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Pump 11 Plus, see page 8



EC1 55-3333 Pump 33, see page 14



PHD 22/2000 Hpsi, see page 20



EC1 70-2027 Harvard MP II Mini-Peristaltic Pump, see page 39

pumps

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Harvard Apparatus - Setting the Standards in Pumping Technology

Harvard Apparatus offers a broad selection of syringe, peristaltic and continuous flow pumps to suit almost every application. Syringe pump models have been expanded to include new innovative pumps with the widest range of flow rates and forces of any manufacturer. The following guide and tables were designed to answer most questions regarding syringe and peristaltic pumps. Please review the following pages then contact our technical support department for further assistance, if needed.

Harvard Apparatus has a long history of inventing, innovating and manufacturing syringe pumps. Harvard Apparatus invented the lead screw based

syringe pump in the 1950's and introduced the first microprocessor pump, the now legendary Pump 22, in the 1980's. Our syringe pumps are so accurate, even at low flow rates, that they have become the standard for mass spectrometry calibration and anywhere accurate volumes must be delivered. The innovations continue with recent additions to the PHD 22/2000 programmable pump line with enormous pressure and flow capability; the New 11 Plus, the standard for general laboratory experiments; the New Pump 11 Pico Plus for picoliter and small volume injections; an entire new selection of peristaltic pumps; an expanded line of component pumping modules for the OEM and do-it-yourself markets, and much, much more.

We are frequently asked to assist in the selection of the appropriate pump for a variety of research applications. The following list was developed as a guide to help you quickly and easily choose the right pump for your application. Consider the following questions when selecting your pump. If your specifications do not appear to be met by these pumps, please call our technical support department for further assistance.

1. Brief overview of advantages and disadvantages of each type of pump, see below and next page.
2. Syringe Pump Selection Guide, see pages 4 and 5.
3. Syringe Pump Application Guide, see pages 6 and 7.
4. Peristaltic Pump Selection Guide, see page 38.

1. Pump Types: Advantages and Disadvantages



SYRINGE PUMP

(PHD 22/2000 Programmable and Pump 11 Pico Plus Shown)

Syringe pumps provide the most accurate delivery of fluids. They use a syringe for the fluid reservoir. The syringe pump motor moves the pusher block forward which depresses the syringe plunger causing the dispensing of fluid. See pages 8 to 22.

PERISTALTIC PUMP

(MP11 Mini-Peristaltic and 66/77 Peristaltic Pumps Shown)

Peristaltic pumps dispense fluid using a rotating head mechanism. The rotating head has a number of rollers that depress the tubing driving the fluid forward. These pumps have an external reservoir and therefore can accommodate a much larger volume of fluid. See pages 38 to 42.

Choosing the Right Pump for Your Application & Budget

1. Pump Types: Advantages and Disadvantages (continued)



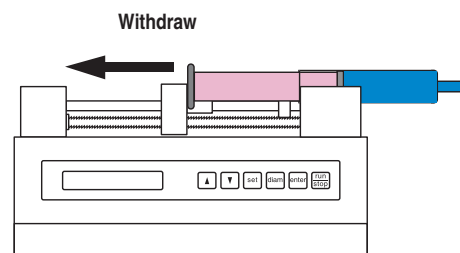
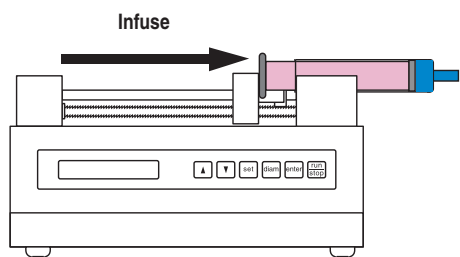
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SYRINGE PUMPS



A motor driven threaded rod (lead screw) slowly turns, moving the plunger of the syringe in, and pushing the fluid out. Reversing the direction of the motor allows for withdrawal of fluids.

ADVANTAGES

- Works at pressures up to 3000 psi
- Highest precision < 0.1%
- Pulse free flow
- Accurately dispense very small to large volumes < $\pm 0.5\%$
- Easily sterilizable
- Can dispense or withdraw
- Many easily programmable dispensing profiles: gradients
- 1 to 10 channels of operation

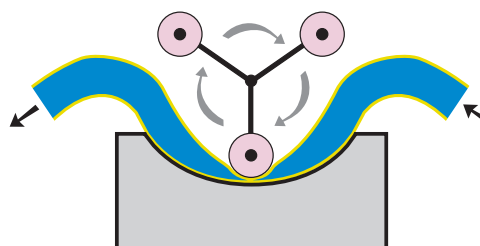
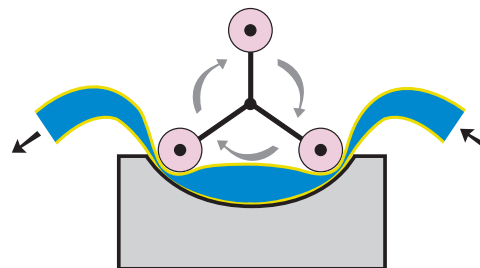
DISADVANTAGES

- Pumps finite volumes
- Slightly more expensive

TYPICAL APPLICATIONS

- Pumping sample/ calibrant into Mass Spectrometer
- Accurate dispensing of drugs in animals
- High pressure flow into reaction chamber

PERISTALTIC PUMPS



In this example three rollers on rotating arms pinch the tube against an arc and push the fluid along. There are usually three or four sets of rollers.

ADVANTAGES

- Pumps continuous volumes
- Sterilizable
- Less expensive for multiple channel dispensing
- 1 to 16 channels of operation
- Can dispense or withdraw

DISADVANTAGES

- Low pressure operation, 30 psi or less
- Pulsing flow
- Moderate precision 1 to 3%

TYPICAL APPLICATIONS

- Perfusion flow across tissue or cells
- Pump in and out with balanced flow
- Transfer bulk liquids ie. controlled animal feeding

Choosing the Right Pump for Your Application & Budget

2. Syringe Pump Selection Guide

Answer questions, then call Technical Support if you require additional assistance

Features & Specifications

STANDARD PUMP MODEL	INFUSION ONLY					INFUSE/WITHDRAW										PUSH/PULL
	Pump 11 Plus EC1 70-2208	Pump 11 Plus EC1 70-2209	Pump 22 EC1 55-2222	Physio 22 EC1 70-2222	PHD 22/2000 EC1 70-2000	Pump 11 Plus EC1 70-2211	Pump 11 Plus EC1 70-2212	Pico Plus EC1 70-2213	Nanomite EC1 70-2217	Pump 22 EC1 55-2226	Pump 33 EC1 55-3333	PHD 22/2000 EC1 70-2001	MRI PHD 22/2000 EC1 70-2130	PHD 22/2000 Hpsi -	PHD 4400 Hpsi -	
PROGRAMMABLE PUMP MODEL	-	-	-	-	-	-	-	-	-	-	-	Available	Available	Only Programmable	Only Programmable	Available
Number of Syringes	1	2	2 to 10*	2 to 10*	2 to 10*	1	2	2	1	2 to 10*	2	2 to 10*	2	4	1	4 (2 on each side of pusher block)
Minimum Syringe Size	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	0.5 µl	20 ml	2.5 ml	0.5 µl
Maximum Syringe Size	50/60 ml	10 ml	140 ml	140 ml	140 ml	50/60 ml	10 ml	10 ml	1 ml	140 ml	140 ml	140 ml	140 ml	200 ml	100 ml	30 ml ⁺
Minimum Flow Rate	0.0014 µl/hr	0.0014 µl/hr	0.002 µl/hr	0.002 µl/hr	0.0001 µl/hr	0.0014 µl/hr	0.0014 µl/hr	3.3 pl/min	3.3 nl/hr	0.002 µl/hr	0.0004 µl/hr	0.0001 µl/hr	0.0001 µl/hr	1.5 µl/hr	0.0076 µl/min	0.0001 µl/hr
Maximum Flow Rate	26.56 ml/min	7.91 ml/min	55.1 ml/min	55.1 ml/min	220.82 ml/min	26.56 ml/min	7.91 ml/min	0.4394 ml/min	1901 µl/min	55.1 ml/min	106.6 ml/min	220.82 ml/min	220.82 ml/min	112 ml/min	182.40 ml/min	70.518 ml/min
Average Linear Force (lbs)	16	16	47	47	50 or 66**	16	16	25	12	47	57	50 or 66**	50	433	200	50 or 66**
RS-232 Computer Control	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TTL Connection	No	No	Yes	Yes	Yes	No	No	Footswitch	Footswitch	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dimensions (H x W x D)	13 x 22.9 x 11.4 cm (5 x 9 x 4.5 in)	13 x 22.9 x 11.4 cm (5 x 9 x 4.5 in)	28 x 22.2 x 14 cm (11 x 8.75 x 5.5 in)	28 x 22.2 x 14 cm (11 x 8.75 x 5.5 in)	15.9 x 22.8 x 27.9 cm (6.3 x 9 x 11 in)	13 x 22.9 x 11.4 cm (5 x 9 x 4.5 in)	13 x 22.9 x 11.4 cm (5 x 9 x 4.5 in)	11.4 x 22.9 x 11.4 cm (4.5 x 9 x 4.5 in)	8.9 x 22.9 x 11.4 cm (3.5 x 9 x 4.5 in)	28 x 22.2 x 14 cm (11 x 8.75 x 5.5 in)	15.2 x 31.1 x 28.6 cm (6 x 12.5 x 11.25 in)	15.9 x 22.8 x 27.9 cm (6.3 x 9 x 11 in)	9.5 x 27.9 x 22.9 cm (3.75 x 11 x 9 in)	9.5 x 27.9 x 22.9 cm (3.75 x 11 x 9 in)	17 x 23 x 29 cm (6.7 x 9 x 11.4 in)	15.9 x 22.8 x 27.9 cm (6.3 x 9 x 11 in)
Pump Head Dimensions (H x W x D)	-	-	-	-	-	-	-	-	1 x 18.5 x 5 cm (2.5 x 7.25 x 2 in)	-	-	-	22.9 x 43.2 x 30.5 cm (9 x 17 x 12 in)	22.9 x 43.2 x 30.5 cm (9 x 17 x 12 in)	-	-
Weight	2.1 kg (4.6 lbs)	2.1 kg (4.6 lbs)	4.5 kg (10 lbs)	4.5 kg (10 lbs)	4.5 kg (10 lbs)	2.1 kg (4.6 lbs)	2.1 kg (4.6 lbs)	2.3 kg (5 lbs)	2.06 kg (4.6 lbs)	4.5 kg (10 lbs)	6.8 kg (15 lbs)	4.5 kg (10 lbs)			6.4 kg (14 lbs)	4.5 kg (10 lbs)
Page	8	8	12	13	16	8	8	9	10	12	14	16	15	20	21	16

* Depends upon the Syringe Rack

- Single or Dual Syringe Rack
- 4 x 140 Syringe Rack
- 6 x 10 Syringe Rack
- Microliter Syringe Rack

- Maximum syringe size varies depending upon pump model
- Holds four 60 ml or 140 ml plastic syringes only
- Holds six 30 to 60 ml syringes or ten 0.5 µl to 20 ml syringes
- Holds four 0.5 µl to 10 ml syringes

**Available in standard force= 50 lbs or high force= 66 lbs

•Low RFI (Radio Frequency Interference) Pump

+ Push/Pull pump can hold syringes up to 140 ml if full stroke is not required. Larger syringes will not fully infuse or withdraw.

Syringe Pump Questions

How many syringes will be used simultaneously?

What size syringe will be used?

What flow rate(s) will be used? See pump reference pages 47-49

What is the total volume to be delivered?

Does the pump need to withdraw (fill the syringe) as well as infuse (dispense)?

What is the viscosity of the liquid you are pumping? See pump reference pages 46 and 53

What are the pressure requirements of your experiment? See pump reference pages 46 and 53

Does the pump need to continuously infuse over a 24 hour period of time?

Does the pump need to be programmable (store up to 4 programs with 10 sequences each)?

Does the pump need to be controlled with a computer?

Does the pump need to have TTL capabilities (ex. external control of valves, use of footswitch, etc)?

Choosing the Right Pump for Your Application & Budget

3. Syringe Pump Application Guide

Find your application and go to the pages indicated for more information

Syringe Pump Application Guide

	OEM SYRINGE PUMP MODULES (RS232)																	
	Pump 11 Plus	Pump 11 Pico Plus	Nanomite	Pump 22	Physio 22	Pump 33	PHD 22/2000		PHD 22/2000 Push/Pull	MRI PHD 22/2000	PHD 22/2000 Hpsi	PHD 4400 Hpsi	Multiple Animal Feeding Station	Biomedical Dispensing System	Micro-liter	Milliliter	Programmable	High Pressure
See Page	8	9	10	12	13	14	16		16	15	20	21	26	11	31	32	33	35
Accurate Delivery of Coatings		X					X		X								X	X
Animal Feeding	X			X			X						X					
Biomedical Dispensers	X													X				
Bulk Fluid Transfer						X			X								X	
Cell Cultures						X			X									
Cellular Injection		X	X		X		X								X	X		
Continuous Infusions						X			X						X	X	X	
Doping	X			X			X											
Drug Delivery (same infusion rates)	X			X			X											
Drug Delivery (different infusion rates)	X (RS232)*			X (RS232)*		X					X (RS232)*							
Drug Delivery (time released)							X					X						
Drug Development				X			X											
Electrospinning	X						X											X
Fluid Blending	X (RS232)*			X (RS232)*		X	X (RS232)*					X			X	X		
Fluid Blending (2 independent channels)						X									X	X		
Fluid Sampling	X	X	X	X		X	X								X	X	X	
Gradients	X (RS232)*			X (RS232)*		X	X (RS232)*								X	X	X	
High Pressure Injection		X									X	X						X
Highly Corrosive Fluids											X	X		X			X	X
HPLC	X	X				X			X									
Injecting Into High Pressure Reaction Vessels		X									X	X						X
Injection Pressure Calculations	X			X			X											
Instrument Injections	X			X			X								X	X	X	X
Low Pressure Chromatography	X																	
Mass Spectrometry	X	X		X			X											
Medical Coating Delivery														X			X	X
Microdialysis	X	X		X			X											
MRI Studies									X									
Multiple Simultaneous Feeding Stations	X (RS232)*			X (RS232)*			X (RS232)*						X			X		
Nano Fluidics		X					X								X			
Nutritional Studies	X			X									X					
OEM Modules															X	X	X	X
Oocyte Applications		X			X													
Patch Clamping					X													
Remote Pumping of Hazardous Material			X				X				X	X			X	X	X	X
Stereotaxic Devices			X															
Titration	X (RS232)*			X (RS232)*		X									X	X		
Viscous Solutions		X									X	X						X

*Note: Can be done using RS232 Computer Control

Choosing the Right Pump for Your Application & Budget

3. Syringe Pump Application Guide (continued)

Pump 11 Plus



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- Volume dispense feature
- Infusion only or infuse/withdraw
- Single or dual syringe models available
- Small, compact size
- Legendary reliability – 2 year warranty

Harvard Apparatus' Syringe Pump 11 Plus combines smoother flow and updated features to create a high performance syringe pump with a basic syringe pump price!

Bright Display and Easy-To-Use Interface

A two-line 16 character vacuum fluorescent display and six membrane keys make this a powerful, easy-to-use syringe pump. Only two entries are required to start pumping; Syringe Inside Diameter (mm) and flow rate. The flow rate can be changed while the pump is running.

Two Modes of Operation, Constant Flow Rate & Volume Dispense

The Pump 11 Plus will operate continuously in RATE mode or accurately dispense a specific amount of fluid in VOLUME mode.

Versatile

Select from two different models. The standard Pump 11 Plus model has the following features:

- Infusion Only
- End of Travel Limit Stop
- Anti-Siphon Bracket

The Pump 11 Plus Advanced model has the same features as the standard model, but also includes:

- Infusion/Withdrawal
- Dual RS-232 Communications

Both models are available with either a single syringe configuration or dual syringe configuration. Select the pump that best fits your application.

Non-Volatile Memory

The micro-stepping pump profiles deliver very smooth and consistent flow over the entire flow rate range. These pumps now feature non-volatile memory. The pump remembers its last syringe size, flow rate used and configuration settings. An advanced universal power supply means there is no need to change AC line switches, fuses or wires.

The Pump 11 Plus will operate on any AC line voltage from 100 VAC to 240 VAC, either 50 or 60 Hz. The Pump 11 Plus offers the same power failure mode as our PHD 22/2000 syringe pump series. In a power failure the pump can either Resume or Stop pumping when power is returned.

Safety

The Pump 11 Plus motor will not shut itself off in case of overload, rather it will remain in a stalled position with no damage. An adjustment collar on the guide rod prevents the syringe plunger from hitting bottom.

CE Mark Approved

The Pump 11 Plus meets all relevant European EMC and Safety requirements for laboratory equipment.

Specifications

Type	Microprocessor single or dual syringe, infusion only or infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe:	
Type	Plastic or glass
Size (single syringe)	0.5 µl to 50/60 ml
Size (dual syringe)	0.5 µl to 10 ml
Flow Rate:	
Single Syringe	0.0014 µl/hr to 26.56 ml/min
Dual Syringe	0.0014 µl/hr to 7.91 ml/min
Non Volatile Memory	Storage of all settings
RS-232	Advanced models only
TTL	No
Average Linear Force	16 lbs
Drive Motor	0.9° step angle motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	3,200 steps
Step Resolution	0.33 µm/step
Step Rate:	
Minimum	6.8 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate:	
Minimum	2.9068 µm/min
Maximum	47.6 mm/min
Input Power	12 VDC 1.5 Amps
Voltage Range (Power Supply)	Universal input 100/240 VAC, 50/60 Hz, 18 watts (Use only Harvard Apparatus approved supply and line cord)
Dimensions, H x W x D	13 x 22.9 x 11.4 cm (5 x 9 x 4.5 in)
Weight	2.1 kg (4.6 lb)

Order # Product

EC1 70-2208	Harvard Pump 11 Plus Single Syringe
EC1 70-2209	Harvard Pump 11 Plus Dual Syringe
EC1 70-2211	Harvard Pump 11 Plus Advanced Single Syringe with Dual RS-232
EC1 70-2212	Harvard Pump 11 Plus Advanced Dual Syringe with Dual RS-232

Pump 11 Pico Plus



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EC1 70-2213 Pump 11 Pico Plus



CE



EC1 70-2215 Foot Switch (included)

Applications

- Cellular injection i.e. oocytes
- Micro flow for FIA or capillary LC
- Micro reactor delivery
- Remote to micromanipulator injections are easy non-obstructed viewing and no heavy weight to hinder positioning

Features

- Infuse/withdraw capability
- Dual syringes for broad flow rate range
- Flow rates can be set in milliliters, microliters, nanoliters and picoliters
- The injection can be controlled by initiating the manual start button, RS-232 through your computer or with the included foot pedal
- From the keypad the user can set pump to:
 - Infusion mode
 - Withdrawal mode (reversing switch on back panel)
- Micro tubing and connectors are available
- Volume mode - enter a target volume, pump will stop when value achieved
- Adjustable infusion limit switch and adjustable withdraw mechanical stop
- Legendary reliability – 2 year warranty

Specifications

Type	Microprocessor dual syringe infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe:	
Type	Plastic or glass
Size Minimum	0.5 µl
Size Maximum	10 ml
Flow Rate:	
Minimum	1.3 pl/min
Maximum	0.8788 ml/min (using 2 x 10 ml syringes combined output)
Non Volatile Memory	Storage of all settings
RS-232	Yes
TTL	Footswitch Control
Average Linear Force	25 lbs*
Drive Motor	1.8° step angle geared 36:1 motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	14,400 steps
Step Resolution	0.0184 µm/step
Step Rate:	
Minimum	1 pulse in 27.6 sec
Maximum	200 steps/sec
Pusher Travel Rate:	
Minimum	0.0388 µm/min
Maximum	0.8333 mm/min
Input Power	12 VDC 1.5 Amps
Voltage Range (Power Supply)	Universal input 100/240 VAC, 50/60 Hz, 18 watts (Use only Harvard Apparatus approved supply and line cord)
Dimensions, H x W x D	11.4 x 22.9 x 11.4 cm (4.5 x 9 x 4.5 in)
Weight	2.3 kg (5 lbs)

* Actual force is higher. Not recommended for applications more than 25 lbs of force.

Order # Product

EC1 70-2213 Pump 11 Pico Plus

Nanomite Syringe Pump



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Applications

- Space limited
- Micro reactor delivery
- High pressure
- Cellular injection
- Chamber dosing
- Micro-dispensing
- Stereotaxic devices

Features

- 11 pounds of pumping force
- Bright blue LED run indicator
- Remote pump head
- Legendary reliability- 2 year warranty

The Nanomite is an exceptionally small syringe pump ideal for space limited applications. The Nanomite consists of a control unit, an injection unit, a 6 foot cable to connect the two units and a footswitch.

Bright Display and Easy-To-Use Interface

A two-line 16 character vacuum fluorescent display along with six membrane keys make this a most attractive but powerful, easy-to-use syringe pump. Only two entries required to start pumping; syringe Inside Diameter (mm) and pumping flow rates. The flow rate can be changed while the pump is running.

Two Modes of Operation, Constant Flow Rate & Volume Dispense

The Nanomite will operate continuously in RATE mode or accurately dispense a specific amount of fluid in VOLUME mode.

Audible alarm when target volume is reached.

Smooth Flow

Enhanced micro-stepping pump profiles deliver very smooth and consistent flow, that is virtually pulse free.

Nonvolatile Memory

The pump remembers its last syringe size, flow rate used and configuration settings.

Power Fail Mode

In a power failure the pump can either RESUME or STOP pumping when power is returned.

CE Mark Approved

The Nanomite meets all relevant European EMC and Safety requirements for laboratory equipment.

Specifications

Type	Microprocessor single syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe:	
Type	Glass
Size Minimum	0.5 µl
Size Maximum	1 ml
Flow Rate:	
Minimum	3.3 nl/hr
Maximum	1901 µl/min
Non Volatile Memory	Stores diameter, rate and configuration settings
RS-232	Yes
TTL	Footswitch control
Average Linear Force	11 to 12 lbs
Drive Motor	1.8° step angle motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	1,600 steps
Step Resolution	0.7933 µm/step
Step Rate:	
Minimum	1 pulse in 27.6 sec
Maximum	200 steps/sec
Pusher Travel Rate:	
Minimum	7.0 µm/min
Maximum	114 mm/min
Input Power	12 VDC 1.5 Amps
Voltage Range (Power Supply)	Universal input 100/240 VAC, 50/60 Hz, 18 watts (Use only a Harvard Apparatus approved supply and line cord)
Dimensions, H x W x D:	
Control Unit	8.9 x 22.9 x 11.4 cm (3-1/2 x 9 x 4-1/2 in)
Injector Unit	1.0 x 18.5 x 5.0 cm (2-1/2 x 7-1/4 x 2 in)
Weight:	
Control Unit	1.7 kg (3.80 lb)
Injector Unit	0.36 kg (0.80 lb)

Order # Product

EC1 70-2217 Nanomite Syringe Pump

Biomedical Dispensing System



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EC1 70-2233 Biomedical Dispensing System



Applications

- Delivery of small adhesives
- Delivery of drugs
- Delivery of medical coatings

Features

- Anodized aluminum cover
- Left and right hand configurations
- Computer or keypad control
- 2 year warranty

The Harvard Apparatus Biomedical Dispensing System is an ideal system for the accurate delivery of low volume solutions. The volume is minimized by the left and right-handed configurations that make up the system. The use of an anodized aluminum cover makes this dispenser perfect for use in clean room environments. The Harvard Apparatus 2 year warranty illustrates the dependability and reliability you can count on. The Biomedical Dispensing System can be operated via the keypad, footswitch or RS-232 computer control.

This system includes one left-hand configured pump and one right-hand configured pump.

Specifications

Type	Microprocessor single syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe:	
Type	Plastic or glass
Size Minimum	0.5 µl
Size Maximum	50/60 ml
Flow Rate:	
Minimum	0.0014 µl/hr
Maximum	26.56 ml/min
Non Volatile Memory	Storage of all settings
RS-232	RJ11-4
TTL	No
Average Linear Force	16 lbs
Drive Motor	0.9° step angle motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	3,200 steps
Step Resolution	0.33 µm/step
Step Rate:	
Minimum	6.8 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate:	
Minimum	2.9068 µm/min
Maximum	47.6 mm/min
Input Power	12 VDC 1.5 Amps
Voltage Range (Power Supply)	Universal input 100/240 VAC, 50/60 Hz, 18 watts (Use only Harvard Apparatus approved supply and line cord)
Dimensions, H x W x D	13 x 22.9 x 11.4 cm (5 x 9 x 4.5 in)
Weight	2.1 kg (4.6 lb)

* Actual force is higher. Not recommended for applications with more than 25 lbs of force.

Order # Product

EC1 70-2233 Biomedical Dispensing System

Pump 22

Multiple Syringe Pump



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- **Legendary reliability – 2 year warranty**
- **Versatile**
- **Easy to use**
- **Nonvolatile memory**
- **Computer control**

The Harvard 22 syringe pump is the pump that set the industry standard! It is the world's most popular syringe pump. Harvard Apparatus' long-standing tradition of providing rugged and reliable products is the foundation upon which this pump was built.

Since the introduction of the first pump 22 many features and innovations have been added to the pump to offer a complete line of pumps for multiple syringe applications. We offer versions of the pump 22 for 4 microliter syringes, a 10 syringe rack and a syringe rack for 1 to 4, 60 ml or 140 ml syringes. An anti-siphon model is also available for infusion applications where the line pressure is lower than the syringe pressure. The anti-siphon bracket securely retains the syringe plunger to prevent unintended loss of fluid from the syringe. This is important for pumps positioned vertically.

This pump features an LED display and numeric keypad for easy entry of syringe diameter data and flow rates. Flow rate units can be set in $\mu\text{l/hr}$, $\mu\text{l/min}$, ml/hr and ml/min . An optical encoder monitors leadscrew rotation to accurately maintain any flow rate. The run LED flashes when syringe plunger movement stops unexpectedly. A complete line of accessories for the Pump 22 are available including a footswitch, audible alarm, reversing switch and serial cables, see page 30.

The pump 22 can be controlled using RS-232 (serial) commands, see page 21. Multiple syringe pumps can be interconnected by daisy chaining pumps. Up to 100 pumps can be addressed independently using internal reference addresses from 0 to 99. The default setting is 0. A set of sample programs, using the Basic programming language, is included with each pump.

Specifications

Type	Microprocessor multiple syringe, infusion only or infuse/withdraw
Accuracy	$\pm 0.35\%$
Reproducibility	$\pm 0.05\%$
Syringe:	
Type	Plastic, glass or stainless steel
Size Minimum	0.5 μl
Size Maximum	140 ml
Flow Rate:	
Minimum	0.002 $\mu\text{l/hr}$
Maximum	55.1 ml/min
Non Volatile Memory	Storage of all settings
RS-232	25-pin connector
TTL	Shared port with RS-232
Average Linear Force	47 lbs
Drive Motor	0.9° step angle motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	3,200 steps
Step Resolution	0.33 $\mu\text{m/step}$
Step Rate:	
Minimum	6.8 sec/step
Maximum	416.7 $\mu\text{sec/step}$
Pusher Travel Rate:	
Minimum	2.9068 $\mu\text{m/min}$
Maximum	47.6 mm/min
Power	30 W, 0.5 A fuse
Voltage Range	95 to 130 VAC, 60 Hz; 220 to 260 VAC, 50 Hz, selectable
Dimensions, H x W x D	28 x 22.2 x 14 cm (11 x 8.75 x 5.5 in)
Weight	4.5 kg (10 lb)

Order # Product

EC1 55-2222	Pump 22 Infusion Only with Standard 2-Syringe Holder
EC1 55-2275	Pump 22 Infusion Only with Anti-Siphon Standard 2-Syringe Holder ¹
EC1 55-5920	Pump 22 Infusion Only with 6/10 Multi-Syringe Rack
EC1 55-2314	Pump 22 Infusion Only with 4 x 140 Multi-Syringe Rack
EC1 55-4150	Infusion Only with Microliter Rack
EC1 55-2226	Pump 22 Infusion/Withdraw with Standard 2-Syringe Holder
EC1 55-2219	Pump 22 Infusion/Withdraw with 6/10 Multi-Syringe Rack
EC1 55-2316	Pump 22 Infusion/Withdraw with 4 x 140 Multi-Syringe Rack
EC1 55-4153	Pump 22 Infusion/Withdraw with Microliter Syringe Holder

1. Anti-Siphon syringe holder secures syringe plunger to pusher block

syringe pumps

PHYSIO 22

Low RFI Syringe Pump for Physiological Experiments



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Physio 22

Applications

- Patch Clamping
- Oocyte applications
- Cellular injections

Features

- Low electrical noise
- Pulse less flow
- High accuracy

The PHYSIO 22 Pump delivers high accuracy, pulseless flow with no electrical noise to interfere with the sensor signal while performing physiological analyses. This specialty pump is based on our legendary Syringe Pump 22, but with a special toroidal transformer designed for minimum RFI (Radio Frequency Interference). This new transformer cuts electrical noise so that it is almost non-existent.

The electrical noise difference between our standard pump 22 and this new model is quite dramatic. Standard pumps generate a magnetic field which will induce a current into the conductive media coming out of the syringe. This will create noise in the biological reading/recordings. With the new PHYSIO 22, even the most sensitive sensors will not show a noise spike. With the new toroidal transformer the noise disappears completely.

This pump features an LED display and numerical keypad for easy entry of syringe diameter data and flow rates. Flow rate units can be set in $\mu\text{l/hr}$, $\mu\text{l/min}$, ml/hr and ml/min . An optical encoder monitors leadscrew rotation to accurately maintain any flow rate. The run LED flashes when syringe plunger movement stops unexpectedly. A complete line of accessories for the Pump 22 are available including a footswitch, audible alarm, reversing switch and serial cables, see page 30.

The pump 22 can be controlled using RS-232 (serial) commands. Multiple syringe pumps can be interconnected by daisy chaining pumps. Up to 100 pumps can be addressed independently using internal reference addresses from 0 to 99. A set of sample programs, using the Basic programming language, is included with each pump.

These types of applications are particularly sensitive to electrical noise and therefore would benefit tremendously by using our new PHYSIO 22 Syringe Pump.

This pump is currently available as infusion only with standard 2-syringe rack or infusion only with 6/10 syringe rack. An infuse/withdraw model is available by special order. Please call for details.

A spurious electromagnetic signal was recently found within the design of the Physio 22 which allowed the introduction of a small 50/60 Hz signal into a shielded environment. In particular, a small transformer within the Physio 22 generated an electromagnetic field which was sensed by an adjacent perfusion line. The problem was corrected by replacing the offending transformer with one incorporating toroidal architecture. This change in design successfully contains the stray electromagnetic field and renders the device electrically silent.

Specifications

Type	Microprocessor multiple syringe, infusion only
Accuracy	$\pm 0.35\%$
Reproducibility	$\pm 0.05\%$
Syringe:	
Type	Plastic, glass or stainless steel
Size Minimum	0.5 μl
Size Maximum	140 ml
Flow Rate:	
Minimum	0.002 $\mu\text{l/hr}$
Maximum	55.1 ml/min
Non Volatile Memory	Storage of all settings
RS-232	25-pin connector
TTL	Shared port with RS-232
Average Linear Force	47 lbs
Drive Motor	0.9° step angle motor
Motor Drive Control	1/4 microstepping
Motor Step per One Rev. of Leadscrew	3,200 steps
Step Resolution	0.33 $\mu\text{m/step}$
Step Rate:	
Minimum	6.8 sec/step
Maximum	416.7 $\mu\text{sec/step}$
Pusher Travel Rate:	
Minimum	2.9068 $\mu\text{m/min}$
Maximum	47.6 mm/min
Power	30 W, 0.5 A fuse
Voltage Range	95 to 130 VAC, 60 Hz; 220 to 260 VAC, 50 Hz, selectable
Dimensions, H x W x D	28 x 22.2 x 14 cm (11 x 8.75 x 5.5 in)
Weight	4.5 kg (10 lb)

Order # Product

EC1 70-2222	PHYSIO 22 Syringe Pump with Standard 2-Syringe Holder
EC1 70-2223	PHYSIO 22 Syringe Pump with 6/10 Multi-Syringe Rack

syringe pumps

Pump 33 Dual Syringe Pump



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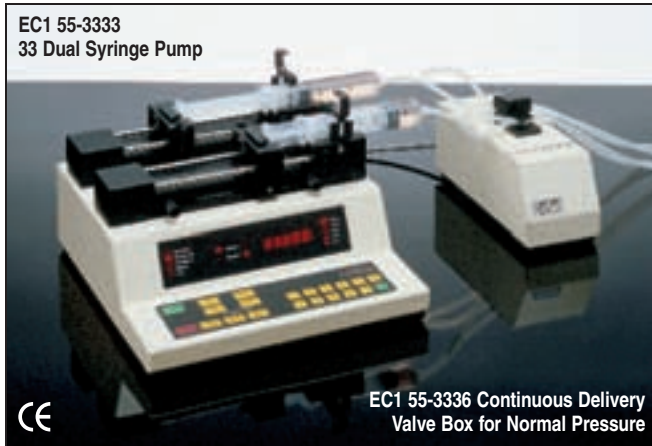
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- Two independent pumps in a single package
- Operate each pump independently at its own flow rate to either infuse or withdraw
- Synchronize the two pumps for all types of exchange procedures and dilutions of identical amounts
- Deliver or withdraw continuously, 24 hours a day
- 2 year warranty

The Harvard 33 Dual Syringe Pump offers continuous infusion or withdrawal, 24 hours a day, 365 days a year with the accuracy and low flow of a Harvard Apparatus syringe pump.

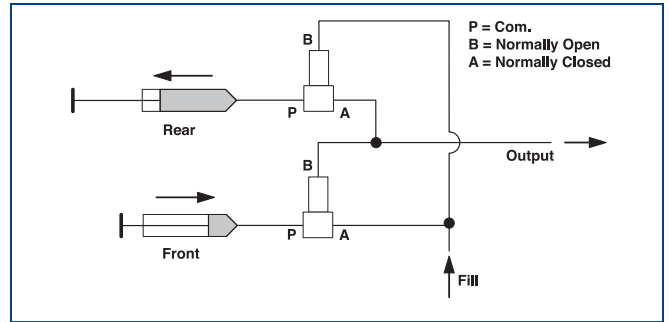
The Harvard 33 Dual Syringe Pump is a breakthrough in pumping technology. The 33 has two independent pumping channels linked through hardware and software. When combined with a valve box (page 30), it provides the continuous delivery of a peristaltic or piston pump with the accuracy, absence of pulsation and low flow rates of a syringe pump.

The Harvard 33 Dual Syringe Pump opens up whole new pumping possibilities. These are some of the applications of this pump:

- **The injection of dyes, perfumes and flavoring in industrial applications**
- **Applications with liquids or viscous materials in micro-manufacturing**
- **Continuous injections of reactants into reactor vessels**
- **Simultaneous samplings from two sites**
- **Continuous injection for long term toxicology testing**

Several modes of operation are available to accommodate a range of setups and experimental protocols. A unique movable limit switch mechanism is used to change direction or stop operation of the pump depending on the mode of operation.

Reciprocal/Parallel Mode - Syringe mechanisms can run in the same or opposite directions (i.e. both infusing/withdrawing at the same time or one infusing and the other withdrawing)



Proportional Mode - Different flow rates and syringe diameters can be set for each syringe mechanism

AutoStop Mode - Pump stops operation when a limit switch is activated.

Continuous Run Mode - When a limit switch is activated each syringe mechanism reverses direction.

The pump has high pressure capability, TTL and RS-232 interface for data acquisition and control. The communication ports enable daisy-chaining of up to 100 pumps.

Specifications

Type	Microprocessor dual drive, single syringe, infuse/withdraw
Accuracy	±0.35%
Reproducibility	±0.1%
Syringe:	
Type	Plastic, glass or stainless steel
Size Minimum	0.5 µl
Size Maximum	140 ml
Flow Rate:	
Minimum	0.0004 µl/hr
Maximum	106.6 ml/min
Non Volatile Memory	Storage of all settings
RS-232	RJ11-4 conductor
TTL	9-pin connector
Average Linear Force	57 lbs
Drive Motor	2 motors, each 0.9° step angle motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/4 microstepping
Motor Steps per Rev. of Leadscrew	1,600 steps at 1/2 stepping or 3,200 steps at 1/4 stepping
Step Resolution	0.33 µm/step
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate:	
Minimum	0.726699 µm/min
Maximum	95.25 mm/min
Power	45 W, 1.0 A fuse
Voltage Range	95 to 130 VAC, 60 Hz; 220 to 260 VAC, 50 Hz, selectable
Dimensions, H x W x D	15.2 x 31.1 x 28.6 cm (6 x 12.5 x 11.25 in)
Weight	6.8 kg (15 lb)

Order # Product

EC1 55-3333 Harvard 33 Dual Syringe Pump

PHD 22/2000

MRI Compatible Syringe Pumps



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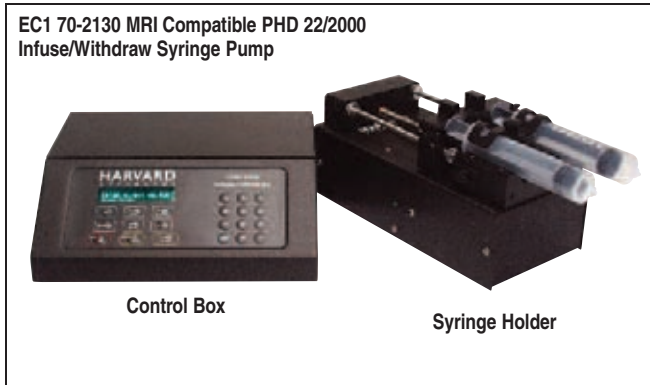
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- High accuracy and precision
- Low flow rate
- 2 year warranty

Our new MRI Compatible Pump is based on the design of one of our most tried and trusted syringe pumps. The PHD 22/2000. This new pump is made of mostly non-magnetic materials and can be placed near to an imaging magnet when it is in use! **The control box should be positioned at least 5 feet away from the opening of the magnet and not in direct line of the opening.** The exact distance is dependent upon the strength of the magnet. This will now make drug or dye perfusions possible while the magnet is on. It is based on our existing PHD 22/2000 syringe pump but we have taken away most of the magnetic components and replaced them with non-magnetic materials. This pump is a remote model where the syringe pumping mechanism is separated from the control box by a 30 foot cable. This allows the pump to be started and stopped near the magnet, via a RUN/STOP switch that was added to the syringe box. If additional space is required between the control box and pumping mechanism, a 60 foot cable is also available. For more details on the PHD 22/2000 Pump Line, see pages 16 to 19.

Program Description

The programming functions of this pump provide powerful capabilities for advanced experiments. While in program mode this pump can perform the following tasks at a predetermined time or when prompted by a signal from an external device:

- **Start or stop pumping**
- **Change pumping direction (infuse-withdraw)**
- **Change flow rates**
- **Pump a precise volume and stop**
- **Pause operation**
- **Ramp up or down flow rates**

In program mode the above tasks can be linked together into powerful programs to simplify your automation projects.

Specifications

Type	Microprocessor dual syringe, infuse/withdraw
Accuracy	±0.35%
Reproducibility	±0.05%
Syringe:	
Type	Plastic or glass
Size Minimum	0.5 µl
Size Maximum	140 ml
Flow Rate:	
Minimum	0.0001 µl/hr
Maximum	220.82 ml/min
Non Volatile Memory	Stores all settings
RS-232	RJ11-4 conductor
TTL	9 pin D-Sub. Connector
Average Linear Force	50 lbs
Drive Motor	1.8° step angle motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/32 microstepping
Motor Steps per one Rev. of Leadscrew	800 steps at 1/2 stepping or 12,800 at 1/32 stepping
Step Resolution	0.082 µm/step
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
Power	65 W, 0.5 A fuse
Voltage Range	universal input 100/240 VAC, 50/60 Hz
Cable Length	9.1 m (30 ft)
Dimensions, H x W x D:	
Control Box	9.5 x 27.9 x 22.9 cm (3.75 x 11 x 9 in)
Syringe Holder	22.9 x 43.2 x 30.5 cm (9 x 17 x 12 in)

Order # Product

EC1 70-2130	MRI Compatible PHD 22/2000 Infuse/Withdraw Remote Pump with 2-Syringe Rack
EC1 70-2131	MRI Compatible PHD 22/2000 Infuse/Withdraw Programmable Remote with 2-Syringe Rack

syringe pumps

PHD 22/2000

Advanced Syringe Pumps



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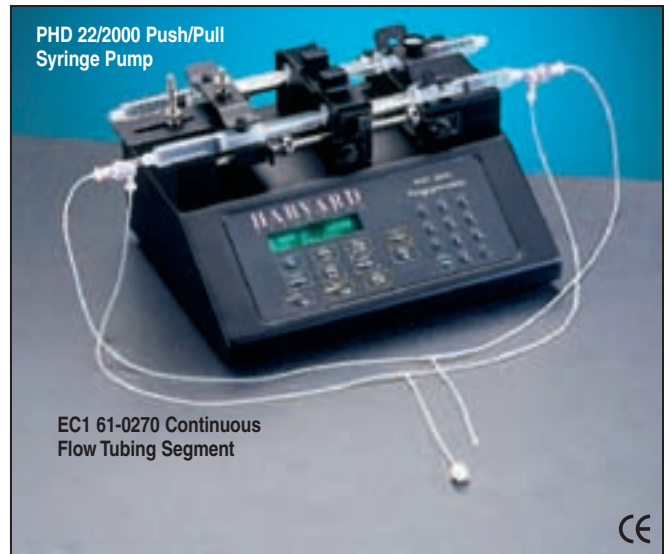
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- High accuracy and precision
- Low flow rates
- Ultimate flexibility and versatility
- 2 year warranty

Forty years ago Harvard Apparatus perfected the leadscrew principle and created the first syringe pump. Since that time, tens of thousands of Harvard Apparatus pumps have earned a reputation as the most reliable research partners in every major laboratory in the World. The PHD 22/2000 syringe pump series gives you the lowest flow rates, the highest accuracy, the smoothest flow, advanced programmability from the keypad and yet, is very easy to use. It is also incredibly quiet so it won't disturb your experimental subjects.

Highest Accuracy and Precision

A welded steel chassis, machined Delrin™ components, upgraded guide rods, and advanced electronics give accuracy within 0.35% and reproducibility within 0.05%.

Lowest Flow Rates

A micro stepping motor and control software give the lowest flow rates ever, down to 0.0001 µl/hour.

Versatility

There is a PHD 22/2000 syringe pump to meet every need, whether it be simple infusion, infusion and withdrawal, or programming capabilities.

- 1. Infuse Only:** This pump is suitable for applications that require high accuracy and low rates but, do not need to withdraw fluid and do not need programmability. Should you need withdrawal or program capabilities later on, the infusion only pump can be upgraded.
- 2. Infuse/Withdraw:** The PHD 22/2000 infuse/withdraw pump has identical performance to the infusion only model (above), but can also withdraw (refill).

- 3. Programmable:** The PHD 22/2000 Programmable pump has the most advanced programming functions and yet is very easy to use. The pump can store up to four programs of 10 sequences each. Programs are stored in non-volatile memory. No other pump can give you this level of control and flexibility. The programmable pumps may also be programmed using Symphony, Harvard Apparatus' Windows™ pump manager software, see page 28.

Easy to Use

A bright, easy to read, two-line fluorescent display can be easily read from across the lab. A target volume key makes it easy to dispense a set volume. An ergonomic 'Autolock' release mechanism is easy for even small hands to operate and can never be left unlocked. The numerical keys utilize the familiar 'telephone' layout.

Upgrade

We offer pumps that can be upgraded. If you buy an infuse/withdraw pump and later decide you want programmability you can upgrade it. You pay a lot less than buying a whole new pump, see page 19.

Program Description

The programming functions of this pump provide powerful capabilities for advanced experiments. While in program mode this pump can perform the following tasks at a predetermined time or when prompted by a signal from an external device:

- Start or stop pumping
- Change pumping direction (infuse-withdraw)
- Change flow rates
- Pump a precise volume and stop
- Pause operation
- Ramp up or down flow rates

In program mode the above tasks can be linked together into powerful programs to simplify your automation projects.

PHD 22/2000

Advanced Syringe Pumps (continued)



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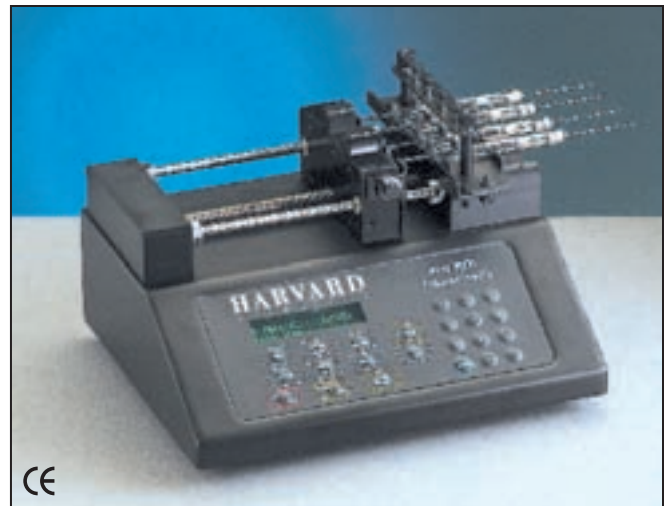
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High Pressure Syringe Pumps

Every version of the PHD 22/2000 Pump is now available with a stronger motor that can provide more force. These pumps are ideal when working with viscous fluid or when driving multiple syringes. The standard force PHD 22/2000 series syringe pump delivers an average nominal force of 50 lbs. while the high power version delivers 66 lbs. If you require even greater force see the PHD 22/2000 Hpsi or the Pump 4400 Hpsi. See page 20 to 21.

Remote Syringe Pump

Use the remote pump in hazardous environments where the researcher is safer when distanced from the material being pumped. This pump includes a 30 foot cable allowing the syringe pumping mechanism and the control box to be separated. Every version of the PHD syringe pump is available in a remote model (pictured above).

Push/Pull Syringe Pump

The push/pull syringe pump holds a total of 4 syringes; 2 on either side of the pusher block. It will accommodate syringes from 0.5 μ l to 30 ml. This pump can simultaneously infuse and withdraw the exact amount. Use this when you do not want the volume infused to alter pressure. With the addition of a EC1 61-0270 Tubing Segment or a valve box, it can also provide continuous infusion. It is available in both infuse/withdraw and programmable models. The right side syringe holder is the standard 2-syringe rack found on all PHD 22/2000 syringe pumps. This standard holder will accept all the PHD 22/2000 multi-syringe racks (right side only).

Syringe Racks

The PHD 22/2000 is offered with a variety of syringe racks to meet your specific application.

- The push/pull syringe pump holds 4 syringes, 2 in each direction, for syringe sizes 0.5 μ l to 30 ml
- The standard 2-syringe rack holds 2 syringes from 0.5 μ l or 140 ml
- The 4 x 140 multi-rack holds four 60 ml or 140 ml plastic syringes only
- 6/10 multi-rack will hold up to 10 syringes from 0.5 μ l to 20 ml and up to 6 syringes from 30 ml to 60 ml
- The microliter syringe rack independently holds 4 microliter syringes, from 0.5 μ l to 10 ml, enabling syringes of different sizes to run simultaneously.

Specifications

Type	Microprocessor multiple, infusion only, infuse/withdraw or programmable
Accuracy	$\pm 0.35\%$
Reproducibility	$\pm 0.05\%$
Syringe:	
Type	Plastic, glass or stainless steel
Size Minimum	0.5 μ l
Size Maximum	140 ml (30 ml for push/pull models)*
Flow Rate:	
Minimum	0.0001 μ l/hr
Maximum	220.82 ml/min
Non Volatile Memory	Stores all settings
RS-232	RJ11-4 conductor
TTL	9 pin D-Sub. Connector
Average Linear Force:	
Standard	50 lbs
High Pressure	66 lbs
Drive Motor	1.8° step angle motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/32 microstepping
Motor Steps per one Rev. of Leadscrew	800 steps at 1/2 stepping or 12,800 at 1/32 stepping
Step Resolution	0.082 μ m/step
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 μ sec/step
Pusher Travel Rate:	
Minimum	0.18 μ m/min
Maximum	190.676 mm/min
Power	65 W, 0.5 A fuse
Voltage Range	Universal input 100/240 VAC; 50/60 Hz
Cable Length	9.1 m (30 ft) for remote models only
Dimensions, H x W x D	15.9 x 22.8 x 27.9 cm (6.3 x 9 x 11 in)
Weight	4.5 kg (10 lb)

*Push/Pull pump can hold syringes up to 140 ml if full stroke is not required. Larger syringes will not fully infuse or withdraw.

syringe pumps

PHD 22/2000

Advanced Syringe Pumps (continued)



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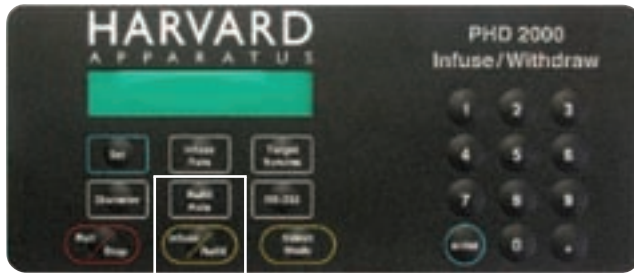
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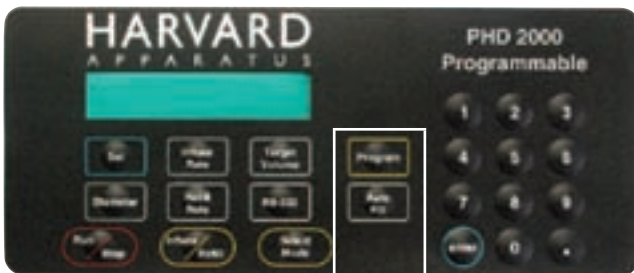
Infusion Only Models

This keypad is on all the infusion only models and offers a single pumping direction. It provides access to all the basic functions of the pump. It features a "Target Volume" button that permits the dispensing of a predefined volume. This is a nice feature when you want to dispense a specific volume. This mode is very safe because it protects syringes and will stop the pump automatically even if the user is not present.



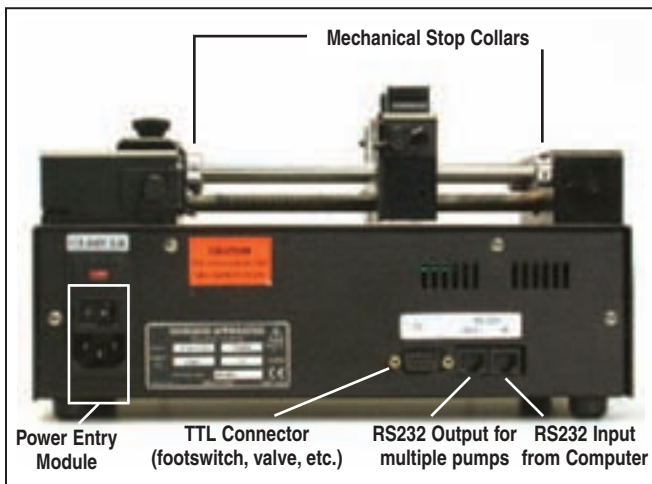
Infuse/Withdraw Models

With the addition of the "Infuse/Refill" and "Refill Rate" buttons on this keypad, the infuse/withdraw models permit the pusher block to move both forward and reverse. This allows the syringes to infuse and withdraw. The reversal is manually controlled via the keypad or RS232. For continuous delivery with automatic reversal see the programmable models below.



Programmable Models

This keypad has two additional buttons. The "Program" and "Auto Fill" buttons. With this pump you can actually program a sequence of pumping steps (four sets of 10 sequences). You can start or stop the pump, change the pumping direction, change the flow rate, pump a precise volume and stop, pause the pump and even ramp up or ramp down the flow rate. All of these tasks can be linked together in a sequence providing a powerful tool to simplify and automate complicated pumping processes. The Auto Fill key is useful when the user would like to deliver a large volume of fluid. The user sets a target volume and then programs the refill volume for the syringe. The pump will automatically refill the syringe as many times as required to reach the target volume. Then the pump will automatically stop. This process does require the use of a valve.



Rear Panel of the Pump

On the back side of all PHD 22/2000 Syringe Pumps are two RS232 ports. One is for input from a computer and the second is for output when daisy chaining more than one pump together. Up to 100 pumps can be addressed independently using internal reference addresses from 00 to 99. The default is 00. The I/O port is a 9-pin D sub connector and is used for TTL control. Also on the back is the universal power entry module which encompasses the ON/OFF switch, fuse and universal power supply. This power supply will accept power input from 110 to 240 VAC, 50/60 Hz. The mechanical stop collars cause the pump to stop automatically, thus protecting expensive syringes.

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Advanced Syringe Pumps (continued)



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PHD 22/2000 Syringe Pumps

Syringe Pump Versions	Infusion Only*		Infuse/Withdraw		Programmable	
	Standard Force	High Force	Standard Force	High Force	Standard Force	High Force
Standard Syringe Pumps						
Standard 2-Syringe	EC1 70-2000	EC1 71-2000	EC1 70-2001	EC1 71-2001	EC1 70-2002	EC1 71-2002
6/10 Multi-Rack	EC1 70-2003	EC1 71-2003	EC1 70-2006	EC1 71-2006	EC1 70-2009	EC1 71-2009
4 x 140 Multi-Rack	EC1 70-2004	EC1 71-2004	EC1 70-2007	EC1 71-2007	EC1 70-2010	EC1 71-2010
Microliter Rack	EC1 70-2005	EC1 71-2005	EC1 70-2008	EC1 71-2008	EC1 70-2011	EC1 71-2011
Remote Syringe Pumps						
Standard 2 Syringe	EC1 70-2100	EC1 71-2100	EC1 70-2101	EC1 71-2101	EC1 70-2102	EC1 71-2102
6/10 Multi-Rack	EC1 70-2103	EC1 71-2103	EC1 70-2106	EC1 71-2106	EC1 70-2109	EC1 71-2109
4 x 140 Multi-Rack	EC1 70-2104	EC1 71-2104	EC1 70-2107	EC1 71-2107	EC1 70-2110	EC1 71-2110
Microliter Rack	EC1 70-2105	EC1 71-2105	EC1 70-2108	EC1 71-2108	EC1 70-2111	EC1 71-2111
Push/Pull Syringe Pumps						
Standard	–	–	EC1 70-2020	EC1 71-2020	EC1 70-2019	EC1 71-2019
Remote	–	–	EC1 70-2120	EC1 71-2120	EC1 70-2119	EC1 71-2119

*Infusion Only models do not include an anti-siphon bracket or a retaining bracket. These can be ordered as a special.

Harvard PHD 22/2000 Pump Series

Order # Syringe Rack Kits and Upgrades

Syringe Rack Kits¹

EC1 70-2012	PHD 22/2000 6/10 Multi-Rack Upgrade Kit
EC1 70-2013	PHD 22/2000 4 x 140 Multi-Rack Upgrade Kit
EC1 70-2014	PHD 22/2000 Microliter Rack Upgrade Kit
EC1 70-2015	PHD 22/2000 Anti-Siphon Kit (Infusion Only Pump)

Upgrades²

EC1 70-2016	PHD 22/2000 Infusion to Infuse/Withdraw
EC1 70-2017	PHD 22/2000 Infuse/Withdraw to Programmable
EC1 70-2018	PHD 22/2000 Infusion Only to Programmable

- These multiple syringe racks will fit any PHD 22/2000 series syringe pump listed above and are easily interchangeable.
- Upgrades are available for Infusion Only and Infuse/Withdraw models of PHD 22/2000 series pumps. All upgrades must be factory installed.

Remote Extension Cables

Replacement cables for PHD 22/2000 remote syringe pumps including the PHD 22/2000 Hpsi, see page 20. The cables can also be used to increase or decrease the distance between the syringe pumping mechanism and the control box.

Order # Product

EC1 72-0199	Remote Extension Cable, 1.5 m (5 ft)
EC1 72-1405	Remote Extension Cable, 9.1 m (30 ft)

Continuous Flow Tubing Segment

This continuous flow tubing segment is used with the PHD 22/2000 Push/Pull Syringe Pump. When used with the programmable model it makes continuous 24/7 flow possible.

Specifications

Tubing	0.062 in. ID Tygon® tubing
Tubing Length	3 x 112 in. sections
Max. Pressure	15 p.s.i.
Valve Materials	Polycarbonate, silicone

Order # Product

EC1 61-0270	Continuous Flow Tubing Segment
EC1 72-6133	Replacement Dual Check Valves, pkg. of 10

syringe pumps

PHD 22/2000 Hpsi

High Volume & Pressure Programmable Syringe Pump



- High capacity — up to 800 ml with four 200 ml syringes
- Ultra high pressure — provides over 400 lbs of pumping force
- ±0.5% precision
- ±0.1% reproducibility
- Programmable — advanced capabilities with programming from the keypad
- Built to last — rugged construction for a lifetime of service
- Accepts only Harvard Apparatus' stainless steel syringes
- 2 year warranty

High Capacity

The PHD 22/2000 Hpsi Syringe Pump provides the highest capacity output of all of Harvard Apparatus' microprocessor syringe pumps. This pump can hold up to four stainless steel syringes from 20 to 200 ml. By combining the output from four 200 ml syringes, this pump is able to infuse up to 800 ml of fluid without refilling.

Ultra High Pressure

The PHD 22/2000 Hpsi Syringe Pump delivers over 400 pounds of force against the syringe plungers, higher than any other pump we manufacture. For applications with viscous fluids or requiring high pressure, this is the pump to handle the job.

Versatility

This Programmable PHD 22/2000 Hpsi syringe pump provides advanced capabilities directly from the keypad. No external computer is required. The pump can store up to four programs of 10 sequences each. Programs are stored in non-volatile memory. No other pump can provide this level of control and flexibility with the accuracy of the PHD 22/2000 syringe pump series. Like all Harvard Apparatus' pumps, this high capacity pump is easy to use.

Built-to-Last

This pump uses high quality, industrial grade components that will deliver years of smooth operation.

To Accommodate Almost Every Workbench

This pump is provided with a standard 5 foot cable that connects the control box to the pumping mechanism box. If additional distance is required between the controller and pump, a 30 foot remote extension cable is offered as an accessory.

Stainless Steel Syringes

Only Harvard Apparatus' 20 ml to 200 ml stainless steel syringes can be used with this pump. They can withstand high pressure applications and provide years of service, see Syringes and Needles pages 2 and 3. This pump cannot use 2.5 ml and 8 ml stainless steel syringes.

*Flow Rates for PHD 22/2000 Hpsi (High Volume and Pressure)
The Rates listed are for single stainless steel syringe*

Syringe Size	Minimum	Maximum
20 ml	1.5 µl/hr	20 ml/min
50 ml	3.4 µl/hr	46 ml/min
100 ml	5.0 µl/hr	68 ml/min
200 ml	8.2 µl/hr	112 ml/min

Specifications

Type	Microprocessor multiple syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.05%
Syringes (Min/Max)	Holds 20 to 200 ml stainless steel syringes
Flow Rate:	
Minimum	1.5 µl/hr
Maximum	112 ml/min
Non Volatile Memory	Stores all settings
RS-232	RJ11-4 conductor
TTL	9 pin D-Sub. Connector
Average Linear Force	433 lbs
Drive Motor	1.8° step angle geared 1:10 motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/32 microstepping
Motor Steps per one Rev. of Leadscrew	8,000 steps at 1/2 stepping or 128,000 steps at 1/32 stepping
Step Resolution	0.0397 µm/step
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate:	
Minimum	0.09 µm/min
Maximum	71.210 mm/min
Power	75 W, 0.75 A fuse
Voltage Range	Universal input 100/240 VAC, 50/60 Hz
Cable Length	152 cm (5 ft) approx.
Dimensions, H x W x D:	
Control Box	9.5 x 27.9 x 22.9 cm (3.75 x 11 x 9 in)
Syringe Holder	22.9 x 43.2 x 30.5 cm (9 x 17 x 12 in)

Order # Product

EC1 70-2023	PHD 22/2000 Hpsi Programmable Syringe Pump
EC1 72-0199	Remote Extension Cable, 1.5 m (5 ft)
EC1 72-1405	Remote Extension Cable, 9.1 m (30 ft)
EC1 70-2022	RS-232 D-Sub 9 Pin to RJ11-4 Connection Cable
EC1 70-2263	SS Syringe, 200 ml, with 1/16 inch SWAGELOK®
EC1 70-2264	SS Syringe, 200 ml, with 1/8 inch SWAGELOK®
EC1 70-2265	SS Syringe, 200 ml, with 1/4 inch SWAGELOK®
EC1 70-2266	SS Syringe, 200 ml, with Luer Lock

syringe pumps

PHD 4400 Hpsi

High Force/High Pressure Programmable Syringe Pump



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- Delivers >200 lbs (91 kg) linear pumping force across a wide flow rate range
- Accurate and smooth flow
- Ideally suited for stainless steel syringes
- Easy-to-use interface
- Control from your PC via serial interface
- 2 year warranty

The PHD 4400 Hpsi Programmable Syringe Pump is a single syringe infuse-withdraw pump equipped with all the functions of the PHD 22/2000 Programmable Model, but with a high-power stepper motor to provide up to 200 lbs. of linear force.

Pressure and Speed

The PHD 4400 Hpsi can deliver up to 182.40 ml/min using a 100 mm stainless steel syringe. Maximum pressure is dependent on syringe size. For stainless steel syringes, see Syringe and Needles pages 2-3.

Flexibility and Easy Programmability

- **Two standard infusion modes (continuous or volume dispense)**
- **Internal programmable pump control in all models**
- **In Program Mode, complex infuse and withdraw applications can be easily created, stored in the pumps nonvolatile memory and recalled for later use.**
- **Autofill Mode provides continuous delivery when the pump is used in conjunction with either a standard or high pressure valve box and a fluid reservoir.**

Ease of Use

Setting the pump is quick and easy. Input the inside diameter of the syringe or use the internal Syringe Lookup Table to automatically input the syringe diameter based on the syringe manufacturer and size. Select a mode (continuous delivery or volume dispense) and a rate and you are ready to go.

Features

Universal Input Power Supply: No need to change AC line switches, fuses, or wires.

Nonvolatile Memory: Stores all operational data and program sequences.

Stall Detection: An optical detector verifies motor movement. Stalls due to jamming or excessive back pressure are reported.

Visual/Audible Alarms

Power-Up Options: Powers-up in Standby or Running Mode after power interruption.

RS-232 Connections: Allows computer control of single pump or daisy-chaining of multiple pumps. Also allows for scale and printer connections.

TTL Connections: Allows for synchronizing pump with external devices, controlling an external valve, changing direction of travel, etc.

Modes of Operation

Pump Runs continuously in the infuse or refill directions until stopped.

Volume Runs until specified volume has been pumped or refilled.

Program Pump operates according to specified sequence of instructions.

(Note: All modes interact with Autofill feature.)

Specifications

Type	Microprocessor single syringe, infuse/withdraw
Accuracy	±0.35%
Reproducibility	±0.05%
Syringe:	
Type	Stainless steel**
Size Minimum	2.5 ml
Size Maximum	100 ml
Flow Rate:	
Minimum	0.0076 µl/min using 2.5 ml stainless steel syringe
Maximum	182.40 ml/min using 100 ml stainless steel syringe
Nonvolatile Memory	Stores all settings
RS-232	RJ-11 4-conductor
TTL	9-pin D-sub connector
Average Linear Force	>200 lbs (91 kg)*
Fluid Pressure*	>1,800 psi with an 8 ml stainless steel syringe, for example
Drive Motor	1.8° step angle motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/32 microstepping
Motor Steps per One Rev. of Leadscrew	800 steps at 1/2 stepping or 12,800 at 1/32 stepping
Step Resolution	0.082 µm/step
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
Power	75 W, 0.75 A fuse
Voltage Range	Universal input 100/240 VAC, 50/60 Hz
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)
Remote Cable	9.1 m (30 ft) Length

* For work range, refer to User's Manual for details.

** Plastic and glass syringes are not recommended because of high force.

Order # Product

EC1 70-2200 PHD 4400 Hpsi Programmable Syringe Pump, Standard

EC1 70-2201 PHD 4400 Hpsi Programmable Syringe Pump, Remote

975 and 2274 Mechanical Syringe Pumps



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'975' Mechanical Compact Syringe Pumps



'2274' Mechanical Compact Syringe Pump

'975' Mechanical Compact Syringe Pumps

This is the pump that built Harvard Apparatus' reputation for reliability and precision. The AC synchronous motor and gear box provide low flow rates and a complete absence of pulsation. Its synchronous motor is regulated by the supply line frequency giving the ultimate accuracy of $\pm 0.01\%$. Its thirty speed mechanical gear box is an engineering marvel that will give years of service.

This pump's syringe holder can hold either one or two plastic or glass syringes ranging in size from 2 ml to 100 ml.

Two additional syringe holders are supplied and can be easily installed. The first will hold up to three 20 ml syringes and the second up to four 5 ml syringes.

Specifications

Type	Mechanical multiple syringe, infusion only
Motor	30-speed
Syringe/Size:	Glass and plastic
Holder for up to 2 Syringes	2 ml to 100 ml
Holder for up to 3 Syringes	20 ml only
Holder for up to 4 Syringes	5 ml only
Dimensions, H x W x D	355 x 171 x 89 mm (14 x 6-3/4 x 3-1/2 in)
Weight	5.4 kg (12 lb)

Order #	Model	Product
EC1 55-1689	975	115 VAC, 60 Hz
EC1 55-1697	975A	230 VAC, 50 Hz
EC1 55-1705	975B	115 VAC, 50 Hz

'975' and '2274' Features

- Infusion only
- Speed accuracy $\pm 0.01\%$
- 30-speed mechanical gear box with positive locking action
- Ratio between adjacent settings has been held to only 1.4 to 1. The range over the 30-gear settings is 17,000 to 1
- A gear overload clutch stops pusher block advance when the required force exceeds 25 lbs.

Flow Rate Ranges

'975' Flow Rate			'2274' Flow Rate		
Syringe Volume	Low ($\mu\text{l}/\text{min}$)	High (ml/min)	Syringe Volume	Low ($\mu\text{l}/\text{min}$)	High (ml/min)
1 ml	0.074	1.347	10 μl	0.0000073	0.1260
3 ml	0.266	4.759	25 μl	0.0000182	0.3150
6 ml	0.541	9.601	50 μl	0.0000364	0.6300
12 ml	0.854	15.035	100 μl	0.0000730	1.2600
20 ml	1.416	24.721	250 μl	0.0001820	3.1500
35 ml	1.935	33.624	500 μl	0.0003640	6.3000
60 ml	2.424	41.981	1000 μl	0.0007300	12.6000

'2274' Mechanical Compact Syringe Pump

This pump is exactly like the '975' compact/syringe pump, see above, with these exceptions:

- **The motor is 100 times slower**
- **Single syringe holder is supplied for holding one or two syringes from 10 μl to 50 ml**

This pump is ideal for infusions into single cells.

Specifications

Type	Mechanical microliter multiple syringe, infusion only
Motor	30-speed, 100 times slower than the Model '975' Pump
Syringe/Size	Up to 2 syringes; glass and plastic; 10 μl to 50 ml
Dimensions, H x W x D	356 x 152 x 89 mm (14 x 6 x 3-1/2 in)
Weight	5.4 kg (12 lb)

Order #	Model	Product
EC1 55-3206	2274	115 VAC, 60 Hz
EC1 55-3214	2274A	230 VAC, 50 Hz

Pumps for Continuous Flow Applications 24/7



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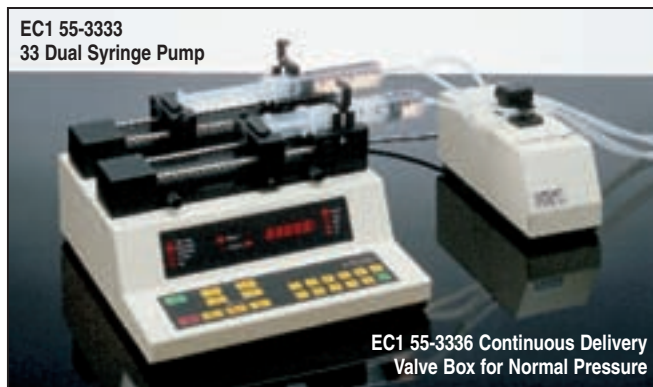
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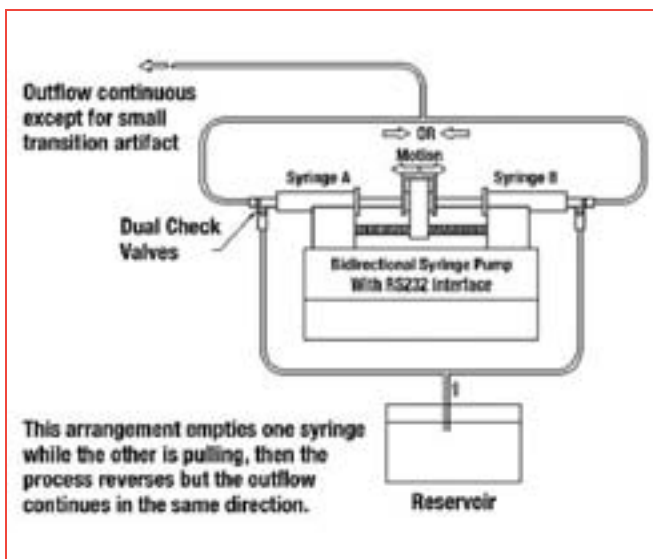


PHD 22/2000 Push-Pull Programmable



EC1 55-3333
33 Dual Syringe Pump

EC1 55-3336 Continuous Delivery
Valve Box for Normal Pressure



Applications

- HPLC and LPLC
- Continuous calibration stream
- Large volume solvent blending

Benefits

- High accuracy
- High precision
- High pressure
- Pulseless flow
- 2 year warranty on all HAI syringe pumps

Harvard Apparatus has two ways to solve your need to have a high precision syringe pump and continuous flow. This is important in applications where high precision, high accuracy and pulseless flow is necessary.

1. PHD 22/2000 Push-Pull Programmable

This is the simplest method to provide continuous flow for your application. The pump has a syringe holder that will mount syringes in opposing directions. Each pump will hold 4 syringes, two in one direction and two in the opposite direction. When the pusher block is moving in the

forward direction, the forward facing syringes are dispensing while the opposite facing syringes are refilling. When the pusher block reaches the end of travel, the pump direction reverses so now the forward facing syringes are refilling while the opposite syringes are dispensing.

The PHD 22/2000 Push-Pull Pump programmable model offers the greatest flexibility in control because it allows you to program exactly the sequence of steps you want. It allows for continuous cycling. This Pump is also available in a remote model where the syringe pumping mechanism is separated from the control box by a 30 foot cable.

The PHD 22/2000 Push-Pull Programmable is available in a high force model, up to 66 pounds of force, that is ideal if you are working with viscous fluids, see pages 16 to 19 for complete pump details. We also have a special push/pull model that will hold up to 20 syringes, 10 in each direction. Please call for details.

2. Syringe Pump 33: Two Pumps in One!

This amazing pump can do a variety of applications including continuous delivery and push pull style delivery. This pump has two independent motors. With the addition of a valve box you can have one syringe delivering while the other syringe is refilling. When the first syringe is empty the pump simply reverses direction and the second syringe will deliver while the first syringe refills. This pump can do this 24/7. See Harvard Pump 33 on page 14.

In addition to the syringe pump a valve will be necessary to provide continuous delivery. We have many valving options to pick from. Select either passive or active valves. Select from high or low pressure Valves. We have ones with low dead space volume and/or high purity fluid paths. Please contact technical support for assistance.

Order #	Product
EC1 61-0270	Continuous Flow Tubing Segment for PHD 22/2000 Push/Pull Syringe Pump, 20 p.s.i.
EC1 55-7002	'Auto Fill' Valve, Normal Pressure, 30 p.s.i.
EC1 55-1145	'Auto Fill' Valve, High Pressure, 200 p.s.i.
EC1 55-7000	Syringe Pump 33 Continuous Delivery Valve, Normal Pressure, 30 p.s.i.
EC1 55-7001	Syringe Pump 33 Continuous Delivery Valve, High Pressure, 200 p.s.i.

Special high pressure valves are available that can tolerate up to 1,250 p.s.i., please call for additional information.

Pumps for Continuous Delivery Applications



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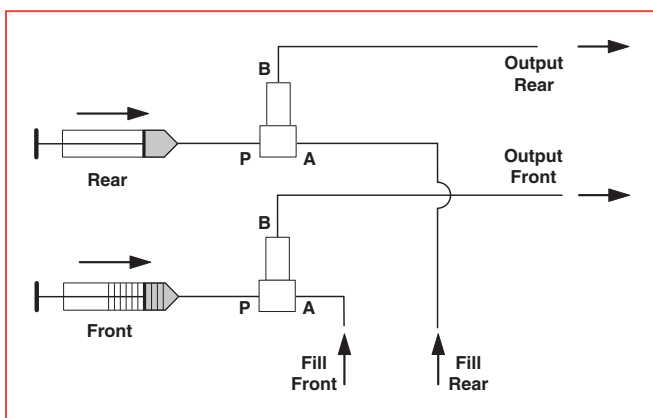
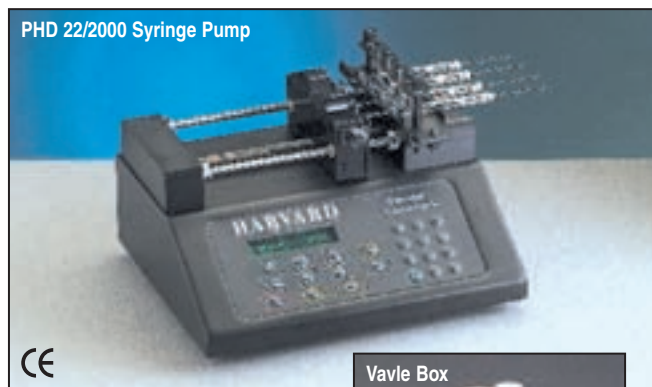
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require additional equipment in order to allow the syringe to refill.

There are three pumps that are ideal for continuous delivery.

- **PHD 22/2000 Push/Pull Programmable Syringe Pump**
- **Pump PHD 22/2000 Programmable Syringe Pump**
- **Dual Syringe Pump 33**

The PHD Push/Pull (see page 16) and Dual Syringe Pump 33 (see page 14) allow a syringe(s) to be refilling while a syringe(s) is dispensing. This allows for multiple deliveries with minimal time between dispenses. The programmable pumps offer the advantage of being able to string together a sequence of steps so the delivery process becomes automated allowing the user to leave the pump unattended.

Applications

- HPLC and LPLC
- Calibrating mass spec
 - Calibration made easy
 - Hands free with multiple injections
 - No more loading by hand
- Injecting fluid into different vials on a fraction collector
 - Fully automate the process so all you need is to keep the reservoir full
- Controlled drug injections over time

Benefits

- 24/7 delivery of calibrant
- Maximize syringe size for accuracy
- Reservoir is external

Continuous delivery is the process by which a specific volume is delivered multiple times. It may be a couple of deliveries or many deliveries over a long period of time. The only requirement of the system is that the time delay between deliveries must be long enough for the syringe to refill.

This is different from continuous flow where the fluid delivery is continuous over time. There are no “non-delivery periods” in continuous flow applications. Whether continuous delivery or continuous flow, both

Using RS-232 for Continuous Delivery Applications

Another way to provide continuous delivery is to control a syringe pump via an external computer. The RS-232 port is used for that purpose. The Pump 11 Plus Advanced, Pump 11 Pico Plus, Harvard 33, Harvard 22 and all the PHD 22/2000 Syringe Pumps have this interface. The end user must write the computer control code that tells the pump what to do. Also note that the time between injections is limited by the speed at which the syringe can refill.

Additional Equipment

In addition to the syringe pump a valve will be necessary to provide continuous delivery. We have many valving options to pick from. Select either passive or active valves. Select from high or low pressure Valves. We have ones with low dead space volume and/or high purity fluid paths. Please contact technical support for assistance.

Order #	Product
EC1 61-0270	Continuous Flow Tubing Segment for PHD 22/2000 Push/Pull Syringe Pump, 20 p.s.i.
EC1 55-7002	'Auto Fill' Valve, Normal Pressure, 30 p.s.i.
EC1 55-1145	'Auto Fill' Valve, High Pressure, 200 p.s.i.
EC1 55-7000	Syringe Pump 33 Continuous Delivery Valve, Normal Pressure, 30 p.s.i.
EC1 55-7001	Syringe Pump 33 Continuous Delivery Valve, High Pressure, 200 p.s.i.

Special high pressure valves are available that can tolerate up to 1,250 p.s.i., please call for additional information.

Pumps for Low Flow Applications



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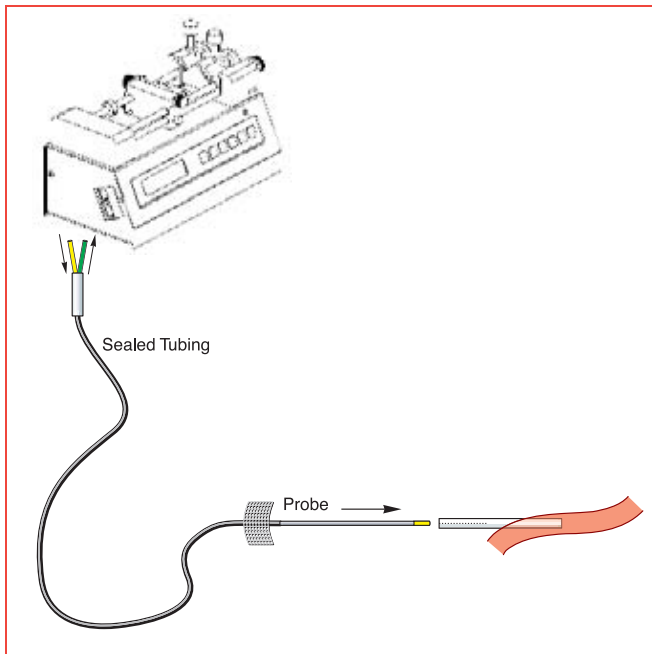
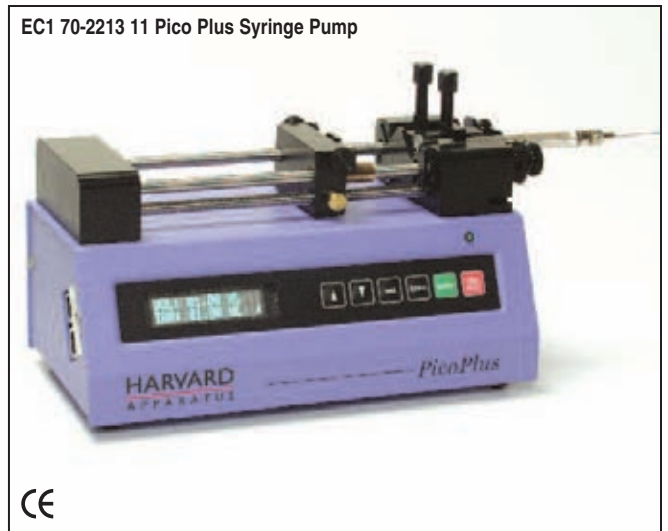
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Applications

- Microdialysis
- Oocyte Cell Injection
- Micro Flow for FIA or Capillary LC
- Micro Reaction Deliver

Harvard Apparatus has long been producing syringe pumps that are ideal for low flow applications. These types of applications usually require a smooth, non-pulsatile flow that is extremely accurate.

Two pumps in the Harvard Apparatus Syringe Pump family are perfectly suited to these types of applications.

11 Pico Plus Syringe Pump

The Harvard Pump 11 Pico Plus is an infuse/withdraw pump. This pump is perfectly suited for the low flow, high accuracy procedures required for microdialysis and oocyte cell injection. This pump provides flow rates from 3.3 picoliters/minute up to 0.8788 milliliters/minute (using 2 x 10 ml syringes combined output). This pump can hold two syringes that need not be the same size. Each syringe is held by its own clamp. Different flow rates may be obtained by using two different size syringes should your application require it. See page 9 for pump details.

The lowest flow rate is achieved by using a microliter syringe. The highest flow rate by combining the output of two 10 milliliter syringes. Cell injection is possible by using the included foot switch or by controlling the pump via the key pad or the RS-232 interface.

PHD 22/2000 Syringe Pumps

The PHD 22/2000 family of pumps is the most versatile series of syringe pumps Harvard Apparatus offers. See pages 16 to 19 for pump details. It is available in infusion only, infuse/withdraw and the advanced programmable model. Each of these is available with a variety of syringe racks. For low flow applications the microliter syringe rack will hold 4 syringes from 0.5 microliter to 10 milliliter. Like the 11 Pico Plus, each syringe is held by a individual clamp allowing removal or insertion of one syringe without disturbing another. Also different sized syringes may be held in the rack.

The PHD 22/2000 Syringe Pumps are also available in a high force model. This is why they are more suited to applications such as Micro Flow for FIA or Capillary LC Micro Reaction Delivery.

Order # Product

EC1 70-2208 Pump 11 Plus, Infusion Only, see page 8

EC1 70-2213 Pump 11 Pico Plus, Infuse/Withdraw, see page 9

EC1 70-2000 PHD 22/2000, Infusion Only, see pages 16-19

EC1 70-2001 PHD 22/2000, Infuse/Withdraw, see pages 16-19

EC1 70-2002 PHD 22/2000, Programmable, see pages 16-19

Special high pressure valves are available that can tolerate up to 1,250 p.s.i., please call for additional information.

Syringe Pumps for Mass Spectrometry



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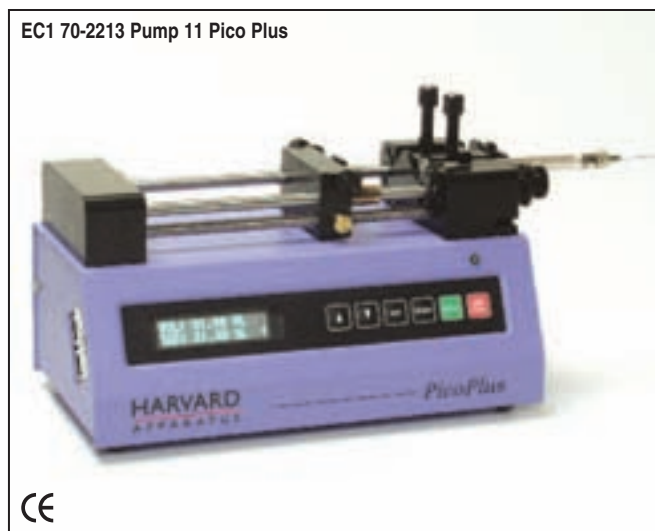
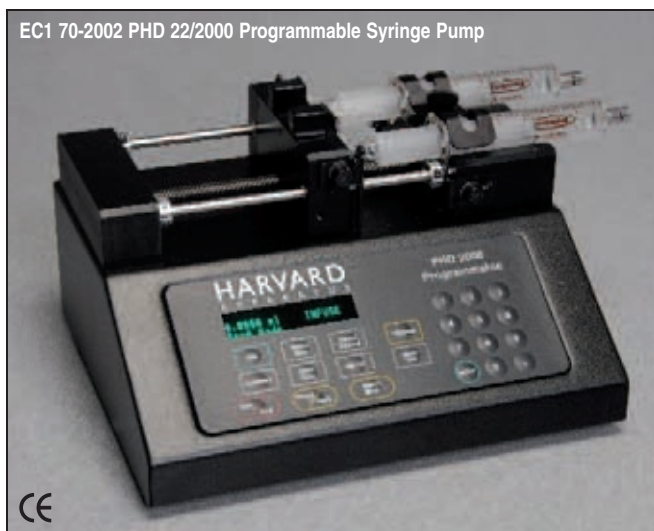
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Applications

- Matrix delivery
- Calibration solution delivery
- 24/7 delivery of calibration solutions
- Delivery of sample

Features

- Smooth, pulse-less flow
- High accuracy at low flow rates
- Systems for 24/7 delivery
- Pumps for automatic calibration

Harvard Apparatus is the leader in providing pumps for Mass Spectrometry applications. These syringe pumps offer a smooth, pulse-less flow at low flow rates with the high accuracy and precision needed to handle the varied needs of Mass Spectrometry.

The most widely used pump for Mass Spectrometry is the Harvard Apparatus Pump 11 Plus. Below is a list of pumps that we recommend for mass spec applications:

Order #	Product
EC1 70-2001	PHD 22/2000 Infuse/Withdraw with RS-232, see pages 16-19
EC1 70-2002	PHD 22/2000 Infuse/Withdraw Programmable with RS-232, see pages 16-19
EC1 70-2213	Pump 11 Pico Plus, Infuse/Withdraw with RS-232, see page 9
EC1 70-2211	Pump 11, Single Syringe Infuse/Withdraw with RS-232, see page 8
EC1 70-2212	Pump 11, Dual Syringe Infuse/Withdraw with RS-232, see page 8

These pumps are all infuse/withdraw models with RS-232 communication capabilities. The PHD 22/2000 Programmable Pump has the added benefit that allows you to program up to 10 steps directly from the pump and control a valve without the use of a PC. All the other pumps require RS-232 to control switching valves for 24/7 operation. For more details see Pumps for Continuous Flow or Pumps for Continuous Delivery on page 23 and 24 respectively.

Calibration Solution Delivery

Not only can you deliver samples automatically, you can also deliver a calibration solution automatically every hour, every day or every week. Use one of our Harvard Apparatus Pumps with RS-232 communications plus a valve. It is that easy. Use the PHD 22/2000 Programmable pump and it can be done directly from the keypad. This feature may be important so that you can maintain your ISO 9000, GLP or GMP compliance.

Matrix Delivery

Harvard Apparatus pumps are the ideal choice for your matrix delivery needs. When preparing a sample for injection into the mass spec system it is crucial that the correct amount of matrix is added to your sample. These pumps can precisely deliver the small amount of matrix you need so that your Maldi-TOF mixture is exactly what you want.

Multiple Animal Feeding System

applications



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Applications

- Effects of dietary factors on large animal populations
- Dietary prevention of chronic disease studies
- Diet and alcohol interactive effects on metabolic systems

Features

- 10 syringe capacity – mechanism can be modified to hold more syringes or smaller sized syringes
- High linear force pump - 433 pounds of force to move the syringe plungers
- Programmable flow rate with time or transducer response
- Utilizes 60 cc or 140 cc plastic syringe or 50 cc or 100 cc glass (customs available)
- RS-232 and TTL communications
- Proven high reliability, can run 24 hours a day for weeks, 2 year warranty

This Multiple Animal Feeding System is an ideal system for multiple animal feeding studies or other applications which require precise parallel pumping. The standard syringe rack can hold up to 10 syringes ranging in size from 60cc to 140cc.

You can use plastic or glass syringes. Other syringes sizes may be used. See Syringe and Needles pages 4 to 10 for a more complete listing of available syringes.

The Broad performance characteristics of the Feeding System make it ideal for small drug or large volume nutritional variables on large animal populations.

- **High pressure**
- **Large flow rate range**
- **High reliability**
- **High accuracy and precision**

This Multiple Animal Feeding System is comprised of a PHD 22/2000 Hpsi Syringe Pump with 10-syringe multi-rack. The syringe pump has a 5 foot cable that connects the control box to the syringe pumping mechanism. If additional distance is required between the controller and pump, a 30 ft. remote extension cable is available.

Specifications

Type	Microprocessor multiple syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.05%
Syringes (Min/Max)	Holds 60 ml or 140 ml plastic syringes or 50 ml or 100 ml glass syringes
Flow Rate:	
Minimum	3 µl/hr
Maximum	82.4 ml/min
Non Volatile Memory	Stores all settings
RS-232	RJ11-4 conductor
TTL	9 pin D-Sub. Connector
Average Linear Force	433 lbs
Drive Motor	1.8° step angle geared 1:10 motor
Motor Drive Control	Microprocessor controlled from 1/2 to 1/32 microstepping
Motor Steps per one Rev. of Leadscrew	8,000 steps at 1/2 stepping or 128,000 at 1/32 stepping
Step Resolution	0.0397 µm/step
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 µsec/step
Pusher Travel Rate:	
Minimum	0.09 µm/min
Maximum	71.210 mm/min
Power	65 W, 0.5 A fuse
Voltage Range	95 to 130 VAC, 60 Hz; 220 to 260 VAC, 50 Hz, selectable
Cable Length	152 cm (5 ft) approx.
Dimensions, H x W x D:	
Control Box	9.5 x 27.9 x 22.9 cm (3.75 x 11 x 9 in)
Syringe Holder	22.9 x 43.2 x 30.5 cm (9 x 17 x 12 in)

Order # Product

EC1 70-2230	Multiple Animal Feeding System, programmable
EC1 72-1405	Remote Extension Cable, 9.1 m (30 ft)
EC1 72-1836	Hamilton GasTight® Glass Syringe 50cc, Teflon Luer Lock Termination, pkg. of 1
EC1 72-1837	Hamilton GasTight® Glass Syringe 100cc, Teflon Luer Lock Termination, pkg. of 1
EC1 72-2375	Monoject® Sterile Syringes, 60cc, Luer Lock Termination, pkg. of 20
EC1 72-2399	Monoject® Sterile Syringes, 140cc, Luer Lock Termination, pkg. of 20

For a more complete selection of available Syringes, see Syringe and Needles pages 4 to 10.

Symphony – The Windows™ Pump Manager



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- Windows™ based software
- Remotely control and program your pump from your PC
- Graphically displays what your pump is doing
- Control multiple pumps
- Printable log of pumping events

Symphony is designed to work with Harvard Apparatus Programmable Syringe Pumps. Only the PHD 22/2000 programmable series of syringe pumps and the PHD 4400 Hpsi programmable syringe pump will work with Symphony.

Easy to Use

Symphony is an easy to use, Windows™ based application. You change pump parameters using common Windows™ controls like pull-down menus, direct numeric entry, on-off buttons and 'spin' controls.

Interactive Pump Control Window

The interactive pump control window allows you to set, on-the-fly, all pump parameters including:

- **Syringe type and diameter**
- **Flow rates**
- **Pumping modes (pump, volume, program and auto-fill)**

Values can be directly entered into fields or selected via scrolling.

Single or Multiple Pump Control

Multiple pumps can be controlled by Symphony. Create the protocol for the first pump and then connect other pumps directly to that pump. This creates a daisy chain which allows the software to drive all pumps in the



chain. Note that the protocol is identical for each pump in the chain.

Information at a Glance

The main window displays all of the pumping parameters for the individual pump in an easy to read format. Information such as

volume delivered, direction of flow, pumping mode, syringe used, and flow rates, are clearly displayed. Even the communications port identity and status is displayed. The researcher needs only to glance at this window to know what the pump is doing.

Reliable Communication with No Guess Work

On the interactive pump control window, there is a pump status box. A light will blink green if communication is normal and red if you have a communication error. At a glance you will know if the software is communicating with your pump. There is no guess work.

From the interactive pump control window you gain access to all other Symphony windows through pull down menus or icon buttons.

Pump Program Window

The program window allows you to create, review, edit, save, recall and download programs. Using standard Windows™ software icons and menus, programming your pump is as simple as clicking a mouse. Once created, a program can be downloaded to any pump in the communications chain and it can be saved and recalled for later use. Note that programming only works with a PHD 22/2000 Programmable Pump or PHD 4400 Hpsi. It will not work with PHD 22/2000 Infusion Only or PHD 22/2000 Infusion/Withdraw syringe pumps.

Use one of the five sample programs included with Symphony or create your own.

Pump Graph Window

This window displays an easy to read graph that resembles a continuously running strip chart recorder. This allows you to monitor infuse and refill rates and volume dispensed. Infusion values are displayed in blue and refill values in red. The vertical axis scale (range) and horizontal axis, chart speed (period), are selectable.

Log Sheet

Symphony creates a log sheet that tracks the activity of your pumps. Later, the information can be reviewed using a Windows™ text editor or word processor program. The log update period is user selectable. Files are stored in *.vpl file format and can be printed and saved as needed.

System Requirements (Minimum)

Hardware	Intel compatible 486/33 computer with 8 MB RAM, hard disk drive with 2 MB available space, 3.5 inch floppy disk drive, mouse
Software	Windows™ 3.1, 95, 98, 2000
Monitor	VGA or higher display and driver capable of 800 x 600 resolution with one unused serial communication port

Order # Product

EC1 70-3000 Symphony - The Windows™ Pump Manager

LabVIEW™ Driver - Take Control Of Your Syringe Pump



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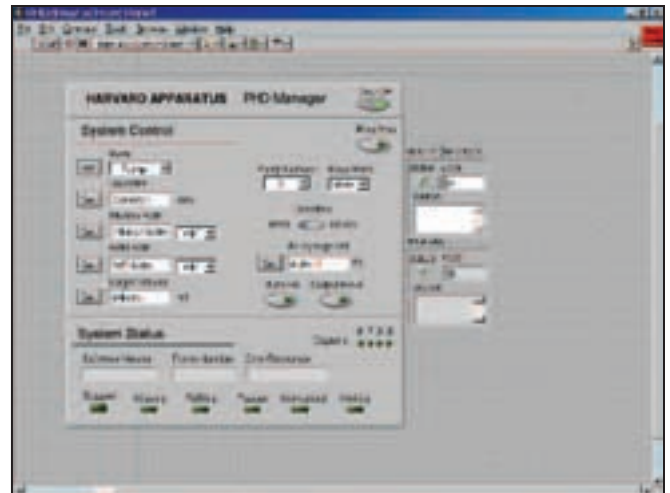
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Provides

- Virtual control from a PC of one or more syringe pumps
- Syringe pump control for many LabVIEW™ system applications

LabVIEW™ Drivers for Harvard Apparatus PHD 22/2000 syringe pump family, Pump 22 and Pump 11 Plus are available. Built using the popular LabVIEW™ programming application for National Instruments.

LabVIEW™, the most widely used software for test, measurement, and control, delivers faster time to measurement with LabVIEW™ 7. It's easy to develop intuitive LabVIEW™ block diagrams for your I/O, analysis, and presentation needs. From simple data acquisition to advanced embedded software development, LabVIEW™ delivers productivity you can measure.

LabVIEW™ delivers a powerful graphical development environment for signal acquisition, measurement analysis, and data presentation, giving you the flexibility of a programming language without the complexity of traditional development tools.

Engineers and scientists in virtually every industry find that LabVIEW™ delivers real benefits for a wide variety of applications. Use LabVIEW™ to reduce time to develop your lab applications and boost your productivity. This software is available as a free download on-line. Visit www.ni.com. Search for "Harvard Apparatus labview drivers." This will bring up three options. Select the driver that matches your Harvard Apparatus Syringe Pump.

These drivers can also be emailed. Please call technical support for your free copy.

Using RS-232 communications and LabVIEW™ allows access to the following parameters:

- Set Auto-Fill Mode
- Set-Up Target Volumes
- Infuse Rate
- Refill Rate
- Diameter of Syringe
- On/Off Button
- Run/Stop
- Baud Rate
- Pump ID Number
- Direction of Flow
- Output for TTL
- Mode Selection
- System Status
- Software Version
- Command Response
- TTL Monitoring Errors

Valves, Cables, Connectors, Footswitches and Alarms



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EC1 55-7001 Continuous Delivery Valve Box - High Pressure



EC1 55-7000 Continuous Delivery Valve Box- Normal Pressure



EC1 55-7002 'Auto Fill' Valve Box - Normal Pressure

- Available for normal or high pressure

'Auto Fill' Valve Box

The 'Auto Fill' valve box for normal pressure has a one sided pinch assembly. For use with the PHD 22/2000 (Infuse/ Withdraw and Programmable models only, see page

16, and the PHD 4400 Hpsi pump, see page 21. Supplied with 3.2 mm ID x 6.4 mm OD (1/8 x 1/4 in) silastic tubing and 115/230 VAC, 50/60 Hz electrical connector with syringe pump connector cable. Maximum pressure 50 p.s.i.

The 'Auto Fill' valve box for high pressure is for use with PHD 22/2000 Infuse/Withdraw and Programmable models only, see page 16, and the pump 4400 Hpsi, see page 21. 304 stainless steel throughout. Supplied with 6.4 mm (1/4 in) ID stainless steel tubing with SWAGELOK® fittings to mate with Harvard Apparatus stainless steel syringes, and 115/230 VAC, 50/60 Hz electrical connector with syringe pump connector cables. Maximum pressure 200 p.s.i. Wetted parts are stainless steel and viton. **Specials-** wetted parts can be changed for compatibility.

Continuous Delivery Valve Box

The Continuous Delivery Valve Box for Normal Pressure is supplied with 3.2 mm ID x 6.4 mm OD (1/8 x 1/4 in) silastic tubing and a connector cable to the syringe pump. For use with the Pump 33 (EC1 55-3333) only, see page 14. Maximum pressure 30 p.s.i.

The Continuous Delivery Valve Box High Pressure has the valve assembly with lines for two syringe connections. Made of 304 stainless steel throughout it with 6.4 mm (1/4 in) ID stainless steel tubing with SWAGELOK® Fittings and the connector cable to the syringe pump. For use with the Pump 33 (EC1 55-3333) only. Maximum pressure 200 p.s.i. Wetted parts are stainless steel and viton.

Order #	Product
EC1 55-7000	Syringe Pump 33 Continuous Delivery Valve Box, Normal Pressure, 30 p.s.i.
EC1 55-7001	Syringe Pump 33 Continuous Delivery Valve Box, High Pressure, 200 p.s.i.

Order #	Product
EC1 55-7002	'Auto Fill' Valve Box, Normal Pressure, 30 p.s.i.
EC1 55-1145	'Auto Fill' Valve Box, High Pressure, 200 p.s.i.

RS-232 and Daisy Chain Cables

EC1 70-2022, EC1 55-7760 and EC1 72-2478 cables are for use with Pump 11 Plus Advanced, see page 8; Pump 11 Pico Plus, see page 9; Pump 33, see page 14; PHD 22/2000, see page 16; PHD 22/2000 Hpsi, see page 20; PHD 4400 Hpsi, see page 21; and Pump 66 and 77, see page 40. EC1 55-4145 and EC1 55-2239 cables are for use with Pump 22 only, see page 12. When controlling a syringe pump using a computer, a single RS-232 cable is required to connect the computer to the pump. If multiple pumps are being controlled by one computer then one Daisy-chain cable is required for each additional pump.

Order #	Product
EC1 70-2022	RS-232 Connection Cable, 7 ft, 9 Pin D-Sub
EC1 55-4145	RS-232 Connection Cable, 7 ft, 25 Pin D-Sub, Pump 22 ONLY. Do Not Use for Daisy Chaining
EC1 55-7760	Daisy-Chain Cable, (2 ft) Need 1 Per Pump
EC1 72-2478	Daisy-Chain Cable, (7 ft) Need 1 Per Pump
EC1 55-2239	Daisy-Chain Cable and Adapter, (7 ft), Pump 22 ONLY Order 1 for Each Pump in the Chain

Pump 22 Reversing Switch

Allows pump to operate in either Infusion or Withdraw modes. Requires Withdrawal Bracket which is not included. Call for details

Order #	Product
EC1 55-2217	Pump 22 Reversing Switch



EC1 55-2317

Audible Alarm

Activated when the syringe reaches the end of its travel or back pressure exceeds the capacity of the Pump. Plugs into a 9-pin or 25-pin TTL connector. Measures 6.4 x 6.4 x 1.3 cm (2-1/2 x 2-1/2 x 1/2 in). For use

with Pump 33, see page 14; and Pump 22, see page 12. Note: Cannot plug in alarm and RS-232 cable at the same time unless alarm is modified.

Order #	Product
EC1 55-2317	Audible Alarm



EC1 55-4144

Foot Switch

The EC1 55-4144 foot switch is for use with all Versions of the PHD 22/2000, see pages 16 to 19; all Versions of the Pump 4400 Hpsi, see page 21; Pump 33, see page 14; Pump 66/77, see page 40.

The EC1 55-2215 foot switch is for use with the Pump 22 only, see page 12. These start/stop foot switches which plug into the TTL connector provide 'hands-off' control.

Order #	Product
EC1 55-4144	Foot Switch
EC1 55-2215	Foot Switch, Pump 22 ONLY

OEM Pump Modules



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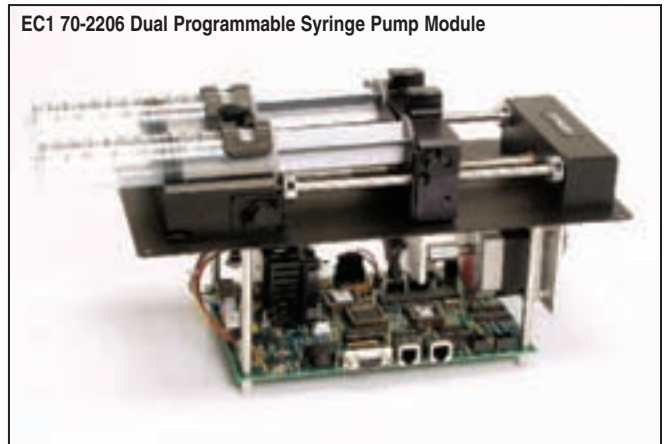
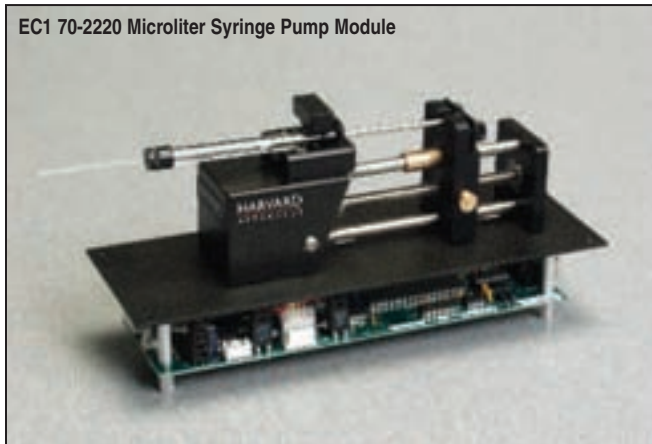
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Harvard Apparatus combines our 104 years of fluidics expertise, along with our 14 point Fluidics Capability Array to offer our customers OEM modules. These modules can be used to complete your own system or to customize a pump for your specific application.



- Performance – accuracy, precision and smooth flow
- Force – 6, 20, 50, 200 or 425 pounds of linear force
- Wide Flow Rate Ranges – picoliters to milliliters
- Variable Syringe Sizes and Syringe Racks
- Reliability – 2 year warranty
- Control – local or remote
- Materials – magnetic or non-magnetic
- Programmability – keyboard, internal or RS-232
- Accessories – valves, tubing, adapters, syringes
- Power – battery or wall adapter
- Flow Characteristics – infuse only, infuse/withdraw and push/pull
- Size – different footprints available

Our broad product and technology offerings, in combination with our many years of solving difficult fluidics problems, provides the platform for excellent service and support at affordable prices.

Whether you are in an academic setting and want your students to understand first principals by building systems themselves, or if you are in manufacturing and your process needs a custom dispensing unit, let Harvard Apparatus assist you.

Some application areas:

- Microfluidics
- Mass spectrometry calibration
- Adhesive dispensing
- Liquid Chromatography
- Electrospinning
- Biomedical drug delivery onto stints
- Cell culture

We have added several standard Syringe Pump OEM Modules to our catalog, including a Microliter Module, a Milliliter Module, a PHD Module and a High Pressure Module, see pages 31 to 36. If these OEM modules will not work for your application please call technical support to discuss your specific needs. We can build a pump especially for you!

Microliter Syringe Pump Module



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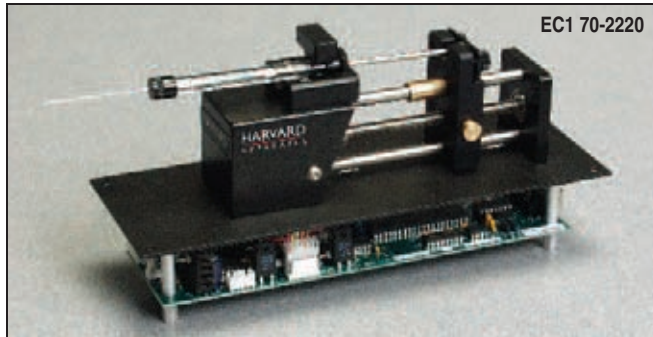
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- RoHs compliant
- Low cost syringe pump
- Easy to incorporate legendary syringe pump technology into your equipment
- Precisely dispenses micro-liter volumes
- Smooth flow
- Two modes of operation
 - Constant flow rate
 - Volume dispense

The new “ μ l” Pump Module is a low cost, highly precise, single syringe infuse/withdraw pump capable of low to moderate back pressures. It is available in one version only and will hold one syringe of any make from 0.5 μ l to 1 ml. The inside diameter of the syringe and desired flow rate are entered via the RS-232 serial port, and the internal microprocessor drives a precision stepper motor to produce accurate fluid flow. This unit is designed to operate inside an enclosure, cabinet, or on top of a bench. The board may be removed for “remote” operation.

Two Modes of Operation - Constant Flow Rate and Volume Dispense

The “ μ l” Pump Module will operate continuously in RATE mode or accurately dispense a specific amount of fluid in VOLUME mode. When starting the pump, RATE mode will be the default mode. To operate in Volume mode, set a target volume and the pump will change modes to suit desired operation. This is the safest way to use the “ μ l” Pump Module. The pump will automatically stop when target volume is dispensed.

Smooth Flow

New micro-stepping pump profiles deliver very smooth and consistent flow.

Nonvolatile Memory

The pump remembers it's last syringe size, flow rate used and configuration settings in its non-volatile memory.

Location Requirements for the Syringe Pump

- A sturdy, level, clean and dry surface
- Minimum of one inch (2.5 cm) clearance around the pump
- Adequate power supply
- Operating temperature 0° to 35°C (32° to 95°F)
- Relative humidity 20% to 80%

Protecting Small, Fragile Syringes

The “ μ l” Pump Module will hold microliter size syringes down to 0.5 μ l size. These small syringes have fine wire plungers that may be damaged if allowed to bottom out. The “ μ l” Pump Module is equipped with adjustable limit switches on the bottom side of the mounting plate. Make sure to adjust the limit switches to prevent damage to small syringes.

This Pump Module is supplied complete with the following components:

Component	Quantity
Syringe Pump Unit	1
RS-232 Cable	1
User documentation	1
Grease, 6 oz. jar	1

Specifications

Type	Microprocessor single syringe, infuse/withdraw
Accuracy	$\pm 0.5\%$
Reproducibility	$\pm 0.1\%$
Syringe Type	Holds 1 syringe made from either glass or plastic
Syringe Size	0.5 μ l to 1 ml
Flow Rate:	
Minimum	0.0014 μ l/hr with 0.5 μ l syringe
Maximum	0.854 ml/min with 1 ml syringe
Linear Force	6 lb, maximum
Display	None
Keypad	None
Interface	RS-232 with simple command language
Limit Switch	One for each direction (end of travel)
Drive:	
Motor	0.9° step angle motor
Control	L/R Drive, 0.75A per phase, 1/4 stepping
Drive Ratio	1:1 (Direct Drive)
Lead Screw Pitch	48 threads per inch (1/4-48)
Step Rate	6.8 sec/step to 416.7 μ sec/step
Pusher Travel Rate	2.9 μ m/min to 47.6 mm/min
Connectors:	
RS-232	4 pin RJ-11 telephone jack; dual RS-232 ports
DC Power	4-pin Header (Friction lock)
Power	+12VDC, 5%, 1A (12W) (User supplied)
Dimensions, H x W x D	11.4 x 23.5 x 8.3 cm (4.5 x 9.25 x 3.25 x 4.5 in)
Mounting Dimensions	22.2 x 7.0 cm (8.75 x 2.75 in) - Mounting holes for (4) #8 screws
Weight	0.84 kg (1.85 lbs)
Environmental:	
Operating Temp.	0 to +35°C (natural convection cooling)**
Storage Temp.	-20 to +70°C
Humidity	20 to 80% RH non-condensing

** Note: operating temperature may be extended with forced air cooling

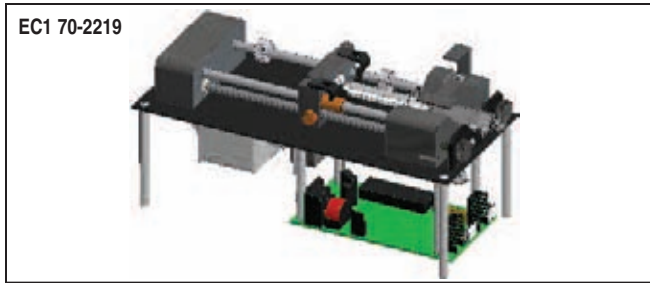
Milliliter Syringe Pump Module



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- RoHs compliant
- Low cost syringe pump
- Ideal pump for do-it-yourselfers and OEM equipment designers
- Easy to incorporate legendary syringe pump technology into your equipment
- Precisely dispenses milliliter volumes
- Smooth flow
- Nonvolatile memory
- Two modes of operation
 - Constant flow rate
 - Volume dispense

The new “ml” Pump Module is designed as a low cost, highly precise, single syringe infuse/withdraw pump capable of low to moderate back pressures.

There is only one version of the “ml” Pump Module available at this time. A dual “ml” Pump Module version can be produced upon customer request. Typically, the “ml” Modular Pumping Component holds one syringe of any make, from 0.5µl to 60ml. The inside diameter of the syringe and desired flow rate are entered via your PC, and the internal microprocessor drives a precision stepper motor to produce accurate fluid flow. This unit is designed to operate inside an enclosure, cabinet, or on top of a bench. The board may be removed for “remote” operation.

Two Modes of Operation - Constant Flow Rate and Volume Dispense

The “ml” Pump Module will operate continuously in RATE mode or accurately dispense a specific amount of fluid in VOLUME mode. When starting the pump, RATE mode will be the default mode. To operate in Volume mode, set a target volume and the pump will change modes to suit the desired operation. This is the safest way to use the “ml” Pump Module. The pump will automatically stop when target volume is dispensed.

Smooth Flow

New micro-stepping pump profiles deliver very smooth and consistent flow.

Nonvolatile Memory

The pump remembers it's last syringe size, flow rate used and configuration settings in its non-volatile memory.

Location Requirements for the Syringe Pump

This pump module was designed to operate inside an enclosure, cabinet, or on top of a bench/table. The circuit board may be removed to a “remote” location if desired.

- A sturdy, level, clean and dry surface
- Minimum of one inch (2.5cm) clearance around the pump
- Adequate power supply
- Operating temperature 0° to 35°C (32° to 95°F)
- Relative humidity 20% to 80%

This Pump Module is supplied complete with the following components:

Component	Quantity
Syringe Pump Unit	1
RS-232 Cable	1
User documentation	1
Grease, 6 oz. jar	1

Specifications

Type	Microprocessor single syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe Type	Holds 1 syringe made from either glass or plastic
Syringe Size:	
Minimum	0.5 µl
Maximum	50/60 ml
Flow Rate:	
Minimum	0.0014 ml/hr with 0.5 µl syringe
Maximum	26.56 ml/min with 50/60 ml syringe
Linear Force	25 lbs, peak
Display	None
Keypad	None
Interface	RS-232 with simple command language
Limit Stop	End of limit travel mechanical stop
Drive:	
Motor	0.9° step angle motor
Control	L/R Drive, 0.75A per phase, 1/4 stepping
Drive Ratio	2.4:1
Lead Screw Pitch	1/4 • 20 threads per inch
Step Rate:	
Minimum	6.8 sec/step
Maximum	416.7 msec/step
Pusher Travel Rate:	
Minimum	2.9068 mm/min
Maximum	47.6 mm/min
Connectors:	
RS-232/Power	9-pin D-sub; single RS-232 port
Power	+15 to +40VDC (12W min) (user supplied)
Dimensions, H x W x D	13.5 x 24.1 x 10.8 cm (5.3 x 9.5 x 4.25 in)
Mounting Dimensions	22.9 x 9.5cm (9.0 x 3.75 in) - Mounting holes for (4) #8 screws
Weight	1.27 kg (2.8 lbs)
Environmental:	
Operating Temp.	0 to +35°C (natural convection cooling)**
Storage Temp.	-20 to +70°C
Humidity	20 to 80% RH non-condensing

** Note: operating temperature may be extended with forced air cooling

Order # Product

EC1 70-2219	Milliliter Syringe Pump Module without Power Supply
EC1 70-2226	Milliliter Syringe Pump Module with Power Supply

NEW Programmable Syringe Pump Module



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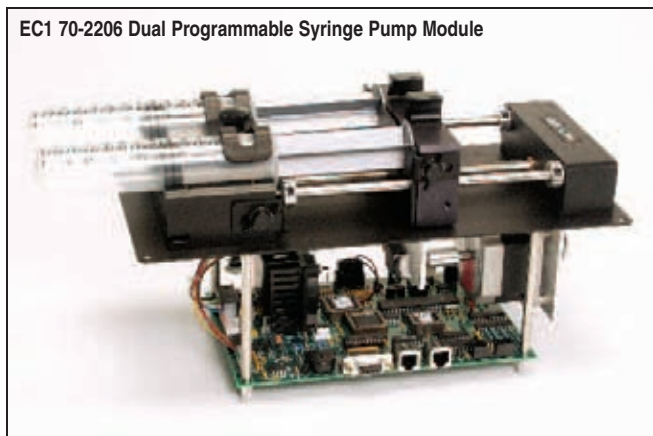
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- Easy to incorporate legendary syringe pump technology into your equipment
- Ideal medium force syringe pump for do-it-yourselfers and OEM equipment designers
- Precisely dispenses volumes at medium pressure
- Smooth flow
- Nonvolatile memory
- Three modes of operation:
 - Constant flow rate
 - Volume dispense
 - Programmable

The Programmable Syringe Pump Module employs a microcontroller which controls a small step angle motor that drives a finer pitch leadscrew and Pusher Block. Microstepping techniques are employed to further reduce the step angle, eliminating flow pulsation. Data can be entered via computer using the RS-232 connector located on the micro controller. The microcontroller calculates the cross-sectional area of the syringe selected and calibrates the flow rate and volume accumulation. The numerous features of the Programmable Pump Module result from the use of microprocessor technology.

The Programmable Pump Module provides full programmability along with Infuse/Withdraw capability. This unit is designed to operate inside an enclosure, cabinet, or on top of a bench. The board may be removed for "remote" operation.

Pressure and Speed

The Programmable Pump Module can deliver up to 132.5 ml/minute with a single 140ml syringe. Maximum pressure is dependent on syringe size. Drive produces >47 lbs linear force (66 lbs is available).

Infusion and Refill Rates

Specify independent rates for infusing and refilling. This allows a slow infusion rate then a fast refill.

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 and refills the syringe when it is empty. This permits infusions to be virtually independent of syringe capacity.

Modes of Operation

(Default is pump mode, can be changed thru RS-232)

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 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.

RS-232

Dual RS-232 ports allow multiple pumps to be 'daisy chained' together and remotely controlled from a computer or any device communicating via RS-232.

Up to 100 pumps can be addressed independently using internal reference addresses from 00 to 99. Default setting is 00. Please let us know if you would like your pumps addressed. Addresses need to be factory set unless you have a keypad.

A scale can be connected, enabling the pump to infuse by weight instead of by volume.

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.

Non-Volatile Memory

All operational data entered into the pump from a computer will be stored, including the program.

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.

Program Storage

Programmable model can store up to 4 sets of 10 program sequences for later selection.

Infuse Rate

The Infuse Rate is the rate of pumping while infusing in the Pump or Volume modes.



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NEW Programmable Syringe Pump Module (continued)

Auto Fill

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.

Program Description

The programming functions of this pump provide powerful capabilities for advanced experiments. While in program mode this pump can perform the following tasks at a predetermined time or when prompted by a signal from an external device:

- start or stop pumping
- change pumping direction (infuse-withdraw)
- change flow rates
- pump a precise volume and stop
- pause operation
- ramp up or down flow rates

In program mode the above tasks can be linked together into powerful programs to simplify your automation projects.

Location Requirements for the Syringe Pump

This pump module was designed to operate inside an enclosure, cabinet, or on top of a bench/table. The circuit board may be removed to a "remote" location if desired.

- **A sturdy, level, clean and dry surface**
- **Minimum of one inch (2.5 cm) clearance around the pump**
- **Adequate power supply**
- **Operating temperature 0° to 35°C (32° to 95°F)**
- **Relative humidity 20% to 80%**

This Programmable Pump Module is supplied complete with the following components:

Component	Quantity
Syringe Pump Unit	1
Motor/Encoder Extension Cable, 6 ft.	1
DC Power Extension Cable, 6 ft.	1
RS-232 Cable	1
Symphony Program Diskettes	1
Grease, 6 oz. jar	1
User Documentation	1

**Note: Power supply not included. Must be purchased separately. Please call technical support for more information.*

Specifications

Type	Microprocessor dual syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe Size:	
Minimum	0.5 µl
Maximum	140 ml
Flow Rate:	
Minimum	0.0006 µl/hr with 0.5 µl syringe
Maximum	132.5 ml/min with 140 ml syringe
Linear Force	47 lbs maximum (66 lbs is available)
Drive:	
Motor	1.8° step angle motor
Control	Constant Current (Chopper) Drive, 2A per phase (max.), microstepping (from 1/2 to 1/32)
Pulley Ratio	2:1 (1:2 optional)
Lead Screw Pitch	40 threads per inch (24 threads is available)
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 msec/step
Pusher Travel Rate:	
Minimum	0.108 mm/min
Maximum	114.4 mm/min
Display	Optional 2x20 Line VFD (p/n 2400-235)
Keypad	Optional (p/n 2400-252)
Interface	RS-232 with simple command language
Connectors:	
DC Power	4-pin Header (Friction Lock – Molex or AMP)
RS-232	4-pin RJ-11 Telephone Jack; dual RS-232 ports
User I/O	9-pin D-Sub Female
Power	+12 to +40VDC, ±5%, 75W (user supplied)
Environmental:	
Operating Temp.	0 to +35°C (natural convection cooling)**
Storage Temp.	-20 to +70°C
Humidity	20 to 80% RH non-condensing
Dimensions:	
Overall, H x W x D	16.8 x 14.0 x 30.2 cm (6.625 x 5.50 x 11.875 in)
Mounting	28.9 x 12.7cm (11.375 x 5.00 in), mounting holes for (4) #8 screws
Control Board Mounting	11.43 x 17.78 cm (4.50 x 7.00 in), mounting holes for (4) #6 screws
Weight	3.86kg (8.5 lbs)

*** Note: operating temperature may be extended with forced air cooling*

Order # Product

EC1 70-2206	Programmable Syringe Pump Module Without Power Supply
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High Pressure Syringe Pump Module



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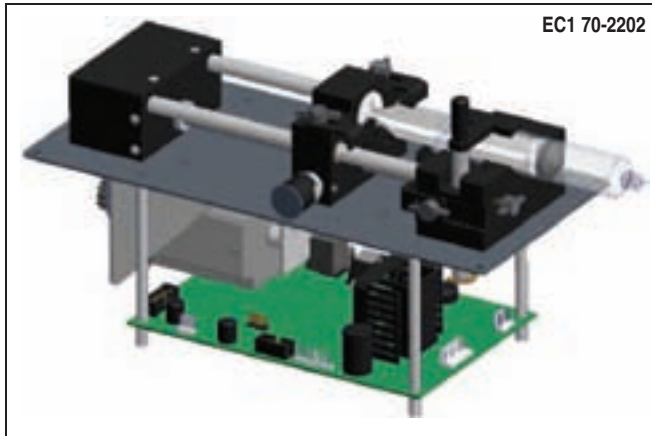
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- Easy to incorporate legendary syringe pump technology into your equipment
- Ideal high force syringe pump for do-it-yourselfers and OEM equipment designers
- Precisely dispenses volumes at high pressure
- Smooth flow
- Nonvolatile memory
- Three modes of operation:
 - Constant flow rate
 - Volume dispense
 - Programmable

The High Pressure Syringe Pump Module employs a microcontroller which controls a small step angle motor that drives a leadscrew and Pusher Block. Microstepping techniques are employed to further reduce the step angle, eliminating flow pulsation. Data can be entered via computer using the RS-232 connector located on the micro controller. The microcontroller calculates the cross-sectional area of the syringe selected and calibrates the flow rate and volume accumulation. The numerous features of the High Pressure Pump Module result from the use of microprocessor technology.

The High Pressure Programmable Pump Module model provides full programmability along with Infuse/Withdraw capability. This unit is designed to operate inside an enclosure, cabinet, or on top of a bench. The board may be removed for "remote" operation.

Pressure and Speed

The High Pressure Pump Module can deliver up to 220.82ml/minute with a single 140ml syringe. Maximum pressure is dependent on syringe size. Drive produces >200 lbs linear force.

Infusion and Refill Rates

Specify independent rates for infusing and refilling. This allows a slow infusion rate then a fast refill.

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 and refills the syringe when it is empty. This permits infusions to be virtually independent of syringe capacity.

Modes of Operation

(Default is pump mode, can be changed thru RS-232)

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 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.

RS-232

Dual RS-232 ports allow multiple pumps to be 'daisy chained' together and remotely controlled from a computer or any device communicating via RS-232.

Up to 100 pumps can be addressed independently using internal reference addresses from 00 to 99. Default setting is 00. Please let us know if you would like your pumps addressed. Addresses need to be factory set unless you have a keypad.

A scale can be connected, enabling the pump to infuse by weight instead of by volume.

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.

Non-Volatile Memory

All operational data entered into the pump from a computer will be stored, including the program.

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.

Program Storage

Programmable model can store up to 4 sets of 10 program sequences for later selection.

Infuse Rate

The Infuse Rate is the rate of pumping while infusing in the Pump or Volume modes.



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High Pressure Syringe Pump Module (continued)

Auto Fill

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.

Program Description

The programming functions of this pump provide powerful capabilities for advanced experiments. While in program mode this pump can perform the following tasks at a predetermined time or when prompted by a signal from an external device:

- start or stop pumping
- change pumping direction (infuse-withdraw)
- change flow rates
- pump a precise volume and stop
- pause operation
- ramp up or down flow rates

In program mode the above tasks can be linked together into powerful programs to simplify your automation projects.

Location Requirements for the Syringe Pump

This pump module was designed to operate inside an enclosure, cabinet, or on top of a bench/table. The circuit board may be removed to a "remote" location if desired.

- **A sturdy, level, clean and dry surface**
- **Minimum of one inch (2.5 cm) clearance around the pump**
- **Adequate power supply**
- **Operating temperature 0° to 35°C (32° to 95°F)**
- **Relative humidity 20% to 80%**

This Pump Module is supplied complete with the following components:

Component	Quantity
Syringe Pump Unit	1
Motor/Encoder Extension Cable, 6 ft.	1
DC Power Extension Cable, 6 ft.	1
RS-232 Cable	1
Symphony Program Diskettes	1
Grease, 6 oz. jar	1
User Documentation	1

**Note: Power supply not included. Must be purchased separately. Please call technical support for more information.*

Specifications

Type	Microprocessor single syringe, infuse/withdraw
Accuracy	±0.5%
Reproducibility	±0.1%
Syringe Size:	
Minimum	0.5 µl
Maximum	140 ml
Flow Rate:	
Minimum	0.001 µl/hr with 0.5 µl syringe
Maximum	220.82 ml/min with 140 ml syringe
Linear Force	200 lbs maximum
Drive:	
Motor	1.8° step angle motor
Control	Constant Current (Chopper) Drive, 2A per phase (max.), microstepping (from 1/2 to 1/32)
Pulley Ratio	2:1 (1:2 optional)
Leadscrew Pitch	24 threads per inch
Step Rate:	
Minimum	27.3 sec/step
Maximum	416.7 msec/step
Pusher Travel Rate:	
Minimum	0.18 mm/min
Maximum	190.676 mm/min
Display	Optional 2x20 Line VFD (p/n 2400-235)
Keypad	Optional (p/n 2400-252)
Interface	RS-232 with simple command language
Connectors:	
DC Power	4-pin Header (Friction Lock – Molex or AMP)
RS-232	4-pin RJ-11 Telephone Jack; dual RS-232 ports
User I/O	9-pin D-Sub Female
Power	+12 to +40VDC, ±5%, 75W (user supplied)
Environmental:	
Operating Temp.	0 to +35°C (natural convection cooling)**
Storage Temp.	-20 to +70°C
Humidity	20 to 80% RH non-condensing
Dimensions:	
Overall, H x W x D	16.8 x 14.0 x 30.2 cm (6.625 x 5.50 x 11.875 in)
Mounting	28.9 x 12.7cm (11.375 x 5.00 in), mounting holes for (4) #8 screws
Control Board Mounting	11.43 x 17.78 cm (4.50 x 7.00 in), mounting holes for (4) #6 screws
Weight	3.86kg (8.5 lbs)

*** Note: operating temperature may be extended with forced air cooling*

Order # Product

EC1 70-2202	High Pressure Syringe Pump Module Without Power Supply
--------------------	--

Choosing the Right Pump for Your Application & Budget

4. Peristaltic Pump Selection Guide

- Broad selection of pumps for every application
- Wide range of flow rates ml/hr to L/min
- Multiple multi-channel models with up to 32 channels
- