PHD 4400
Syringe Pump Series
User's Manual

Harvard
Apparatus

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Warranty & Repair Information

⚠️ **CAUTION:** Refer to page 9, Initial Setup, before plugging in PHD 4400 Hpsi Pump

MANUAL DESCRIPTION

This manual is designed to provide all operational and program information required to operate and maintain the PHD 4400 Hpsi series pumps. The functions and features are described in the Technical Specifications section.

WARRANTY

Harvard Apparatus warranties this instrument for a period of two years from date of purchase. At its option, Harvard Apparatus will repair or replace the unit if it is found to be defective as to workmanship or materials. This warranty does not extend to damage resulting from misuse, neglect or abuse, normal wear and tear, or accident. This warranty extends only to the original consumer purchaser.

IN NO EVENT SHALL HARVARD APPARATUS BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Some states do not allow the exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. **THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR USE, OR OF ANY OTHER NATURE.** Some states do not allow this limitation on an implied warranty, so the above limitation may not apply to you.

If a defect arises within the two-year warranty period, promptly contact ***Harvard Apparatus, 84 October Hill Road, Holliston, Massachusetts 01746*** using our toll free number 1–800–272–2775, or outside the U.S. call 508-893-8999. Our E-mail address is bioscience@harvardapparatus.com. Goods will not be accepted for return unless an RMA (returned materials authorization) number has been issued by our customer service department. The customer is responsible for shipping charges. Please allow a reasonable period of time for completion of repairs or replacement. If the unit is replaced, the replacement unit is covered only for the remainder of the original warranty period dating from the purchase of the original device.

This warranty gives you specific rights, and you may also have other rights which vary from state to state.

REPAIR FACILITIES AND PARTS

Harvard Apparatus stocks replacement and repair parts. When ordering, please describe parts as completely as possible, preferably using a part number obtained from our Customer Service department. If practical, enclose a sample part or sketch. We offer a complete reconditioning service.

SERIAL NUMBERS

All inquiries concerning our product should refer to the serial number of the unit, located on the rear panel (see Figure 2).

CALIBRATIONS

All electrical apparatus is calibrated at rated voltage and frequency. While the flow and volume will stay calibrated the peak pressure may vary.

⚠️ **CAUTION:** Not for clinical use on human patients

General Safety Summary

Please read the following safety precautions to ensure proper use of your syringe pump. To avoid potential hazards and product damage, use this product only as instructed in this manual.

To Prevent Hazard or Injury:

Use Proper Line Cord

Use only the specified line cord for this product and make sure the line cord is certified for the country of use.

Ground the Product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making any connections to the input or output terminals of the product, ensure that the product is properly grounded.

Make Proper Connections

Make sure all connections are made properly and securely. Any signal wire connections to the unit must be no longer than three meters.

Observe all Terminal Ratings

Review the operating manual to learn the ratings on all connections.

Use Proper Fuse

Use only specified fuses with product.

Avoid Exposed Circuitry

Do not touch any electronic circuitry inside of the product.

Do Not Operate with Suspected Failures

If damage is suspected on or to the product do not operate the product. Contact qualified service personnel to perform inspection.

Place Product in Proper Environment

Review the operating manual for guidelines for proper operating environments.

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

 CAUTION Refer to Manual

 Protective Ground Terminal

Technical Specifications

Accuracy	±0.35%
Reproducibility	±0.05%
Syringes (Min/Max)	0.5 µl/140 ml
Syringe Diameter	50 mm
Flow Rate	
Minimum	0.0001 µl/hr (with 0.5 µl syringe)
Maximum	220.82 ml/min (with 140 ml syringe) 374.39 ml/min (with 50 mm diameter syringe)
Calibration	Automatic
Display	2-line, 40-character fluorescent
Memory	Nonvolatile (stores all settings)
Interface	RS232 multiplexed dual bidirectional ports
Connectors	
RS232	RJ11 4-conductor telephone plug
TTL	9-pin D-SUB connector
Linear Force (Max)	200 lbs

Drive	
Motor	1.8° stepper
Control	Microprocessor (from 1/2 to 1/32 microstepping)
Step/Revolution	From 800 to 12,800
Step Rate	
Minimum	27.3 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate	
Minimum	0.18 µm/min
Maximum	190.676 mm/min
Timing Belt Drive	2:1
Lead Screw Pitch	24 threads/in
Power	100-240 VAC, 50/60 Hz, 75 W, 0.75 A fuse
Dimensions, H x W x D	17 x 23 x 29 cm (6.7 x 9.0 x 11.4 in)
Weight	6.4 kg (14 lbs)
Cable Length (Max)	9.1 m (30 ft) for Remote Model only 15 m (50 ft) for RS232 9.1 m (30 ft) for User I/O

Theory of Operation

The PHD 4400 Hpsi series employs a microcontroller which controls a small step angle stepping motor that drives a lead screw and Pusher Block. Microstepping techniques are employed to further reduce the step angle, eliminating flow pulsation. A keypad is used for entry of operating data to the pump. Data can also be entered via an RS232 connector located on the rear panel. The microcontroller, using the internal Syringe Look Up Table, calculates the cross-sectional area of the syringe selected and calibrates the flow rate and volume accumulation. The numerous features of the PHD 4400 Hpsi result from the use of microprocessor technology.

The PHD 4400 Hpsi Programmable model provides full programmability along with Infuse/Withdraw capability. Use of the **REFILL RATE** key, **INFUSE/REFILL** key, **PROGRAM** key, **AUTO FILL** key, Retaining Brackets and Adjustable Stops are all described in the upcoming pages.

Features

Pressure and Speed

PHD 4400 Hpsi can deliver up to 220.82 ml/min with a single 140 ml syringe. Maximum pressure is dependent on syringe size.

Built-In Syringe Table and Custom Syringes

The user may select the syringe to be used from the pump's built-in syringe table. Syringes are arranged according to manufacturer and material, and then according to size. The pump will look up and use the diameter for the syringe you select. (See Appendix A for a listing of the standard syringes.)

If a syringe is to be used, which is not listed in the syringe table, enter the inside diameter of the syringe in millimeters.

Infusion and Refill Rates

Specify independent rates for infusing and refilling. This allows a slow infusion rate, then a fast refill. If Refill Rate is not set, the software defaults to the set Infuse Rate value.

Target Volume

Specify the volume that is to be infused or refilled. The pump will run at the rate specified until this volume has been delivered when in the Volume Mode.

Auto Fill

Auto Fill automatically activates an externally attached solenoid (refer to Appendix L for part number) and refills the syringe when it is empty. This permits infusions to be virtually independent of syringe capacity.

Modes of Operation

Pump:

Runs continuously in the infuse or refill directions until stopped.

Volume:

Runs until a specified volume has been pumped or refilled.

Program:

Pump operates according to a specified sequence of instructions.

Note: All modes interact with Auto Fill.

External Connections

User I/O

Allows pump operations to be synchronized with external devices or by a person at a distance from the pump. Connector pins are available to control direction of pump travel to control an external valve for refilling, and for general use. A simple contact closure to ground or TTL level signals may be used for inputs. (See Section 10 and Appendix I.)

RS232

Multiple pumps can be 'daisy chained' together and remotely controlled from a computer or any device communicating via RS232.

A scale can be connected, enabling the pump to infuse by weight instead of by volume. (See Section 10.)

A printer can be connected to record final volumes or weights whenever the pump stops. In addition the program entered for the program mode can be listed on a connected printer. Both a scale and a printer may be connected simultaneously. (See Section 10.)

Remote Unit (Cat No 70-2201 Only)

Allows connection to the remote syringe pump unit. The remote unit may be positioned up to 30 feet away from the control unit.

Features

Nonvolatile Memory

All operational data entered into the pump from the keypad or from a computer will be stored, including the program. On power up, the display will blink until the pump receives its first command and all settings from when it was powered down will be recalled.

Stall Detection

An optical detector is used to verify expected movement of the motor. If the motor is prevented from turning due to jamming or excessive back pressure, the pump will stop and the display will read: **PUMP STALLED**.

Visual/Audible Alarm

After a power interruption the alarm can be selected to be a silent flashing display or an audible signal in addition to flashing display. Refer to Section 6 for details on setting the Alarm Mode.

Power-Up Options (Pump Mode Only)

Enables the user to select between a standby mode (waiting for a command to begin running) after power is interrupted or a restart mode that begins running the pump at the settings that were in process when the power was interrupted.

Program Storage

Programmable model can store up to four sets of nine program sequences for later selection.

User Interface

The user interface consists of a keypad with a display area. The display consists of a two line, 40 character alphanumeric vacuum fluorescent display. The display will show one of three types of messages: default display, setting display, or an informational message.

The top line of the display is divided into three sections. The first consists of the delivered volume, or time interval remaining in an operation, expressed with five digits plus a decimal point. Next is the units of the previous number expressed as 'ml' for milliliters, 'g' for grams, if a scale is attached, or 'time' for a time interval. Third is the pumping direction, either **INFUSE** or **REFILL**, or the current operating state of the pump. A diamond symbol ◊ in the last character of the display indicates pump chain communication has been received.

Setting displays are used to facilitate entering control information and data into the pump. Data entry will be discussed in detail later in this section.

Informational messages occur at various times to indicate such items as a data setting out of range, or a detected problem, such as the pump stalling. Pressing any key clears the message from the display.

The second line of the display is also divided into three sections. The first is the Running Mode (Pump, Vol, Prog). The second section is the AutoFill indication (no message if Auto Fill is Off, If On, AutoFill **ON** is displayed) The third section is a pair of directional arrow heads (< or >) indicating that the pump is running and in what direction.

The keys are used for entering control information and data into the pump. These keys are grouped into three sections (see Figure 1): Set keys, Toggle keys, and Data Entry keys.

User Interface: Description of Keys
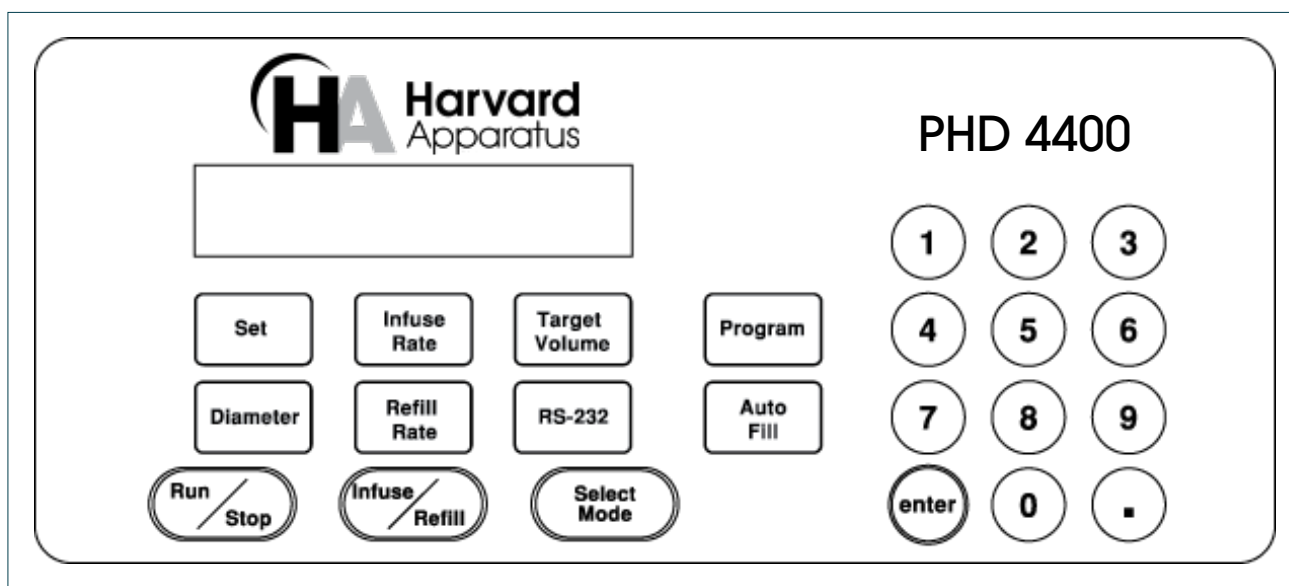
Figure 1. Programmable Model Keypad

Set Keys

SET – Allows modification of a data item in this group of keys. To modify a data item, press the relevant key after pressing the **SET** key. Pressing Set with an appropriate data entry key will also allow the selection of special features. Refer to Entering Data on page 8.

