selection valve is connecting the SF-PF pump to your application.
	Improper plumbing	Check all fluidic fittings for good connection and for leakage.
	Air bubbles are present	Check that there are no air bubbles in the SF-PF pump reservoir or in any of the tubing. If air bubbles are found, purge the pumping reservoir and connecting tubing with your solvent/buffer to be pumped.
	Blockage in the system	Check to make sure that there is no blockage in connecting tubing or within your application.
	Faulty wiring	Visually inspect the wires that connect the Multi-Function Controller™ to the SF-PF pump. If they are damaged, contact WPI.

Pumping stops	Pump has completed the user-defined protocol	Press Start/Stop again to restart the protocol, define a new protocol or initiate a refill.
	Pump has exhausted its available stroke volume	The main setup screen should be visible. Pressing Start/Stop again generates an error message on the LCD screen stating that the available volume is 0. Initiate a refill cycle. See “Refill Operation Procedure” on page 19.
Controller will not work upon being reconnected to external power	Battery charge is too weak	The backup battery loses charge very slowly when the controller is disconnected from an external power source. If the voltage gets low enough, controller will not respond and the battery must be recharged before use. To recharge the battery, simply plug the controller into a 120 VAC outlet for 24 hours.
	Internal electronics failure	Contact WPI.

NOTE: If you have a problem/issue with that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at 941.371.1003 or technicalsupport@wpiinc.com.

SPECIFICATIONS

This unit conforms to the following specifications:

Stroke volume 90µL
Flow rate ..... User-Set (0.25µL/min. to 10µL/min.)
Flow accuracy ..... within 5% of set point
Flow precision ..... better than 3% relative standard deviation
Refill time ..... <10 min.
Wetted materials ..... PEEK[1], FFKM[2], FKM[3]
Fluidic connectors ..... optional accessory kit
Operating temperature ..... 5–40 °C ambient
Operating pressure ..... Range not yet established, <30 psi
Dimensions
 Pump ..... 2.75 x 4.0 x 4.3 cm,
 Controller ..... 14.0 x 10.0 x 3.8 cm
Weight
 Pump 40g
 Controller 220g
Power ..... 5 VDC, 120VAC adapter included

[1]PEEK, polyether(ether)ketone

[2]FFKM, perfluorinated elastomer

[3]FKM, fluorinated elastomer

APPENDIX A: REMOTE OPERATION

The SF-PF pump can be controlled remotely from a computer through a USB connection made between the computer and the rear of the controller. The controller accepts text commands. Any commands sent to the controller is mirrored back to the computer, which can be used to verify that commands were sent. Additionally, queries can be sent to the controller to gain information about the status of the pump and controller. There is also a series of errors that are returned by the controller if the command that was sent was not recognized or was not within the operating parameters of the device.

There are operational enhancements when using the SF-PF pump in the Remote Mode. Specifically, there are three things that you can do in Remote Mode that you cannot do using the front panel.

- **Reverse the direction of the pump**: By entering negative arguments for the Flow, Dispense and Ramp command, you can cause the pump to draw fluid into the reservoir instead of expel it. The controller will not allow you to pump backwards beyond the starting position for the pump, so you must run the pump forward before you can run it backward. You can only run it backward for the same volume that you had previously run it forward. The pump will only run in reverse at the same flow rate range that it will run forward.
- **Ramp the flow rate**: Using the Ramp command, you can cause the flow rate to ramp linearly between two flow rates. You can ramp the flow rates up or down, and you can ramp positive or negative flow. However, you cannot ramp outside of the flow rate range of the SF-PF pump, which includes ramping from positive to negative flow.
- **Set the flow rate in dispense mode**: Using the dispense mode on the front panel, you are restricted to using the factory pre-set flow rate. Remotely, you can set the dispense flow rate. Doing so does not change the pre-set flow rate for subsequent dispenses performed using the front panel.

You can switch freely between front panel operation and remote operation. The USB port settings that match this device are as follows:

Setting	Value
Bits per Second	57600
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

The commands, their arguments, and a brief description of their function and usage are described in the table below. All rates are in nL/min, all volumes are in nL, and all times are in sec.

Syntax: The angle brackets (< >) are used to denote parameters. Do not include the angle brackets when programming the controller. All commands and parameters are

separated using spaces. Send a carriage return after each command or query sent.

Command and <arguments>	Function
Flow <rate>	The pump begins dispensing liquid at the specified flow rate in nL/min. Value can be positive or negative as long as it is within the working range of the SF-PF pump.
Dispense <rate> < volume> <number of dispenses> <delay between dispenses> Ramp <rate 1> <rate 2> <time>	The pump dispenses the specified volume at the specified flow rate for the specified number of times with a delay in between each dose. The pump begins dispensing liquid at Rate 1 and immediately begin ramping to Rate 2. The ramp is linear and the pump achieves Rate 2 at the time specified in argument 3. If no other action is taken, the pump continues to dispense fluid at Rate 2 until the stroke is exhausted.
Stop	Stops the pump
Refill	Initiates a refill. No commands from either the front or rear panel is received while the pump is in refill mode.
Feedback <0 or 1>	Enables (1) or Disables(0) the use of feedback from an external flow sensor (if present)
Off	Turns off the power to the controller. This will immediately initiate a refill.
Vol?	The pump returns the remaining stroke volume in nL
Flow?	The pump returns the output from an external flow sensor, if present.

The errors codes and their meanings are listed in the following table.

Errors	Message
E1	Busy
E2	Unsupported
E3	Invalid Rate
E4	Invalid Volume
E5	Invalid Delay

Examples:

- To initiate flow at 1000 nL/min send “Flow 1000” [CR].
- To Ramp from 1000 nL/min to 2000 nL/min in 60 seconds send “Ramp 1000 2000 60” [CR]
- To initiate a refill, send “Refill” [CR]

APPENDIX B: SIMPLE CONTROLLER PROGRAM

The SF-PF is designed to allow you to easily interface your pump with a computer for simple remote operation. You can use the control program and the front panel of the controller interchangeably without having to send any command to switch between remote and front-panel operation.

Installing the Program

To install the program on your computer, simply go to the disk provided with your pump and run the program: Model 190\SFC Model 190 RC Installers\Simple Model 190 with VISA Installer\Volume\setup.exe.

This installer installs all necessary files needed for your computer to recognize and run the SF-PF pump. When the installer completes, attach your pump to the computer using the USB cord provided with your ePump. The cord attaches to the back of the ePump Model 190 controller and to any functional USB port on your computer. Once the program is installed and the controller is attached, running the program brings up the soft front panel for your pump (Fig. 19).

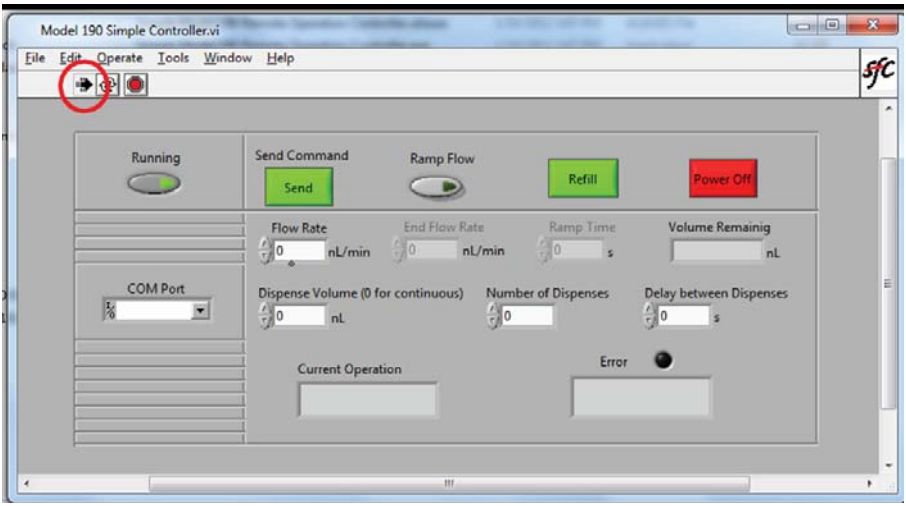

Fig. 19—The soft panel pump controller

Selecting a COM Port

The first thing you must do before sending any commands is to select the COM port that your pump is attached to.

1. Click on the arrow on the right side of the COM Port selection box. A list of all COM ports that this program detects are displayed. Choose the one your pump is connected with.

2. If you are unsure which COM Port your pump is attached to:
   - Chose refresh to make sure that your pump has been identified.
   - Disconnect your pump from the USB cable and chose refresh again. You will see that one of the COM ports disappears. This is the COM Port to which your device was attached.
   - Reattach your controller and chose refresh again. The missing COM Port returns to the list.
   - Select that COM Port and make sure that the correct value shows up in the COM Port window. The correct COM Port must be selected when you start the program. If the program is running, you must stop the program, select the proper COM Port, and then restart the Program.

Starting the Program

To start the program, make sure the Running button is pressed by clicking on it so that the window turns bright green and then press the Run Arrow located under Edit in the Operating Menu (red circle in Fig. 19). If the program is already running, then you don't have to do anything. You can tell if the program is running by looking at the arrow located under the Edit tab in the operation menu. If the arrow is white and stationary, the program isn't running. If the program is running the arrow will be solid black and will have motion marks as if it was moving. The program is running in Fig. 19.

It is important to realize that the program only sends a command to the controller when you click on one of the three large rectangular buttons. The three buttons are the Send button, the Refill button and the Power Off button.

Send Button Commands

The send button is used to send all messages to the pump except refill and power off. Use the numeric controls in the panel below the buttons to create the command that you wish to send. The structure of the command is as follows.

By default, all values are 0. In any case, where the Flow Rate is set to 0, pressing the Send button sends a STOP command to the controller. This will cause the pump to stop pumping. If the pump is not pumping, this will have no effect.

1. To start the pump flowing at a particular flow rate, enter the desired volumetric flow rate in nL/min in the Flow Rate control box and enter 0 in the Dispense Volume. The Flow Rate can be negative.

2. Press the Send button. The pump starts flowing at the specified flow rate and will not stop until you send a stop command, press the start/stop button on the front panel of the pump, press refill or power off on the soft panel, or the pump reaches its maximum stroke volume. For example, pressing the Send Command button on the screen shown in Fig. 20 starts the pump at 5000 nL/min.

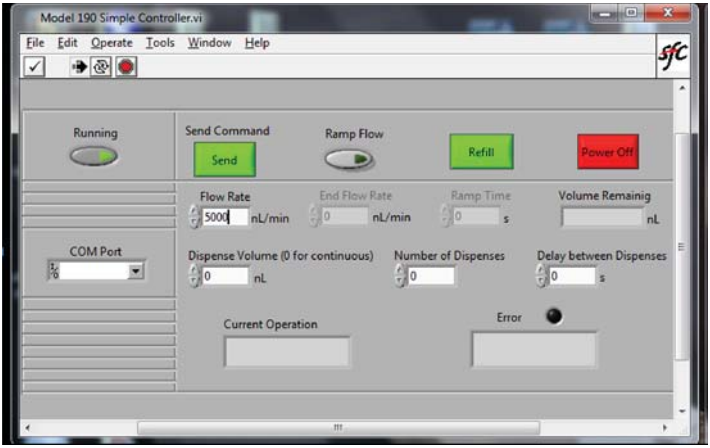

Fig. 20—Starts the pumping at 5000nL/min.

The window shown in Fig. 21 will stop the pumping action.

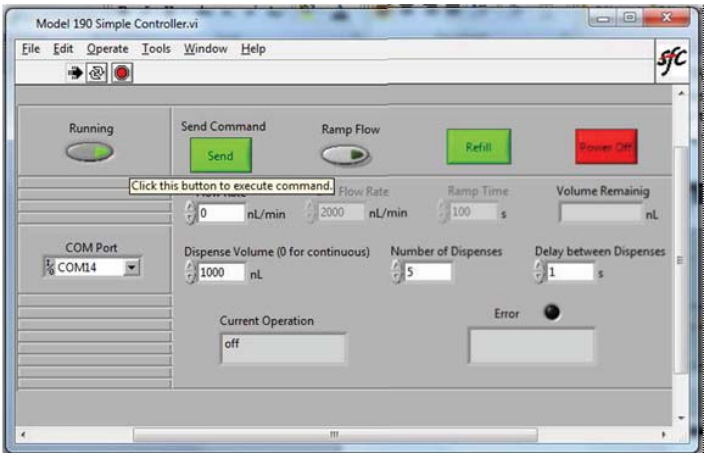

Fig. 21—Stops the pumping action

1. To dispense a set volume or generate a series of dispensed volumes, set the Flow Rate to the desired volumetric flow rate in nL/min.
2. Enter the desired dispensed volume in the Dispensed Volume control box.
3. Enter the appropriate values in the Number of Dispenses and Delay between Dispenses if you want to generate a series of dispenses.
4. Press the Send button to send the command to the controller and start the pumping.

NOTE: The total volume to be dispensed cannot exceed the Volume Remaining or the controller will return an error and the sequence will not start. For example, pressing the Send Command button on the screen shown in Fig. 22 causes the pump to dispense 1000nL at 1000nL/min with a 60 second delay between aliquots.

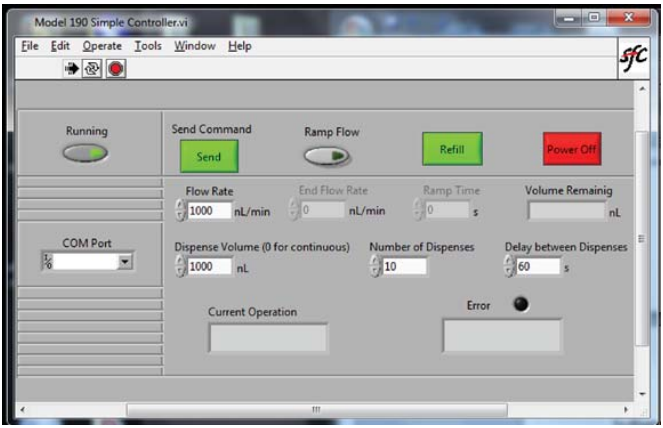

Fig. 22—Setup for a dispense volume

1. To set a ramping flow rate, click on the Ramp Flow selection switch. The window on the button turns bright green and the End Flow Rate and Ramp Time selection boxes are enabled.

2. Press the Send command. The controller automatically ramps the flow in a linear fashion from the value in Flow Rate selection box to the value in End Flow Rate selection box in the time specified in Ramp Time. At the end of the ramp, the flow continues at the End Flow Rate value until instructed otherwise or until the stroke volume is exhausted. If the Ramp Flow button is selected, the Dispensed Volume, Number of Dispenses, and Delay between Dispenses does not work. The Ramp Flow overrides the dispense volume command.

3. To return to the non-ramping mode, simply turn off the Ramp Flow light. For example the screen shown in Fig. 23 starts the pumping at 1000 nL/min. and increase the flow rate by 10 nL/min. every second until after 100s the pump will be pumping at 2000nL/min. Then the pump continues to pump at 2000nL/min. until you command it to do otherwise or until the stroke volume has been exhausted.

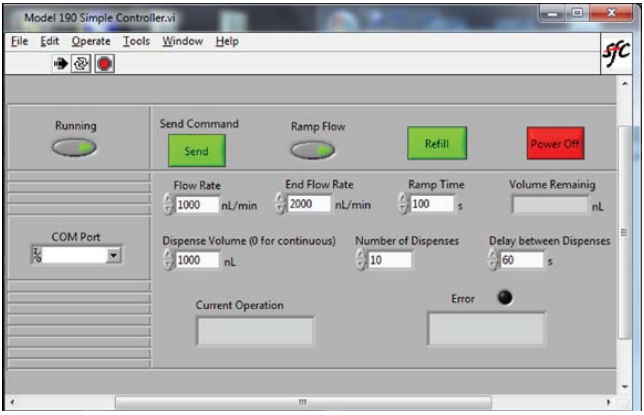

Fig. 23—Shows how to send a ramp command to the pump.

Refill and Power Off Button Commands

Regardless of the values in any of the rate, volume or time control boxes, pressing the Refill or Power Off buttons executes the same sequence of events every time. The Refill button begins a refill.

The Power Off button turns the pump controller off. If the pump is not at equilibrium, pressing the Power Off button first executes a refill and then powers the controller off. Once the controller is powered off, it can only be turned back on using the front panel of the controller itself.

To stop the program at any time, either click on the Running button to turn the light off or press the icon with the red octagon on the Run Options toolbar located at the top of the panel. You can start or stop the program at will without risking any damage to the controller or pump.

NOTE: Stopping or exiting the program while the pump is running does not stop the pump. To stop the pump you must first send the stop command, as described above, or press the Refill or Power Off button while the program is still running. Alternatively, you can stop the pump from the controller's front panel.

APPENDIX C: SEQUENCING PROGRAM

The sequencing program is designed to allow you to easily interface your SF-PF pump with a computer for simple remote operation. You can use the control program and the front panel of the controller interchangeably without having to send any command to switch between remote and front-panel operation.

The sequencing program allows you to create a list of commands to perform at certain times after the program starts.

Installing the Program

To install the program on your computer, simply go to the disk provided with your pump and run the program: Model 190\SFC Model 190 RC Installers\Single Pump Process with Memory\ Single Pump Process with Memory\Volume\setup.exe"

This installer installs all the necessary files for your computer to recognize and run the SF-PF pump. When the installer completes, attach your pump to the computer using the USB cord provided with your pump. The cord attaches to the back of the pump controller and to any functional USB port on your computer. Once the program is installed and the controller is attached, running the program brings up the soft front panel for your pump. It looks like the following image.

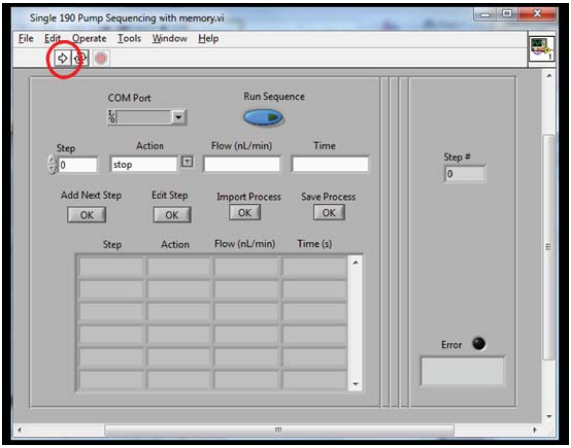

Fig. 24—The soft panel of the SF-PF sequencing controller

Selecting a COM Port

Before sending any commands, select the COM port that your pump is attached to.

1. Click on the arrow on the right side of the COM Port selection box to see a list of all COM ports that this program detects. Choose your COM port.
2. If you are unsure which COM port, refresh to make sure that your pump has been identified.

- Disconnect your pump from the USB cable and chose refresh again. One of the COM Port options disappeared. This is the COM port to which your device was attached.
- Reattached your controller and chose refresh again. The missing COM port returns to the list.
- Select that COM port and make sure that the correct value shows up in the COM Port window. The correct COM Port must be selected when you start the program. If the program is running, you must stop the program, select the proper COM port and then restart the program.

Starting the Program

Start the program by pressing the Run Arrow located under Edit in the Operating Menu (Red Circle in Fig. 24). If the program is running, the arrow located under the Edit tab in the operation menu will be solid black and will have motion marks as if it were moving. If the arrow is white and stationary, the program isn't running. The program is not running in Fig. 24.

It is important to realize up-front that the program only sends commands to the controller when you click on the Run Sequence button. When you press that button, the computer begins sending commands to the pump at the specified time intervals. Pressing the button once executes all steps. If you stop the program, you must re-enter all of the steps again.

Creating a Process

There are two ways to create steps for the sequence that you want the pump to execute: Adding Steps and Editing Steps. Before you can add or edit a step, you must define the step. To do this you must select an action, enter a flow parameter and then enter the length of time before the next step executes.

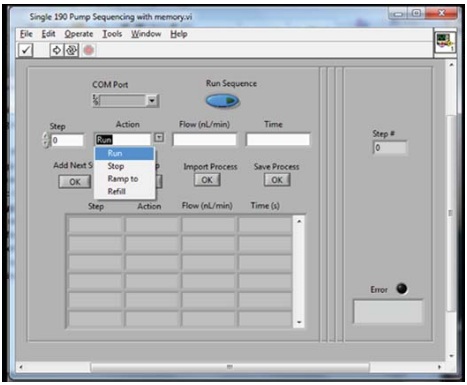

Fig. 25—Selecting a pumping action

1. Select an Action: Select an action from the drop down list shown in Fig. 25. You can see this list by clicking on the arrow next to the Action item box. There are four possible actions you can choose:

- Run: Tell the pump to run at the set flow rate.

NOTE: If this is the last step, then the pump continues running at the specified flow rate until the stroke volume is exhausted. If the pump is to stop at the end of the cycle, make sure that the final command is a Stop command.

- Stop: Stops the pump for the specified amount of time.
- Ramp to: Ramps linearly from the current flow rate specified in the previous step to the flow rate specified in this step. The ramp cannot cause the pump to pump at a flow rate for which it is not calibrated. Therefore, you cannot ramp to a flow rate from stop. You must enter a valid run step prior to sending the ramp. If you want to start the ramp immediately, set the time in the first step to 0.
- Refill: Starts a refill cycle for the pump. Remember once a refill cycle is started, there is no way to stop it. Any commands that you send while the pump is refilling are ignored. Always be sure to enter enough time for the refill to execute before sending another command. Failure to do so causes a "busy" error to be recorded and the program will stop.

2. Set the Flow parameter. The flow parameter is only used with the Run and Ramp to actions. For the Run command it determines the flow rate at which the pump will run, and for the Ramp to command, it is the flow rate that the pump will ramp to. For the Stop and Refill Action items, it is ignored.

3. Set the time. The time tells the controller how long to wait after sending the command before sending the next command, the time between steps. In the case of the ramp to command, this is also the time that the flow takes to ramp from one flow rate to another. For the pump to remain at the second flow rate upon completion of the ramp, enter a Run command at the final flow rate in the next step.

   For example, to ramp from 1000nL/min. to 2000nL/min. in 30 seconds, pump at that rate for 1 min., then stop, enter the following four steps:
   - Run, 1000, 0
   - Ramp to, 2000, 30
   - Run, 2000, 60
   - Stop

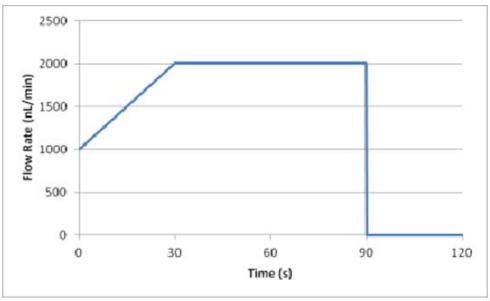

Fig. 26—Flow sequence described in the example

NOTE: The time that is entered for each step is the time before the next command is sent. If your final step isn't stop or refill, the pump continues pumping at the final flow rate even after the process has ended. For example, if the final step is Run, 1000, 60, then the pump runs at 1000nL/min., but it will not stop after 60 seconds. If it should stop, then make the final step in the process a Stop command, such as Stop, 0, 0.

Adding and Editing Steps

Once you have selected an action and qualified it to your application requirements, it is time to put it in the list of steps to be executed. This can be done by adding a step or editing a step.

Add a step by clicking on the OK button under Add Next Step. This causes the step shown above to be inserted next in the sequence. The step number is ignored when adding a step.

Edit a step by pressing the OK button under Edit Step. You can only edit a step that has been previously added.

Saving and Importing Steps

When the program is started, the process array is initialized to 0,0,0. If there is a process that you would like to use repeatedly, you can save the process, and then import it when you wish to use it again. To save a process, first enter all of the process steps into the program according to the procedure outlined above. When you have all of the steps in place, click on the OK button under the text Save Process. A dialog box appears that lets you save the process in whatever file you chose. You do not have to put an extension on the process, but you may. For example, it may be saved as an .xls file by typing .xls after the name.

To import a process, simply click the OK button under the Import Process text. Then, select the process that you have previously saved. You cannot append a saved process onto a process that you are currently writing, nor can you append steps onto a loaded process, but you can edit the steps in a process. You can add steps onto the process by entering them directly into the spreadsheet.

A saved process can be edited outside of the Process Controller interface by opening the saved process in a text file such as Microsoft Excel or Wordpad. You can then add, modify or remove steps and save it again or save it as a new file.

CAUTION: The software lets you enter values that are outside of the operating range of the pump. However, the pump controller will not honor those commands. It is the responsibility of the programmer to send commands that do not exceed the capabilities of the pump that is attached to the controller. The controller sends an error message, if any of the pump's operating parameters are exceeded. This may jeopardize the rest of the protocol.

WARRANTY

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

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Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

Repairs

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

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