INFUSE RATE – Displays/sets current infuse rate. Scrolls through rate units with each press of the key when setting. Displays current programmed rate while running in program mode.

TARGET VOLUME – Displays/sets current volume mode target volume.

PROGRAM – Displays current program number, program sequence and sequence number. Held down, with a printer attached and the pump stopped, prints a program listing.

DIAMETER – Displays/sets current syringe diameter. When held down during setting, accesses built-in syringe table.

REFILL RATE – Displays/sets current refill rate. Scrolls through rate units with each press of the key when setting.

RS232 – Displays/sets current RS232 device(s) attached.

AUTO FILL – Turns Auto Fill feature setting on/off. Also displays/sets syringe refill volume.

Toggle Keys

In this group, when permitted, successive states of the keys' function are selected when the key is pressed.

RUN/STOP – Starts/stops – interrupts running of pump.

INFUSE/REFILL – Changes direction of pusher block travel during operation in Pump and Volume modes. Pump must be stopped or in Pump Mode to reverse direction of pump.

SELECT MODE – Toggles in an incremental loop through **PUMP**, **VOLUME** or **PROGRAM** run modes with each press of the key. The current mode is displayed on the second line of the display.

Data Entry Keys

1, 2, 3, 4, 5, 6, 7, 8, 9, 0, . – Used to enter numeric data values or access special features.

ENTER – Saves and stores displayed data value in memory when setting a data item.

User Interface: Entering Data

Set Keys

Keys with rectangular outlines in this group are used to modify or review settings of the pumps control data. To review the current setting of a control data item, simply hold down the relevant key and the data setting will appear in the top line of the display. In the case of the **PROGRAM** key, if it is held down the data will be sent to the printer if one is attached.

To modify a data setting first press then release the green outlined **SET** key. The display should then read **SET WHAT?**. Press the key in the **SET** key group whose data is to be modified. The display will display the current setting. Data is entered into the pump by either entering a numerical value or by scrolling through a menu of choices. Always press the green outlined **ENTER** key to terminate and store each data request by the pump.

If you are to enter a numerical value, the far left of the display will show **ENTER** followed by the units of the number to be entered. Using the numerical keys on the right side of the keypad enter the new data value (see Figure 1). Up to five digit numbers are accepted, including up to four decimal places.

Entering more than five digits will clear the previous five digits entered in the display. Press the green outlined **ENTER** key when the desired data value is displayed.

If the far left of the display does not show **ENTER**, then a menu of choices is being displayed. Pressing the relevant key, according to the choices being displayed, selects successive menu entries. When the desired selection is displayed, press the green outlined **ENTER** key.

If the data value entered is outside the pump's operating parameters, the display will read **OUT OF RANGE**. Pressing any key will restore the display with the original data value. Enter another data value within the pump's parameters or just press the green outlined **ENTER** key to reuse the original data value.

The data value entered can be reviewed as described above. *Note: Certain data items have multiple settings.* For these, after the **ENTER** key is pressed, the display will prompt you for the additional information. Various rules apply to when, what and how data can be set at various times. See the relevant section for further details.

Special Features Access Table

Pressing the green outlined **SET** key and then the appropriate numerical key will allow the setting of several special features. Pressing the appropriate numerical key again will scroll between the options provided. Refer to the table below. When the desired option is displayed, press the green outlined **ENTER** key.

RS232 Protocol	**SET**	1
Alarm Mode	**SET**	2
Power Up Mode	**SET**	3

Step	Key	Setting RS232 Protocol	Description
1	SET	**SET WHAT?** Pump Mode	Press and release **SET** key
2	1	**MODEL 44 PROTOCO**L Pump Mode	Press and release 1 key - Current RS232 protocol displayed
3	1	**MODEL 22 PROTOCOL** Pump Mode	Press and release 1 key to change RS232 protocol
4	enter	**XXXXX ML INFUSE** Pump Mode	Press **ENTER** to accept + return to main display

Step	Key	Setting Alarm Mode	Description
1	SET	**SET WHAT?** Pump Mode	Press and release **SET** key
2	2	**ALARM: VISUAL ONLY** Pump Mode	Press and release 2 key - Current alarm mode displayed
3	2	**ALARM: VISUAL & AUDIBLE** Pump Mode	Press and release 2 key to change alarm mode
4	enter	**XXXXX ML INFUSE** Pump Mode	Press **ENTER** to accept + return to main display

Step	Key	Setting Power-Up Mode	Description
1	SET	**SET WHAT?** Pump Mode	Press and release **SET** key
2	3	**POWER UP: STANDBY** Pump Mode	Press and release 3 key - Current power-up mode displayed
3	3	**POWER UP: RUNNING** Pump Mode	Press and release 3 key to change **POWER-UP** mode
4	enter	**XXXXX ML INFUSE** Pump Mode	Press **ENTER** to accept + return to main display

Initial Setup
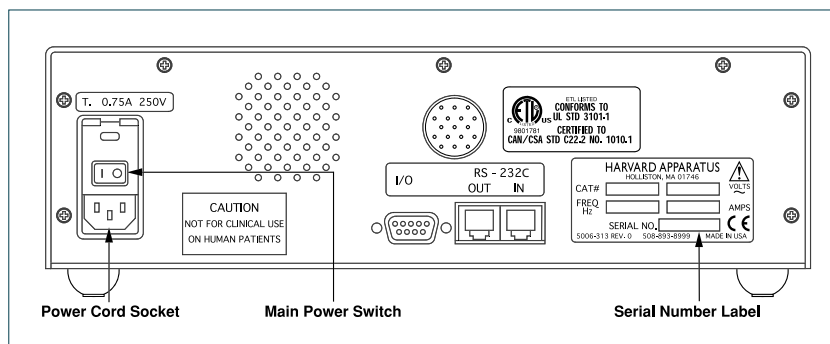
Figure 2a. Rear Panel: Power Entry and Serial Number Label

1. Read the entire manual to become familiar with all features and functions of the PHD 4400 Hpsi.

2. The operating voltage range for the PHD 4400 Hpsi is 100 - 240 VAC, 50/60 Hz. Use only the specified line cord for this product and make sure line cord is certified for country of use.

3. Take this opportunity to fill out and mail the Warranty Card. The Catalog and Serial numbers are located on the Serial Number label on the rear panel. (See Figure 2a.)

4. Turn on the main power switch (see Figure 2a) located directly above the power cord receptacle on the rear panel. The two-line display will illuminate indicating that the power connections are correct. The flashing display indicates that power has just been applied. Pressing any key will reset the blinking display to constant illumination.

5. See operating Instructions on the next page.

6. Fuse Replacement. Turn off power, remove power cord from power module. Use straight blade screw driver, pry open access door. Remove fuse holder, remove fuse(s) from holder. Replace fuse(s) and fuse holder. For continued fire protection, replace fuse only with 250 V fuse of the specified type and rating. (3 AG 0.75 AMP SLO-BLO) (See Figure 3.)

7. Remote Unit Connection (Catalog No 70-2201 only). Connect the control unit to the remote pump unit with the cable provided.
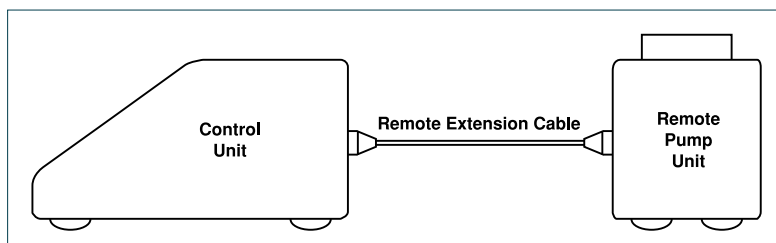
Figure 2b. Remote Unit Connection
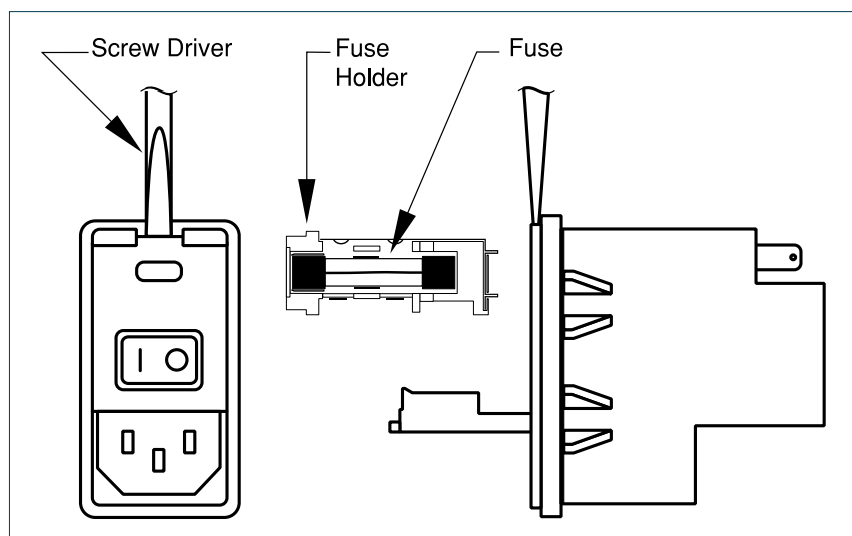
Figure 3. Fuse Replacement

Fuse Replacement

Because of the wide range of functions that the PHD 4400 Hpsi is capable of performing, certain information about your application must be entered into the pump. At minimum, the pump needs to know the diameter of your syringe, the infusion rate and direction of travel.

This is the only information needed to run the pump in the Pump Mode. If not specified, the refill rate will default to the infuse rate. The pump will need additional information to utilize its more advanced features. See the User Interface section for general information on data entry.

⚠️ **CAUTION:** **Use in manner not specified by the manufacturer may impair the protection provided by the equipment**

Operation
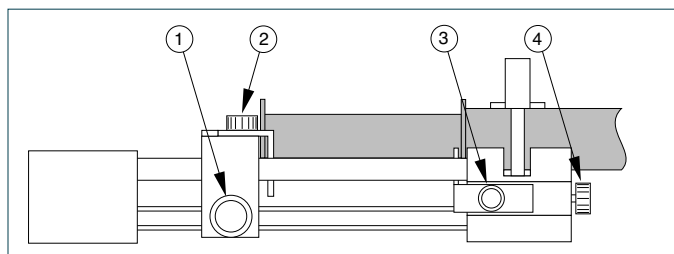
Figure 4. Syringe Loading

Syringe Loading

1. The syringe holder and pusher block are fitted with movable retaining brackets which hold firmly the syringe barrel and plunger when refilling. When loading the syringe into the pump it is necessary to adjust these brackets. The pusher block is fitted with a mechanism to release the drive nut from the lead screw so that the block can be moved freely to facilitate loading the syringe.

2. Loosen the screws on the syringe block and pusher block to free the retaining brackets (2 & 3).

3. To free the pusher block from the lead screw, turn the knob on the front of the block (1) until the knob slips into the slots or front of the machine.

4. The syringe clamp locking screw on the right side of the syringe block (4) should be loosened and the clamp rotated to the side.

5. Place the syringe barrel on the syringe holder block and move the pusher block to accommodate the plunger.

6. Make sure the syringe barrel flange and the plunger flange are held by the retaining clamps. Press the retaining brackets firmly against the flanges and tighten the retaining screws.

7. Rotate the syringe clamp and press down firmly on the syringe barrel. Secure in place by tightening the locking screw (4). For syringes greater than 50 cc, it may be necessary to use the 'V'-shaped clamp provided. Place clamp over the syringe barrel and secure to the holder block with the two long thumbscrews.

8. If desired, adjustable stops to limit the syringe plunger travel may be purchased from Harvard Apparatus (see Appendix J for part number). Install the stops on the two guide rods at the desired locations.

Running the Pump

Pressing the **RUN/STOP** key starts the pump. The pump will operate according to the relevant data entered as interpreted by the selected run mode. Pressing the **RUN/STOP** key while the pump is running stops the pump and the right side of the top line of the display will indicate **INTERRUPT** plus **>** for infusing or **<** for refilling. This indicates that the pumping operation has been suspended and can be continued. Pressing the **RUN/STOP** key again will continue the pumping operation at the point that it was interrupted. Changing any of the settings, including the pumping direction and the run mode, cancels the interrupted operation and resets the display. The pump can also be started and stopped from a remote source.

Diameter

If the inside diameter of the syringe being used is known, enter the value in mm. Otherwise, access the built-in Syringe Table and select the syringe being used. After a new diameter is entered, directly or via the built-in Syringe Table, the Infuse Rate and Refill Rate are set to 0 and the Auto Fill feature is turned off. This is done for safety reasons. The maximum diameter that can be entered is 50 mm.

To access the built-in Syringe Table, after pressing the **SET** key then the **DIAMETER** key, hold down the **DIAMETER** key for about one second. Once the Syringe Table has been accessed, each press of the key will scroll through the manufacturers. Find the manufacturer and material, if applicable, of your syringe. Press the **ENTER** key to enter your selection. Now, using the **DIAMETER** key again, scroll by pressing the **DIAMETER** key until the size of your syringe is displayed, in cc or µL, as indicated on the display. Pressing the **ENTER** key will select the size of the syringe and look up and store the diameter. The diameter will be displayed until the **ENTER** key is released. Thereafter, pressing the **DIAMETER** key will display the selected diameter. In addition, the syringe size selected becomes the default Refill Volume when the Auto Fill feature is turned on. See Appendix A for a listing of the built-in Syringe Table and their respective diameters.

Infuse Rate

The Infuse Rate is the rate of pumping while infusing in the Pump or Volume modes. Also, the Infuse Rate is used as a starting rate for the program model if one is not specified in the program, regardless of pumping direction.

When entering the Infuse Rate, the **INFUSE RATE** key is used to scroll through the allowable units of rate. The allowable units are: ml/mn, ml/hr, µl/mn, µl/hr. While running in the Pump or Volume modes, the Infuse Rate can be changed. If the new rate is valid, it will take effect when the **ENTER** key is pressed. The minimum and maximum rates permitted vary depending on the diameter of the syringe. If an **OUT OF RANGE** message is displayed when entering a rate try using a different syringe for your application.

Refill Rate

The Refill Rate is the rate of pumping while refilling in the Pump or Volume Modes or during Auto Fill. If the Refill Rate has not been set (rate is 0), the Refill Rate will default to the Infuse Rate. When entering the Refill Rate, the **REFILL RATE** key is used to scroll through the allowable units of rate. The allowable units are: ml/mn, ml/hr, µl/mn, µl/hr. While running in the Pump or Volume Modes, the Refill Rate can be changed. If the new rate is valid, it will take effect when the **ENTER** key is pressed. The minimum and maximum rates permitted vary depending on the diameter of the syringe. If an **OUT OF RANGE** message is displayed when entering a rate, try using a different syringe for your application.

Target Volume

The Target Volume is the volume that you desire to deliver at the set Infuse or Refill Rate. The pump must be set for this Volume Mode for this feature to work. When entering the Target Volume, enter the volume desired in mls (milliliters) and press the **ENTER** key.

Operation

Auto Fill

Use the **AUTO FILL** key to toggle between Auto Fill **ON** and **OFF.** If Auto Fill is set to **ON**, the pump will next request the volume of the syringe in mls. The volume of the syringe is used as the refill volume of the syringe. This volume can be set to a volume smaller than the syringe if desired.

When set to **ON**, the syringe is assumed to be empty. Auto Fill continuously monitors the volume of the syringe according to the volume pumped. When the pump determines that the syringe is empty, the operation in progress is suspended and Auto Fill is activated. The pumping direction is then reversed and the pump runs at the refill rate. During the Auto Fill operation, the display will indicate the volume of liquid in the syringe.

When the volume in the syringe reaches the set refill volume, Auto Fill will stop, and the previous operation of the pump will resume. Auto Fill continues to monitor the volume of the syringe. TTL direction output is toggled **ON** during refill. Refill Rate defaults to Infuse Rate if not set.

Note: Auto Fill will only activate while infusing, (i.e., if the pump direction is set to Refill, the pump will not stop when the syringe is full.) Also, if the syringe plunger is manually moved, the pump will lose track of the true syringe volume.

Selecting the Run Mode

After entering any necessary operating data into the pump, select the pumping mode that will be used when the pump is operated. Pressing the **SELECT MODE** key advances the second line of the display to indicate the next run mode. Advance the Run Mode to the desired mode, either Pump Mode, Volume Mode or Program Mode until it is displayed.

PUMP MODE

The pump will continuously pump, infusing or refilling, until stopped. While running, the Infuse and Refill Rates can be changed. The new rate, for the relevant pumping direction, takes effect when the **ENTER** key is pressed. Also, the pumping direction can be changed by pressing the **INFUSE/REFILL** key.

VOLUME MODE

The pump will run, infusing or refilling, until a specified target volume is pumped or refilled. The **TARGET VOLUME** key is used to enter the Volume Mode target volume. Used in conjunction with Auto Fill, the target volume can be greater than the volume of the syringe. While running, the Target Volume, Infuse and Refill Rates can be changed. The new rate, for the relevant pumping direction, takes effect when the **ENTER** key is pressed. Target Volume can be used to enter a Target weight in grams if a scale is attached via RS232.

PROGRAM MODE

In the Program Mode the pump can make complex dispenses including changes in rate and target volume. These complex dispenses are easily programmed from the keypad and are detailed in the Program Mode and the Programming Tutorial sections.

Program Mode

Program Description

A program is made up of a set of sequences. Each sequence being a set of operating instructions for the pump to follow. When the pump is started in the **PROGRAM** run mode, the pump will start at sequence one and execute the operating instructions in that sequence. When the pump has completed the instructions for a sequence, it will go to the next, or specified, sequence and execute the instructions in that sequence. The pump continues this process until it either has reached a **STOP** operation, the pump is manually or remotely stopped, or the last sequence has been completed. Four programs with up to nine sequences each may be entered.

A sequence consists of a sequence number, indicating the order of the sequence; a mode, indicating what operation the sequence will be performing; and the actual data for the operation, such as rates and volumes. The necessary data specified for each sequence will depend on the strategy used.

One of two strategies may be chosen for a sequence's target. Strategy 1 (Target Volume) pumps until a target volume is reached, while Strategy 2 (Time Interval) pumps until a target time interval has lapsed. When Strategy 1 is used, enter a time interval of 0:00:00, then you will be prompted for the target volume. See the Programming Tutorial for example programs.

Entering a Program

It is advisable to plan out your program prior to entering the program into the pump. Press the **SET** key then the **PROGRAM** key to begin entering a program.

The following is a list of possible data that can be requested when entering a program and instructions on entering the data.

Sequence of Operation

Use the **PROGRAM** key to select the sequence's operation. Operations that can be selected are: Profile, Increment (Incr), Decrement (Decr), Dispense, Event, Go To, Pause, Pump, TTL Out, Restart, Stop. When the required operation is displayed press the **ENTER** key. Additional information may be requested.

Rate

Enter the rate, using the **INFUSE RATE** key to change units. *Note: If the rate entered is invalid, an error message will not be given at the immediate time of entry.* An **OUT OF RANGE** error message will be given during the running of the program.

Delta Rate

Enter the rate of Increment or Decrement desired. The units of the rate cannot be specified. Units will be the same as the units of the current pumping rate at the time the sequence is executed.

Target Volume

Enter the required delivered target volume of the sequence. For increment and decrement sequences, the target volume is an incremental target. An incremental target is added to the delivered volume at the start of the sequence.

Time Interval

Enter the time duration of the sequence in the form: hours : minutes : seconds. If sequence Strategy 1 (Target Volume) is used, enter 0:00:00 for the time target. The maximum time interval is 9:99:99

Number of Repetitions

Enter the number of times the sequence is to be repeated. The repetition number can be from 1 to 99,999.

Pumping Direction

Each sequence that specifies a pumping operation, also specifies a pumping direction. Use the **INFUSE/REFILL** key to change the pumping direction (< or >).

Pin Level

Select either **HI** or **LOW** for the logic level of the programmable output pin 4. Use the **PROGRAM** key to change the setting.

Go to Sequence Number

Enter the destination sequence to continue operation of the program. Valid sequence numbers are 1 to 9.

Profile

Runs at specified flow rate until target volume is pumped or a time interval has elapsed. Travel direction is as specified.

Data Specified:		
Strategy 1	Flow Rate	
(Volume)	Time Interval = 0:00:00	
	Target Volume	
	Pumping Direction	
Strategy 2	Flow Rate	
(Time)	Time Interval	
	Pumping Direction	

Program Mode

Incr

Increments current rate by specified value and pumps until the target volume is pumped or a time interval has elapsed. Units of rate will be that of the current rate of the pump or the infusion rate's units, if first sequence. Sequence is repeated the specified number of times. Travel direction is as specified.

Data Specified:	
Strategy 1	Delta Flow Rate
(Volume)	Time Interval = 0:00:00
	Volume Increment
	Number of Repetitions
	Pumping Direction
Strategy 2	Delta Flow Rate
(Time)	Time Interval
	Number of Repetitions
	Pumping Direction

Decr

Same as **INCR** except rate is decremented.

Dispense

Repeatedly dispense specified volume. Runs at specified flow rate until a volume is pumped or a time interval has elapsed, then pump will stop. If no time interval was specified (Strategy 1), the display will show **TRIGGER** and the next dispense will begin after an external or keyboard run command. Otherwise, the sequence will pause for specified time interval. Sequence is repeated the specified number of times. Travel direction is as specified.

Data Specified:	
Strategy 1	Flow Rate
(Volume)	Time Interval = 0:00:00
	Target Volume
	Number of Repetitions
	Pumping Direction
Strategy 2	Flow Rate
(Time)	Time Volume
	Target Interval
	Number of Repetitions
	Pumping Direction

Event

Program Events – A program event is an external event defined as a high to low transition on TTL pin-9. Within a program, a one time event trigger can be set which watches for and acts upon the external event. The triggered event causes an immediate continuation of the program at the specified sequence and the operation of the pump will be according to this sequence.

Data Specified:	Go To Sequence Number

Go To

Causes the program to immediately continue operation at the sequence specified.

Data Specified:	Go To Sequence Number

Pause

Pump stops for specified time then continues with next programmed sequence. Current program rate set to 0, with no change in units.

Data Specified:	Time Interval

Pump

Runs the pump continuously at the specified flow rate without any pumping target. This mode can provide a background flow rate while waiting for an external event to trigger a new sequence specified by the **EVENT** operation.

Data Specified:	Flow Rate
	Pumping Direction

TTL Out

Programmable TTL pin. TTL output pin 4 of the user I/O connector can be set to a **HIGH** or **LOW** level from within a program.

Data Specified:	TTL Pin Level

Restart

Immediately restart program from the first sequence.

Data Specified:	None

Stop

Stops pump and the program terminates.

Data Specified:	None

Program Mode

Program Printout

If a printer is attached and the pump is stopped a program listing can be obtained by pressing the **PROGRAM** key for about one second. **PRINTING PROGRAM** will be displayed while data is being sent.

Program Runtime Error Messages

If while running a program an operation is requested that cannot be performed the pump will stop and an error message will be displayed. Error messages will be displayed with the following format:

Program N SEQ n: message

Where **N** is the Program number and **n** is the sequence number when an error was detected, and **message** is the indicated error as follows:

INFINITE LOOP

A **GO TO** sequence cannot specify the current sequence.

INVALID GO TO

The target of the **GO TO** specified an invalid sequence number.

RATE UNDERFLOW

A decrement sequence decremented a rate to less than or equal to 0.

RATE OVERFLOW

An increment sequence caused an arithmetic overflow.

OUT OF RANGE

Specified or calculated rate is beyond the pumps capabilities with the specified syringe.

VOL TGT ERROR

A sequence with a volume target cannot follow a sequence with a time target, unless the volume delivered is zero or the pump is stopped at the start of the sequence entering it, select Program Mode using the **SELECT MODE** key and press the **RUN/STOP** key.

External Control Interfaces

RS232 Devices
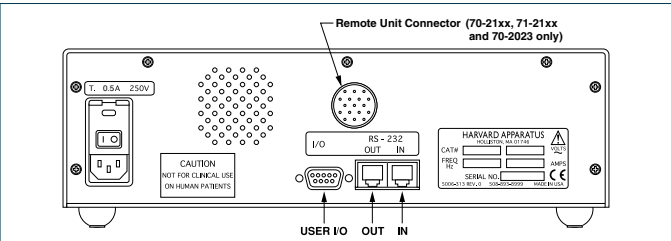
Figure 5. Rear Panel External Connections

External devices that can be attached to the PHD 4400 Hpsi are categorized into either RS232 devices or user I/O devices. Pump Chains, Scales and Printers are RS232 devices, all other devices are user I/O devices. See the Appendix G for specification details on attaching RS232 devices and Appendix I for user I/O specifications.

There are two telephone jack type connectors on the back of the unit (See Figure 5). These are the RS232 ports. Looking at the back of the pump, the connector on the right is **IN** and the left is **OUT**. Attach the RS232 connectors in the appropriate port according to the following chart:

Device	Port
Pump Chain computer side	IN
Pump Chain pump side	OUT
Scale	IN
Printer	OUT

Configuring the Pump for RS232 Devices

Press the **SET** key and then press 1 to select either Model 22 or Model 44 Protocol (Refer to Section 12, Pump Chain Commands). Press the **SET** key, then use the RS232 key to scroll through the menu of allowable RS232 configurations.
Possible configurations are:

> Pump Chain
>
> Scale
>
> Printer
>
> Scale & Printer

After entering the RS232 configuration, additional information may be requested.

External Control Interfaces

Pump Chain

Enter the 2-digit address assigned to the pump. *Note: Each pump in the chain needs a unique address.* After entering the address (up to 99), the baud rate will be requested. Use the RS232 key to toggle between the supported baud rates: 1200, 2400 , 9600 and 19200. *Note: Each pump in the chain must have same baud rate.* See Section 12, Pump Chain Commands for pump chain control information.

Scale

Use the RS232 key to toggle between the supported manufacturers: Mettler, Sartorius and Ohaus. When a scale is attached, the weight will be read from the scale and used as the delivered volume whenever the pumping direction of the pump is set to infuse. When refilling, the syringe diameter is used for volume calculations. When the scale weight is displayed, the units will be grams.

Printer

No additional information requested when entering. With a printer (capable of serial port communication) attached, the pump will print the delivered volume whenever the pump stops or the direction of pumping changes, except before and after Auto Fill of the syringe. If the pump stops due to the pump stalling, an asterisk (*****) will be appended to the volume printed. In addition, the entered pump program can be listed on the printer by pressing the **PROGRAM** key for about one second, with the pump stopped.

User I/O Devices

The pump does not need to be configured to attach a user I/O device. Simply plug the device into the 9-pin connector on the rear of the pump. See Appendix I for wiring specifications.

Foot Switch or Relay

Used to start and stop the pump. Pressing the foot switch performs the same function as pressing the **RUN/STOP** key on the keyboard. The foot switch connector allows remote or automated operation of the pump.

Timer

Opening the timer input starts the pump. Closing the timer input stops the pump. The timer input allows for an externally controlled pumping interval.

Pumping Direction

Sets the direction of pumping. Opening the directional input sets the pump to infuse. Closing the directional input sets the pump to refill. The pumping direction input is recognized only in the situations that the **INFUSE/REFILL** key would be recognized, i.e., when the pump is stopped or running in the Pump Mode.

Valve Control

The valve control output is an indicator of the direction of pump travel. When the output is high, the pump is set to Refill. A low output indicates Infuse.

Programming Tutorial

To run a program after entering it, select Program mode using the **SELECT MODE** key and press the **RUN/STOP** key. The examples on the following pages include: Multiple Infusions, Ramping Up Infusion Rate, Multiple Dispensing, Periodic Dispense Loop, Combination Infuse and Withdraw Profile, Use of Events and Use of Signal.

Multiple Infusion Example

The following program will instruct the pump to infuse according to the above graph. The program instructs the pump to infuse 10 ml at 75 ml/mn then infuse another 5 ml at 25 ml/mn then stop, for a total of three sequences. Since this graph is Rate vs Volume, Strategy 1 will be used when entering the program.

SEQUENCE 1	Key Presses	Explanation
	SET	Allows selection of Programming mode
	PROGRAM	Press until PROFILE selected
	ENTER	Enters selection
	75	Enter rate of 75.000 ml/mn
	INFUSE RATE	Press until units are ml/mn
	ENTER	Enters rate
	0 ENTER	Enter 0 for the time, this indicates Strategy 1
	10 ENTER	10 ml is the first target volume
	INFUSE/REFILL	Toggles direction to infuse
	ENTER	Enters sequence's pumping direction
SEQUENCE 2	**Key Presses**	**Explanation**
	PROGRAM	Press until PROFILE selected
	ENTER	Enters selection
	25	Enter rate of 25.000 ml/mn
	INFUSE RATE	Press until units are ml/mn
	ENTER	Enters rate
	0 ENTER	Enter 0 for the time, this indicates Strategy 1
	5 ENTER	5 ml is the second target volume
	INFUSE/REFILL	Toggles direction to infuse
	ENTER	Enter sequence's pumping direction
SEQUENCE 3	**Key Presses**	**Explanation**
	PROGRAM	Press until STOP selected
	ENTER	Enters selection and ends program entry
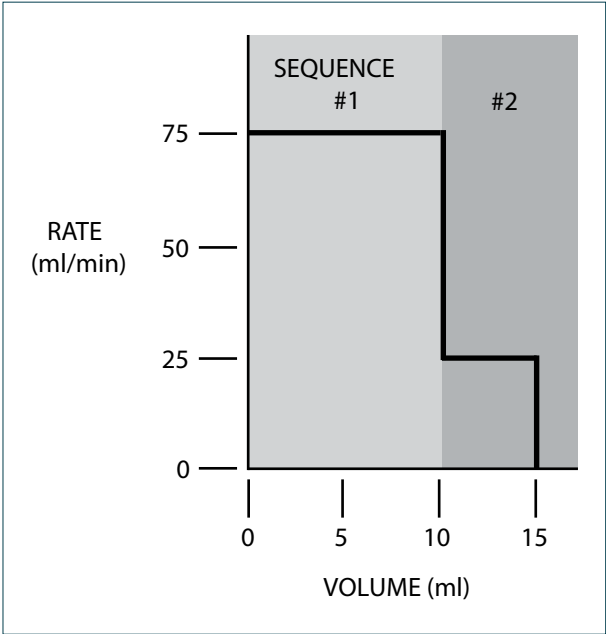
Figure 6. Multiple Infusions.

PROGRAM PRINTOUT

PROG1 SEQ 1	PROFILE
	75.000 ml/mn
	10.000 ml
	INFUSE
PROG1 SEQ 2	PROFILE
	25.000 ml/mn
	5.0000 ml
	INFUSE
PROG1 SEQ 3	STOP

Programming Tutorial

Ramping Up Infusion Rate Example

In this example, the pump will ramp up from 10 ml/mn to 20 ml/mn over 60 seconds, then continue to run at 20 ml/mn for another 10 seconds. This is a Strategy 2 Program requiring four sequences:

1. Specify the initial rate as a profile of 10 ml/mn for one second.

2. Specify the ramp up to 20 ml/mn. Since the minimum resolution of an increment is one second, it will take 59 steps to reach the target rate. Sequence 2 starts at time one second and ends at time 60 seconds, giving it a duration of 59 seconds.

   At one second a step, 59 seconds divided by one second per step equals 59 steps. The increase per step will be 20 ml/mn minus 10 ml/mn, divided by 59 steps or 0.1695 rounded to four decimal places.

3. Continue running at 20 ml/mn for 10 seconds with a profile operation.

4. Stop the pump.

Figure 7. Ramping Up Infusion Rate

PROGRAM PRINTOUT

PROG1 SEQ 1	PROFILE
	10.000 ml/mn
	0:00:01 INTERVAL
	INFUSE
PROG1 SEQ 2	INCR
	0.1695 INCR
	0:00:01 INTERVAL
	INFUSE
PROG1 SEQ 3	PROFILE
	20.000 ml/mn
	0:00:10 INTERVAL
	INFUSE
PROG1 SEQ 4	STOP

Programming Tutorial

Multiple Dispensing Example

Here, a series of dispenses are programmed. Each dispense is started by a trigger, such as pressing the **RUN/STOP** key or pressing an attached foot switch. Seven dispenses are programmed: three of 15 ml at 35 ml/mn, two of 25 ml at 65 ml/mn, and two of 17 ml at 45 ml/mn. The pump's display will show **TRIGGER** when it is waiting for a run trigger and **<** or **>** will not be displayed.

This is a Strategy 1 dispense. A time interval of 0 is specified when entering a Strategy 1 dispense. Since the total volume to be dispensed is 129 ml and the syringe volume is 50 ml, the Auto Fill feature would be very useful with this program.

PROGRAM PRINTOUT

PROG1 SEQ 1	DISPENSE
	35.000 ml/mn
	15.000 ml
	3. REPEAT
	INFUSE
PROG1 SEQ 2	DISPENSE
	65.000 ml/mn
	25.000 ml
	2. REPEAT
	INFUSE
PROG1 SEQ 3	DISPENSE
	45.000 ml/mn
	17.000 ml
	2. REPEAT
	INFUSE
PROG1 SEQ 4	STOP
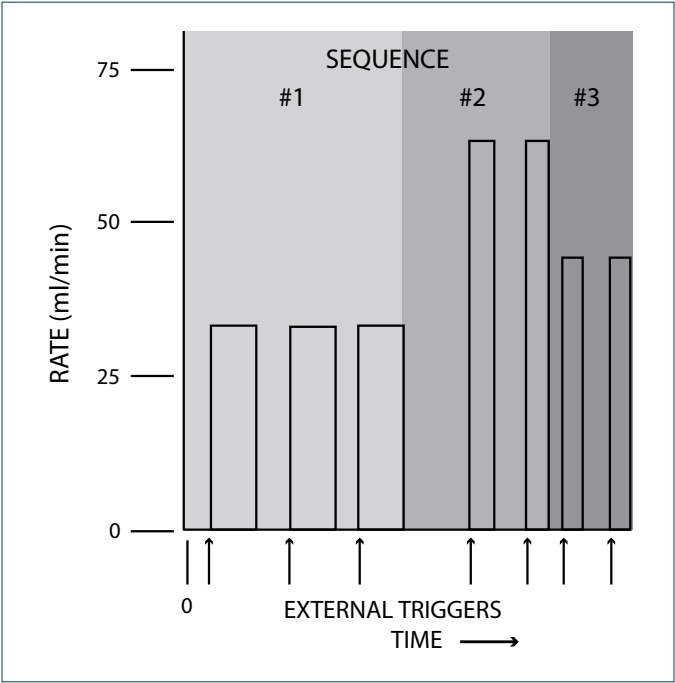
Figure 8. Multiple Dispensing

Programming Tutorial

Periodic Dispense Loop Example

This is an example of a series of periodic dispenses of varying volumes and intervals. For this application Strategy 2 dispenses are used. *Note: between the third and fourth dispenses there is a 45 minute interval.* Each dispense in the first sequence is separated by a pause interval of 1:30. Since after the third dispense there already will be a 1:30 pause, an additional pause of 43:30 is used to extend the pause to the desired 45:00. Sequence 5 is a **RESTART** command, causing the series of dispenses to be continuously repeated until the pump is stopped.

Figure 9. Periodic Dispense Loop

PROGRAM PRINTOUT

PROG1 SEQ 1	DISPENSE
	15.000 ml/mn
	3.500 ml
	0:01:30 INTERVAL
	3. REPEAT
	INFUSE
PROG1 SEQ 2	PAUSE
	0:43:30 INTERVAL
PROG1 SEQ 3	DISPENSE
	25.700 ml/mn
	6.750 ml
	0:05:00 INTERVAL
	2. REPEAT
	INFUSE
PROG1 SEQ 4	DISPENSE
	20.000 ml/mn
	4.300 ml
	0:02:30 INTERVAL
	4. REPEAT
	INFUSE
PROG1 SEQ 5	RESTART

Programming Tutorial

Combination of Infusion and Withdraw Profiles Example

Here is an example of a more complex profile program. Each 'run' of the infusion has been determined to pump 43.155 ml. The first sequence refills the syringe with the volume to be infused then the infusion profile is started, after which the syringe is refilled and the infusion is repeated until the pump is stopped.

PROGRAM PRINTOUT

PROG1 SEQ 1	PROFILE	PROG1 SEQ 5	PROFILE
	75.000 ml/mn		95.000 ml/mn
	43.155 ml		0:00:10 INTERVAL
	REFILL		INFUSE
PROG1 SEQ 2	PROFILE	PROG1 SEQ 6	PROFILE
	50.000 ml/mn		30.000 ml/mn
	0:00:04 INTERVAL		0:00:05 INTERVAL
	INFUSE		INFUSE
PROG1 SEQ 3	DECR	PROG 1 SEQ 7	PROFILE
	4.000 DECR		65.000 ml/mn
	0:00:01 INTERVAL		0:00:05 INTERVAL
	12. REPEAT		INFUSE
	INFUSE	PROG1 SEQ 8	DECR
PROG1 SEQ 4	INCR		5.000 DECR
	5.000 DECR		0:00:01 INTERVAL
	8.000 INCR		11. REPEAT
	0:00:01 INTERVAL		INFUSE
	8. REPEAT	PROG1 SEQ 9	RESTART
	INFUSE		
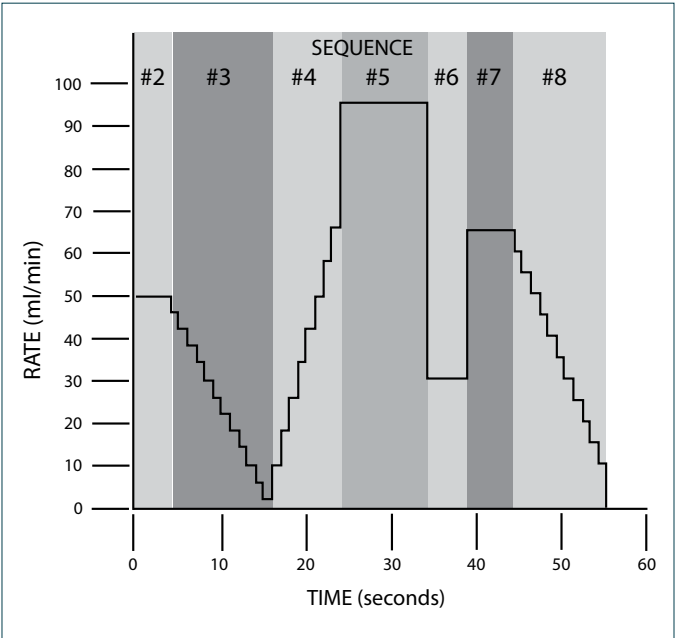
Figure 10. Combination Infusion and Withdraw Profiles

Programming Tutorial
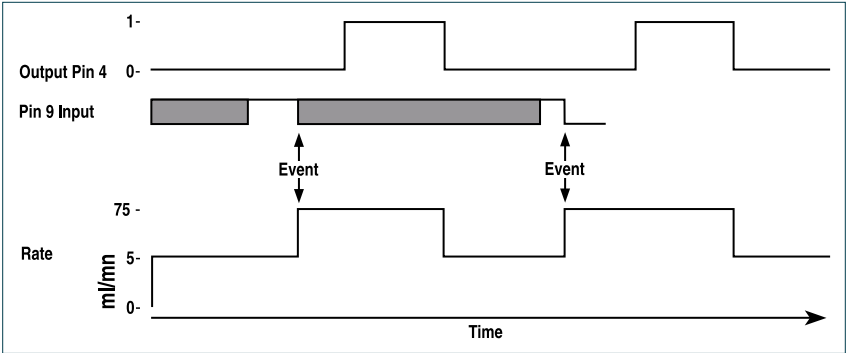
Figure 11. Use of Events

Use of Events Example

This is an example of the PHD 4400 Hpsi working interactively with other laboratory equipment. The pump will continuously pump at 300 ml/hr until an external event, a high to low transition at pin 9, possibly produced by another PHD 4400 Hpsi , causes the pump to deliver a 15 ml bolus at 75 ml/mn. After delivering 5 ml of the bolus, output pin 4 is set to a logic high for the duration of the bolus after which it is dropped. This output pin can be attached to the timer input of another pump, such as a Harvard Pump 22 or 44, to create a precise mixture during the bolus. After the bolus is completed, the Pump 22 would be stopped and the PHD 4400 Hpsi would return to delivering its background rate of 300 ml/hr, waiting for another external event.

PROGRAM PRINTOUT

PROG1 SEQ 1	TTL OUT
	OFF
PROG1 SEQ 2	EVENT
	GO TO 4
PROG1 SEQ 3	PUMP
	300.000 ml/hr
	INFUSE
PROG1 SEQ 4	PROFILE
	75.000 ml/mn
	5.000 ml
	INFUSE
PROG1 SEQ 5	TTL OUT
	ON
PROG1 SEQ 6	PROFILE
	75.000 ml/mn
	10.000 ml
	INFUSE
PROG1 SEQ 7	RESTART

Programming Tutorial

Use of TTL Signal Examples
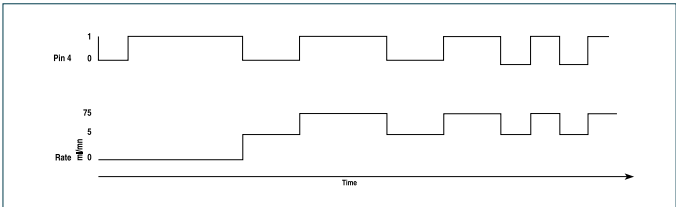
Figure 12. Use of TTL Signal

Before the pumping flow begins, the pump sends a TTL signal to another piece of equipment for 5 seconds, but first verifies that the TTL line is low by turning it off for 1 second, then turns it on. The pumping process consists of an alternation of pumping 3 ml at 53 ml/mn and 5 ml at 75 ml/mn. It uses the TTL output to signal to another device whose sequence it is executing by lowering the TTL line before sequence 5 and raising it before sequence 8.

This is an example of the PHD 22/2000 pump being operated from a remote location. When the pump is powered on, the position of the pusher block is unknown and must be homed to a known position.

At the syringe full position, a limit switch is placed such that it is tripped by the pusher block when the syringe is full. The limit switch is connected to pins 4 and 9, programmable output and the event input, on the user I/O connector. When the pump receives a start signal, it first refills the syringe and stops when the limit switch is sensed. The pump then waits for a start trigger and performs a dispense then refills the syringe and waits again for the next start trigger.

PROGRAM PRINTOUT

PROG1 SEQ 1	EVENT
	GO TO 7
PROG1 SEQ 2	TTL OUT
	ON
PROG1 SEQ 3	PAUSE
	0:00:01 INTERVAL
PROG1 SEQ 4	TTL OUT
	OFF
PROG1 SEQ 5	PAUSE
	0:00:01 INTERVAL
PROG1 SEQ 6	PUMP
	75.000 ml/mn
PROG1 SEQ 7	DISPENSE
	10.000 ml/mn
	0.0001 ml
	1. REPEAT
	REFILL
PROG 1 SEQ 8	PUMP
	75.000 ml/mn
	10.000 ml
	INFUSE
PROG1 SEQ 9	RESTART

PROGRAM PRINTOUT

PROG1 SEQ 1	TTL OUT
	OFF
PROG1 SEQ 2	PAUSE
	0:00:01 INTERVAL
PROG1 SEQ 3	TTL OUT
	ON
PROG1 SEQ 4	PAUSE
	0:00:01 INTERVAL
PROG1 SEQ 5	TTL OUT
	OFF
PROG1 SEQ 6	PROFILE
	53.000 ml/mn
	3.000 ml
	INFUSE
PROG1 SEQ 7	TTL OUT
	ON
PROG 1 SEQ 8	PROFILE
	75.000 ml/mn
	5.000 ml
	INFUSE
PROG1 SEQ 9	GO TO 5

Pump Chain Commands

The Pump Chain RS232 interface is used to enhance the control applications of the PHD 4400 Hpsi. This interface allows all control information, including a program, to be entered into the pump from an external source such as a computer. In addition, this interface allows up to 100 pumps and, in certain cases, other RS232 devices to be controlled from a single RS232 communication port on a computer.

Assign each pump in the pump chain a unique address from 0 to 99. This address is used to identify which pump is to receive a command and which pump is responding. Configure each pump with its assigned address and the baud rate being used. (See Section 10, External Control & Interfaces.)

When the control device communicates with the pump, a diamond appears on the far right of the display indicating that it is receiving RS232 commands. The diamond remains on the display until the pump is turned off or **SET** RS232 is entered on the keyboard, indicating a change in the RS232 configuration.

A pump will not respond to pump chain communication while it is in a setting mode (entered when user presses the **SET** key). The pump can still be controlled from the keyboard while it is in a pump chain. Control data that is changed via RS232 will be stored in the pump's nonvolatile memory.

After each command is received and executed, the pump terminates its responses with a prompt. A prompt is a string of ASCII characters sent by a pump.

The PHD 4400 Hpsi is capable of using two sets of pump interface commands. This will allow users of Harvard Apparatus Model 22 and Model 44 pumps to use existing programs to control the PHD 4400 Hpsi pumps. The two sets of commands are contained on the following pages.

Each command sent to the pump chain is a string of ASCII characters, with leading zero's on numbers and all spaces optional. Numbers are a maximum of five digits. The following symbols are used in describing the commands.

Pump Chain Commands - Model '22' Protocol

(Model 44 Protocol on page 25)

After each transmission to the Pump terminating with a CR character (ASCII 13), the pump enters remote mode and responds with the three character sequence:

> CR LF prompt

The prompt character indicates the status of the pump as follows:

:	When stopped	(ASCII 58 decimal)
>	When running forward	(ASCII 62 decimal)
<	When running reverse	(ASCII 60 decimal)
*	When stalled	(ASCII 42 decimal)

Note: With a pump chain, if no address precedes the command transmitted, the pump at address 0 will respond to the command.

COMMANDS - RESPONSE: CR LF PROMPT

RUN	Infuse (forward direction)
REV	Start (reverse direction) Not accessible on Infusion model
STP	Stop
CLV	Clear volume accumulator to zero
CLT	Clear target volume to zero
MLM number	Set rate, units are milliliters per minute
ULM number	Set rate, units are microliters per minute
MLH number	Set rate, units are milliliters per hour
ULH number	Set rate, units are microliters per hour
MMD number	Set diameter, units are mm. Rate is set to 0
MLT number	Set target infusion volume, units are ml

Numbers between 0 and 1999 will be accepted by the pump. Leading zeros and trailing decimal point are optional. Any number of digits to the right of the decimal point may be transmitted. The number received will be rounded to four significant digits if the leading digit is one, or three significant digits if the leading digit is two to nine.

Pump Chain Commands

Queries - Response: CR LF Value CR LF Prompt

Queries with Numeric Response

DIA	Send diameter value, units in mm
RAT	Send rate value in current range units
VOL	Send current accumulated infused volume, units are ml
TAR	Send target volume, units are ml
VER	Send model and version number

Value format: nnnn.nnn

The transmitted value is an 8 character string with leading zeros converted to SP characters. (ASCII 32) The fifth character is a decimal point (ASCII 46).

Query - Response: CR LF Range CR LF Prompt

Queries with String Response

RNG	Send range message

Range is a character string, one of: ML/H ML/M UL/H or UL/M

Error Responses

CR LF ? CR LF prompt	Unrecognized command
CR LF O O R CR LF prompt	Out of range

Pump Chain Commands - Model '44' Protocol

Symbol	Meaning
[. . .]	Optional
{. . .}	Select one
|	Either/or
f	Digits 0 – 9 or a decimal point
d	Digits 0 – 9
<cr>	Carriage return (ASCII 13)
<lf>	Line feed (ASCII 10)
<float>	f f f f f f
<integer>	ddddd
<time>	d:dd:dd
<text>	Any string of ASCII characters

Command Formats and Meanings

Command Format	Meaning
<cr>	Stops all pumps. All pumps on the pump chain interpret this as a stop command.
pump address, <cr>	Request for prompt. The pump with the indicated address responds with its prompt
optional pump address, command, <cr>	Send a command to a pump. The pump with the indicated address executes the command then responds with its prompt. The optional pump address, if not specified, will default to pump address 0.

After each command is received and executed, the pump acknowledges the command with a prompt. Preceding the prompt may be some additional text responses. The additional text will be one or more lines of ASCII text, each preceded by a line feed and terminated by a carriage return:

<lf>, <text>, <cr>

A prompt is a string of ASCII characters sent by a pump indicating the pumps address and its present state:

<lf>, 1 or 2 digit address, prompt character

Prompt Characters	Meaning
:	Pump stopped
>	Pump infusing
<	Pump refilling
/	Pause interval (pump stopped)
*	Pumping interrupted (pump stopped)
^	Dispense trigger wait (pump stopped)

Pump Commands and Responses

RUN	Starts pumping according to the present setting of the pump. If pump is already pumping, a 'Not Applicable 'response will be given.
STP	Stops pump if it was running. If pump was already stopped, a 'Not Applicable' response will be given.
DEL	Request for volume delivered, in ml. Response is of the following format: space, space, f f f f f f
CLD	Request to zero volume delivered. If the pump was interrupted, it will cancel the interrupted condition. If the pump is running, request will not be accepted and a 'Not Applicable' response will be given. Otherwise, no response is given.

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Pump Chain Commands

RAT [<float> [<units>]]

Request to set or query infusion rate setting.

Set infusion rate:

RAT rate

Set infusion rate and units:

RAT rate units

Rate is of format: f f f f f f

Units are one of:

Definition	
UM	µl/mn
UH	µl/hr
MM	ml/mn
MH	ml/hr

If rate is accepted and valid, rate will become the new infusion rate. If the rate is invalid, an 'Out Of Range' response will be given. Command will not be accepted if the pump is running in the Program Mode and a 'Not Applicable' response will be given.

Query infusion rate: RAT

Response is of the following format:

space, space, f f f f f f units

Where units is one of the following:

ml/mn

µl/mn

ml/hr

µl/hr

RFR [<float> [<units>]]

Request to set or query refill rate setting.

Set refill rate:

RFR rate

Set refill rate and units:

RFR rate units

Rate is of format: f f f f f f

Units are one of:

Definition	
UM	µl/mn
UH	µl/hr
MM	ml/mn
MH	ml/hr

If rate is accepted and valid, rate will become the new refill rate. If the rate is invalid, an 'Out Of Range' response will be given. Command will not be accepted if the pump is running in the Program Mode and a 'Not Applicable' response will be given.

Query refill rate: RFR

Response is of the following format:

space, space, f f f f f f units

Where units is one of the following:

ml/mn

µl/mn

ml/hr

µl/hr

PGR   Request for the rate of pumping set during the running of a program. Response is of the following format:
space, space, f f f f f f units

Where units is one of the following:

ml/mn

µl/mn

ml/hr

µl/hr

DIA [<float>]

Request to set or query syringe diameter setting.

Set diameter:

DIA diameter

Diameter is of format: f f f f f f

Units are MM.

INFUSE and REFILL rates will be set to zero and AUTO FILL will be set to off. If diameter is accepted and valid, diameter becomes new diameter. Diameter will not be accepted if the pump is running and a 'Not Applicable' response will be given. If the diameter is invalid, an 'Out Of Range' response will be given.

Query diameter: DIA

Response is of the following format:

space, space, f f f f f f

Units are MM.

TGT [<float>]

Request to set or query target volume setting.

Set target volume:

TGT volume

Volume is of format: f f f f f f

Units are ML.

If volume is accepted and valid, volume becomes new target volume. Volume will not be accepted if the pump is running and a 'Not Applicable' response will be given. If the volume is invalid, an 'Out Of Range' response will be given.

Pump Chain Commands

Query volume: TGT

> Response is of the following format:
>
> > space, space, f f f f f f
>
> Units are ML.

MOD [{PMP|VOL|PGM}]

> Request to set or query pumping mode
>
> Set: MOD PMP (Puts pump in Pump Mode)
>
> MOD VOL (Puts pump in Volume Mode)
>
> MOD PGM (Puts pump in Program Mode)
>
> Command will not be accepted if the pump is running and a 'Not Applicable' response will be given.
>
> Query: MOD
>
> If mode is PUMP, response will be:
>
> > PUMP
>
> If mode is VOLUME, response will be:
>
> > VOLUME
>
> If mode is PROGRAM response will be:
>
> > PRGRAM

DIR [{INF|REF|REV}]

> Request to set or query pumping direction
>
> Set: DIR INF (sets pumping direction to infusion)
>
> DIR REF (sets pumping direction to refill)
>
> DIR REV (reverses current pumping direction)
>
> Command will not be accepted if the pump is running in volume or program modes and a 'Not Applicable' response will be given.
>
> Query: DIR
>
> If pump direction is infusion, response will be:
>
> > INFUSE
>
> If pump direction is refill, response will be:
>
> > REFILL

AF [{ON|OFF}]

> Request to set or query auto fill setting
>
> Set: AF ON (turns Auto Fill feature on)
>
> *Note: The syringe volume is also needed for auto fill to operate.* (See SYR command)
> AF OFF (turns Auto Fill function off)
>
> Command will not be accepted if the pump is running and a 'Not Applicable' response will be given.
>
> Query: AF
>
> If Auto Fill function is ON, response will be: ON
>
> If Auto Fill function if OFF, response will be: OFF

SYR [<float>]

> Request to set or query syringe volume setting for auto fill.
>
> Used in conjunction with Auto Fill feature.
> (See AF command).
>
> Set syringe volume: SYR volume
>
> > Volume is of format: f f f f f f
> >
> > Units are ML.
> >
> > If volume is accepted and valid, volume will become the new syringe Auto Fill volume.
> >
> > Volume will not be accepted if the pump is running and a 'Not Applicable' response will be given. If the volume is invalid, an 'Out Of Range' response will be given.
>
> Query syringe volume: SYR
>
> Response is of the following format:
>
> > space, space, f f f f f f

IN d

Request to read the TTL logic level of the specified pin on the external 9 pin D-SUB connector. Valid pin numbers for input are:

> 6, 7, 8 and 9
>
> If the pin specified is valid and if the pin level is high, response will be:
>
> > ON
>
> If the pin level is low, response will be:
>
> > OFF
>
> If the pin specified is invalid:
>
> > An 'Out Of Range' response will be given

OUT d = <ON|OFF>

> Request to set the TTL logic level at the specified pin on the external 9 pin D-SUB connector.
>
> Valid pin number for output is: 4
>
> If the pin specified is invalid:
>
> > An 'Out Of Range' response will be given
>
> Example:
>
> Set pin 4 high:
>
> > OUT 4 = ON
>
> Set pin 4 low:
>
> > OUT 4 = OFF

SEQ [<integer>] [<entry>]

> Request to set or query programming sequences. <integer> is sequence number.
>
> Default is Sequence 1. Command only applicable while pump is stopped. Valid sequence numbers, 'n', are 1 to 9. 'n' defaults to 1 wherever it is optional.
> See program examples.

Pump Chain Commands

Query entire program: SEQ

Example response:

> SEQ 1: DISPENSE
>
> 75.000 ml/mn
>
> 43.155 ml
>
> 0:00:01 INTERVAL
>
>   3 REPEAT
>
> INFUSE
>
> SEQ 2: PROFILE
>
> 100.00 ml/mn
>
> 150.00 ml
>
> REFILL
>
> SEQ 3: RESTART

Query program sequence [n]:   SEQ n

> Example response to the command 'SEQ 2' with the previous example's program:
>
> SEQ 2: PROFILE
>
> 100.00 ml/mn
>
> 150.00 ml
>
> REFILL

> Query program sequence n's mode: SEQ [n] MOD

Response will be according to the following table:

Response	Description
STP	Stop
PRO	Profile
INC	Increment
DEC	Decrement
DIS	Dispense
PAS	Pause
RST	Restart
GOT	Go to
EVN	Event
PMP	Pump
OUT	TTL out

Query data item of program sequence n:

Command	Description
SEQ [n] RAT	Query rate
	Response: f f f f f f units
	Where units is one of the following:
	ml/mn
	µl/mn
	ml/hr
	µl/hr
SEQ [n] GOT	Query go to sequence number Response: <n>
SEQ [n] TGT	Query target volume Response: <float>
SEQ [n] INT	Query time interval Response: <time>
SEQ [n] RPT	Query repetition count Response: <float>
SEQ [n] OUT	Query output pin level setting Response: <ON/OFF>
SEQ [n] DIR	Query pumping direction Possible Responses: INFUSE, REFILL

Set mode of program sequence n:

> SEQ [n] MOD mode
>
> Where mode is as follows:

Mode	Description
STP	Stop
PRO	Profile
INC	Increment
DEC	Decrement
DIS	Dispense
PAS	Pause
RST	Restart
EVN	Event
GOT	Go to
OUT	Set output pin
PMP	Pump

> Set data item of program sequence n:

Set sequence's rate:

> SEQ [<n>] RAT <float> [<units>]
>
> Rate is of format: f f f f f f

Units are one of	Description
UM	µl/mn
UH	µl/hr
MM	ml/mn
MH	ml/hr

Pump Chain Commands

Set sequence's go to sequence number:

SEC [<n>] GOT <n>

Set sequence's target volume:

SEQ [<n>] TGT <float>

Set sequence's time or target:

SEQ [<n>] INT <time>

Set sequence's repetition number:

SEQ [<n>] RPT <integer>

Set sequence's pumping direction:

SEQ [<n>] DIR <INF|REF>

Set sequence's output pin level:

SEQ [<n>] OUT <ON|OFF>

VER   Request for version of pump's embedded software.

Pump Chain Error Messages

Error messages are in the format:

<lf>, space, space, <message>, <cr>,

Where <message> is one of the following:

?	Syntax error in a received command
NA	Command not applicable at this time
OOR	Control data is out of the operating range of the pump

*If assistance is needed in programming pump control via RS232
call Harvard Apparatus Customer Service Support at
1-800-272-2775.
Outside of U.S. call 508-893-8999.*

Appendix A: Syringe Diameters in mm

Air–Tite
'All Plastic'

Size	Diameter
2.5 cc	9.60 mm
5	12.45
10	15.90
20	20.05
30	22.50
50	29.00

Hamilton–Microliter
Series Gastight

Size	Diameter
0.5 µl	0.103 mm
1	0.1457
2	0.206
5	0.3257
10	0.460
25	0.729
50	1.031
100	1.46
250	2.3
500	3.26
1.0 ml	4.61 mm
2.5	7.28
5	10.3
10	14.57
25	23.0
50	32.6

Stainless Steel

Size	Diameter
2.5 cc	4.851 mm
20	19.130
50	28.600
100	34.900
200	44.755

Becton Dickinson
Glass-All Types

Size	Diameter
0.5 µl	4.64 mm
1	4.64
2.5	8.66
5	11.86
10	14.34
20	19.13
30	22.70
50	28.60
100	34.90

Renfac

Size	Diameter
2 cc	9.12 mm
5	12.34
10	14.55
20	19.86
30	23.20
50	27.60

Terumo

Size	Diameter
3 cc	8.95 mm
5	13.00
10	15.80
20	20.15
30	23.10
60	29.10

Becton Dickinson
Plastic 'Plasti-pak'

Size	Diameter
1 cc	4.78 mm
3	8.66
5	12.06
10	14.50
20	19.13
30	21.70
50/60	26.70

SGE Scientific
Glass Engineering

Size	Diameter
25 µl	0.73 mm
50	1.03
100	1.46
250	2.30
500	3.26
1.0 ml	4.61 mm
2.5	7.28
5	10.30
10	14.57

Unimetrics
Series 4000 & 5000

Size	Diameter
10 µl	0.460 mm
25	0.729
50	1.031
100	1.460
250	2.300
500	3.260
1000	4.610

Cadence Science, Inc.
Formerly Popper & Sons, Inc.
'Perfektum' Glass

Size	Diameter
0.25 cc	3.45 mm
0.5	3.45
1	4.50
2	8.92
3	8.99
5	11.70
10	14.70
20	19.58
30	22.70
50	29.00
100	35.70

Sherwood–Monoject
Plastic

Size	Diameter
1 cc	4.65 mm
3	8.94
6	12.70
12	15.90
20	20.40
35	23.80
60	26.60
140	38.40

Appendix B: Stainless Steel Syringes

Harvard Apparatus High Pressure Stainless Steel Syringes
200 ml
100 ml
50 ml
20 ml
2.5 ml
8 ml

High Pressure Stainless Steel Syringes

| Syringe Size | With SWAGELOK® | | | With Luer Lock |
	Diameter 1/16 in	Diameter 1/8 in	Diameter 1/4 in	
2.5 ml	70-2269	N/A	N/A	N/A
8 ml	70-2267	70-2268	N/A	N/A
20 ml	70-2251	70-2252	70-2253	70-2254
50 ml	70-2255	70-2256	70-2257	70-2258
100 ml	70-2259	70-2260	70-2261	70-2262
200 ml	70-2263	70-2264	70-2265	70-2266
Replacement Tips, Furnished with Sealing O-Ring				
2.5 ml	70-2246	N/A	N/A	N/A
8 ml	70-2246	70-2245	N/A	N/A
20 - 200 ml	70-2247	70-2248	70-2249	70-2250

Replacement Parts

Cat No	Description
5013-087	Perfluoroelastomer Barrel O-Ring 8 ml
5013-089	Perfluoroelastomer Barrel O-Ring 20 ml
5013-090	Perfluoroelastomer Barrel O-Ring 50 ml
5013-091	Perfluoroelastomer Barrel O-Ring 100 ml
5013-092	Perfluoroelastomer Barrel O-Ring 200 ml
5013-110*	Perfluoroelastomer Tip Seal O-Ring 2.5 ml + 8 ml
5013-109	Perfluoroelastomer Tip Seal O-Ring 20 - 200 ml
72-2472	Replacement Viton O-Ring 20 ml, pkg. of 10
72-2473	Replacement Viton O-Ring 50 ml, pkg. of 10
72-2474	Replacement Viton O-Ring 100 ml, pkg. of 10
72-2475	Replacement Viton O-Ring 200 ml, pkg. of 10
72-2616	Replacement Viton Tip Seal O-Ring, 20 - 200 ml, pkg. of 20
70-2271	Replacement Ball Seal for 2.5 ml
5013-088	Replacement Backup PTFE O-Ring, 8 ml

*Note: 2.5 ml and 8 ml stainless steel syringes should not be used with PHD 22/2000 Hpsi Pumps (70-2023 or PHD ULTRA Hpsi) due to overpressure conditions.

Harvard Apparatus High Pressure Stainless Steel Syringes

Harvard Apparatus offers a complete line of Stainless Steel Syringes intended for high pressure applications with good resistance to most aggressive liquids. Wetted parts are #316 stainless steel or Viton. Syringes are available in 2.5, 8, 20, 50, 100 and 200 ml sizes with removable, replaceable tips.

High Pressure 2.5 ml and 8 ml Stainless Steel Syringes

These syringes have been designed to utilize the high forces available in our syringe pumps to produce pressures up to 7,500 psi and 1,500 psi respectively. The 2.5 ml stainless steel syringe contains one Perfluoroelastomer O-Ring seal and one Ball seal. This syringe is available with a 1/16 inch SWAGELOK® tip only. The 8 ml stainless steel syringe contains two Perfluoroelastomer O-Ring seals and two PTFE O-Ring seals. This syringe is available with a 1/16 inch or 1/8 inch SWAGELOK® tip.

High Pressure 20 ml to 200 ml Stainless Steel Syringes

Dual Viton O-Rings insure against leakage for pressures up to 750 psi. Replacement Viton O-Rings are available, as are the more chemically resistant Perfluoroelastomer O-Rings.

Genuine SWAGELOK® syringe to tube fittings are available in 1/16, 1/8 and 1/4 inch sizes. A Luer lock end fitting is also available. All tips are interchangeable within all syringes in the series (20 to 200 ml).

Harvard Apparatus Stainless Steel Syringes Specifications

Volume	2.5 ml		8 ml		20 ml		50 ml		100 ml		200 ml	
Max Test Pressure (psi)	9,000		4,000		1,500		1,500		1,500		1,500	
Working Pressure (psi)	7,000		1,500		750		750		750		750	
Dimensions	in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)	in	(mm)
Overall Length of Barrel (L1)	6.625	(168.3)	6.73	(170.8)	4.73	(120.1)	5.49	(139.3)	6.73	(170.9)	81.48	(215.4)
Plunger Excursion (Stroke)	4.75	(120.6)	4.42	(112.4)	3.56	(90.3)	4.14	(105.2)	5.67	(143.9)	7.20	(182.8)
Outside Diameter (OD)	0.50	(12.7)	0.50	(12.7)	0.88	(22.2)	1.25	(31.8)	1.50	(38.1)	1.88	(47.63)
Inside Diameter (ID)	0.187	(4.75)	0.375	(9.525)	0.753	(19.13)	1.126	(28.6)	1.374	(34.9)	1.762	(44.75)

Minimum flow rates are taken from the smallest inside diameters and maximum flow rates are taken from the largest inside diameters of the syringes supplied by the eleven most widely used syringe manufacturers.

Nominal Minimum/Maximum Flow Rates for Various Syringes (Actual Limits will vary depending on manufacturer)

Syringe Size	µl/hr		µl/min		ml/hr		ml/min	
	Min	Max	Min	Max	Min	Max	Min	Max
0.5 µl	0.0001	95.330						
1 µl	0.0002	190.70						
2 µl	0.0004	381.30						
5 µl	0.0010	953.17						
10 µl	0.0019					1.9013		
25 µl	0.0046					4.7752		
50 µl	0.0092					9.5511		
100 µl	0.0183					19.153		
250 µl	0.0454					47.532		
500 µl	0.0911					95.492		
1000 µl			0.0031			190.95		
1 ml			0.0033			205.30		
2 ml			0.0119			747.35		
2.5 ml			0.0076			476.21		
3 ml			0.0100					11.231
5 ml			0.0208					21.781
10 ml			0.0301					31.486
20 ml			0.0523					54.804
30 ml			0.0673					70.518
50 ml			0.1019					106.76
100 ml			0.1740					182.40
140 ml			0.2106					220.82

Appendix D: Custom Applications

The Harvard PHD 4400 Hpsi Syringe Pumps lend themselves to a multitude of OEM industrial applications. For all types of custom pumping or pilot plant applications, the pump's programming capabilities can be enhanced. Please contact the Harvard Development Group if we can be of help.

Appendix E: Pressure & Force Specs

Rate ml/min	Starting PSI	Stall PSI	Stall Force Lbs	Stall Force Kg
10	>200	>200	>200	>90
20	>200	>200	>200	>90
30	>200	>200	>200	>90
50	>200	>200	>200	>90
60	>200	>200	>200	>90
70	>200	>200	>200	>90
80	>175	>200	>200	>90
90	>150	>175	>175	>79
100	>125	>150	>150	>68
110	>100	>125	>125	>56
120	>75	>100	>100	>45

Rate

This is the rate indicated with a Harvard Apparatus 50 ml stainless steel syringe. Diameter 28.6 mm, cross-sectional area 1.00 square inches.

Starting PSI

This is the back pressure at which the pump would reliably start. At higher pressures the pump may stall.

Stall PSI

This is the back pressure that finally stalls the pump.

Stall Force

This is the force corresponding to the stall PSI. The same force applied to different size syringes will generate correspondingly higher or lower pressures and flow rates.
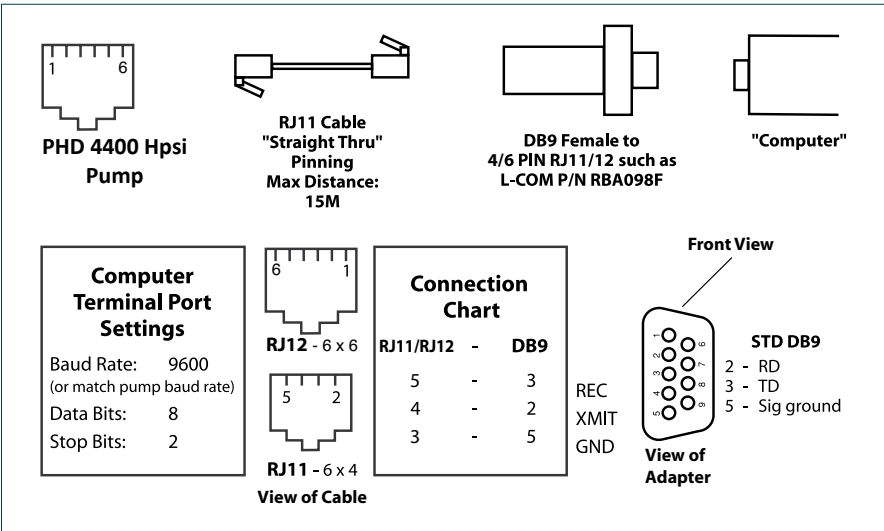
Appendix F: PHD 4400 HPSI to PC Connection

Figure 13. PHD 4400 Hpsi to PC Connection

Appendix G: RS232 Specifications

Pump Chain

Pump Port 1 – Computer control side

Pump Port 2 – Connection for remainder of pump chain

Baud Rate – 1200, 2400, 9600 or 19,200

Word Size – 8

Parity – none

Stop Bits – 2

Scale

Connect scale to Pump Port 1

Supported scales:

Mettler	Sartorius	Ohaus
Baud Rate – 2400	Baud Rate – 2400	Baud Rate – 2400
Word Size – 7	Word Size – 7	Word Size – 8
Parity – even	Parity – even	Parity – even
Stop Bits – 1	Stop Bits – 1	Stop Bits – 1
Pause – 0	**Code Settings:**	Auto print feature – off
	311 – Weigh only (models with PLUS performance package)	Stable data only – off
	211 – External print command without stability	Serial data frame selection – Fr.7
	225 – 2400 baud	
	234 – Even Parity	
	432 – Beeper off	

Printer

Serial printer with print buffer:

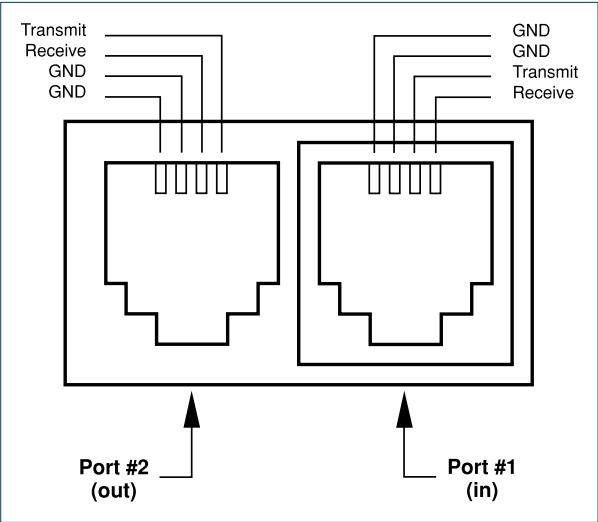| |
|---|
| Baud Rate – 2400 |
| Word Size – 8 |
| Parity – none |
| Stop Bits – 2 |

Figure 14. RS232 Specifications

Appendix H: Symphony

Symphony, the Windows® Pump Manager software, allows you to control your PHD 4400 Hpsi pump from your remote computer. With Symphony, you can orchestrate all pump functions from a virtual control panel via the serial communications link built into every PHD 4400 Hpsi pump.

Cat No	Product
70-2200	PHD 4400 Hpsi Programmable Syringe Pump
70-2201	PHD 4400 Hpsi Remote Programmable Syringe Pump
70-3000	Symphony Software

Appendix I: User I/O Connector Specifications

User I/O (input/output) connections are via a 9 pin D-sub type connector. All inputs are internally pulled up to a logic high.

Pin Assignments

1. Vss (Ground reference, logic low)
    Falling edge starts/stops pump

2. Valve control output:

    Low – Infusing

    High – Refilling

3. Running Output Indicator

    Low - Pump stopped

    High - Pump running

4. Programmable output

5. Logic High Reference (5V, 6 mA)

6. Foot switch input

7. Timer Input

    Rising edge starts pump

    Falling edge stops pump

8. Directional control input

    Rising edge sets pump to infuse

    Falling edge sets pump to refill

9. Event input

    Falling edge triggers program event

Logic Low: 0 V – 0.8 V

              Max. 6 mA current sink

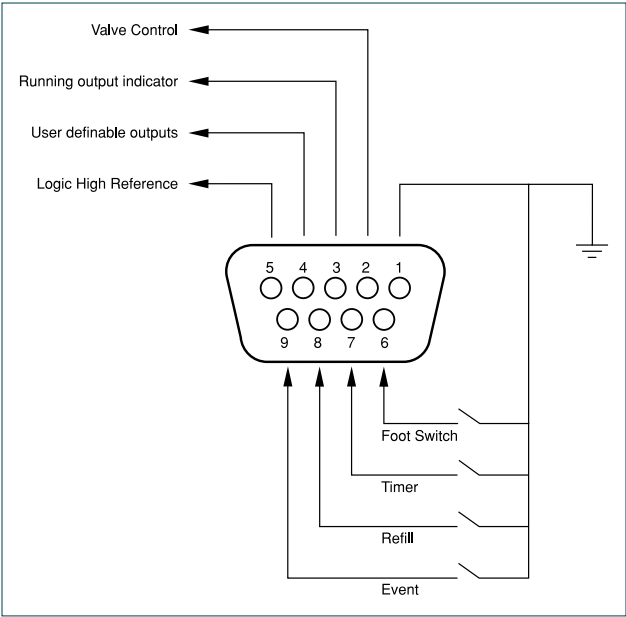Logic High: 2 V – 5 V

              Max. 6mA current source

Figure 15.User I/O Connector Specifications

Appendix J: Accessories & Spare Parts

Auto Fill Accessory

To operate the Auto Fill feature, either the low pressure or high pressure valve assembly is required. Each assembly contains the solenoid valve, connector cable, power cable, and tubing and fittings to connect to the syringe. Operates at 115/230 VAC, 50/60 Hz via a selector switch.

Cat No	Accessories
72-2748	Daisy-Chain Cable, 1.8 m (6 ft)
55-7760	Daisy-Chain Cable, 0.6 m (2 ft)
70-2022	RS232 Cable
72-8340	USB to Serial Connector
55-4144	Foot Switch
55-7002	'Auto Fill' Valve Box–Regular Pressure – to 20 psi
55-7004	'Auto Fill' Valve Box–High Pressure – 200 psi
5108-032	Adjustable Stop

Cat No	Spare Parts
72-0199	Remote Extension Cable, 1.5 m (5 ft)*
72-1405	Remote Ext. Cable, 9.1 m (30 ft)*
0606-086	Magnalube - Lead Screw Lubricant
4430-034	Syringe Clamp
5100-060	Thumb Screw, Syringe Clamp
5100-059	T Knob, Withdraw & Anti-Siphon Bracket
5153-209	Power Cord
5406-001	PHD 4400 Hpsi Operators Manual
5153-554	Fuse, 0.75 A, 250 V
For PHD 4400 Hpsi Remote Syringe Pump	

Appendix K: Maintenance & Troubleshooting

Maintenance

PHD 4400 Hpsi series pumps require no special maintenance other than keeping them clean by avoiding accidental spills of pumped material.

The two guide rods and the lead screw should be sparingly lubricated periodically. The guide rods and the lead screw should be lubricated with Superlube® (Catalog No 5000-048) provided with the pump.

Solvents of any type should never be used to clean the pump. A mild detergent solution may be used to clean the keypad.

Troubleshooting

INFUSION ACCURACY

To ensure infusion accuracy always use new syringe(s) and measure syringe bore diameter and enter actual dimensions in millimeters (mm). Additionally make sure that the guide rods and lead screw are properly lubricated.

RS232 DIFFICULTIES

Verify that the baud rates and data framing parameters on all devices are the same. With the pump chain, a "Communication timeout" error on a computer is usually caused by the computer errantly handshaking on the RTS, CTS and DSR lines. Verify pins 4, 5 and 6, on the 25 pin connector, are jumped on the computer side of the cable.

PHD 4400 Hpsi Display Messages

PUMP STALLED

This indicates that the pusher block travel has been impeded. This may be caused by the syringe plunger hitting bottom, a kink in the tubing, syringe plunger binding or any situation requiring more force to the head of the syringe than the pump is capable of delivering. To restart the pump, remove the cause of stalling and press **RUN**. The pump will continue the interrupted procedure where it stopped.

Note: a large increase in the pumping rate could also stall the motor.

OUT OF RANGE

A value was entered or encountered in a pump program that was beyond the pump's limits. Also, verify that the Infuse Rate is not 0.

Note: rates must be less than 42949. Express larger rates using different units.

EEPROM DATA LOST

The values stored in the nonvolatile memory have been lost. This should never occur under normal operation.

REPLACE NOVRAM

The nonvolatile memory has failed. This should never occur under normal operation.

Appendix L: 'Auto Fill' Valves

There are two 'Auto Fill' Valve models available:

Cat No	Product
55-7002	Supplied with 1/8 inch I.D., 1/4 inch O.D. silastic tubing and connector to syringe
55-7004	Supplied with 1/4 inch O.D. 304 stainless steel tubing with Swagelok fittings for high pressure applications.

Set up consist of three phases: Voltage selection (110 or 220 V), Pump to valve electrical connection and Valve tubing to syringe hook up.

1. Voltage Selection

Valves are shipped from the factory with an American line cord with three wire molded power connector and the pump set for 115-125 VAC.

For 220-240 VAC operation the molded power connector must be cut off and replaced with an appropriate type. The line cord is color coded in International standard colors:

Brown - High   Blue - Neutral   Green - Ground

Observe the polarities when installing the new connector. To adjust the valve for 220 - 240 volt operation an international voltage selector switch must be set. Remove the top panel by removing eight screws, four on each end of the valve. Identify the voltage selector switch located directly below. Using a screw driver turn the switch from 110 to 220. The pump is now set up for 220 volt operation.

2. Pump to Valve Electrical Connection

The cable fitted with a male 9 pin D-sub connector must be connected to the female D-sub connector on the rear of the PHD 4400 Hpsi Syringe Pump. Power can now be switched on with the illuminated power On/Off switch on the front valve housing.

3. Pump to Valve Tubing Connection

Swagelok fitting should be finger tight plus 1 1/4 turn. Tubing is 304 stainless steel 1/4 inch O.D. wall thickness 0.035 inch.
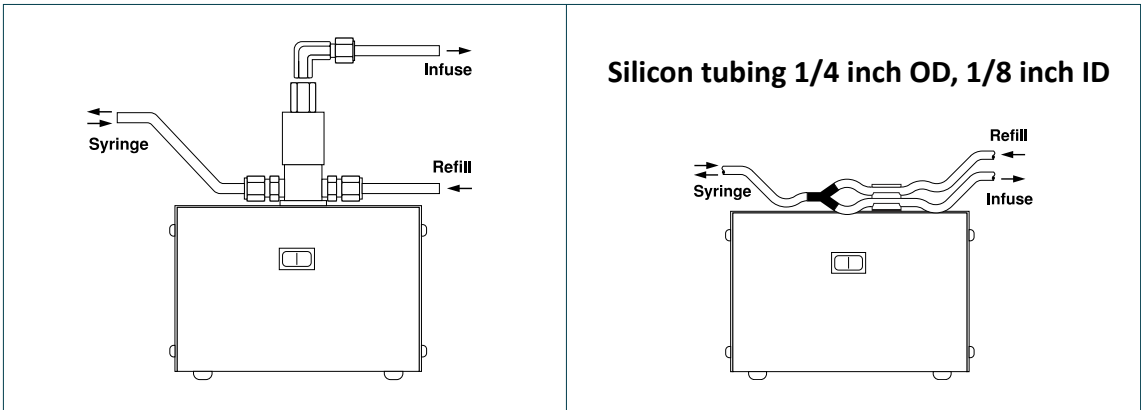

Figure 16. Pump to Valve Tubing Connection

Declaration of Conformity

Application of
  Council Directive(s):   *2006/95/EC, 89/336/EEC*

Standard(s) to which
  conformity is declared: *IEC 61010-1:2010 Ed. 3, EN50082-1, EN50081-1*

Manufacturer's Name: *Harvard Apparatus, Inc.*

Manufacturer's Address: *84 October Hill Road*

     Holliston, Massachusetts 01746 U.S.A.

Type of Equipment: *Syringe Pump*

Model No.:   *4400 Series*

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s) and Standard(s).

Place: *United States of America*

Date: *August 14, 2014*

CE

Harvard Apparatus

_____
(Signature)

Mark Davis
_____
(Full Name)

Director, Global MPE
_____
(Position)

Harvard Apparatus

U.S.A.

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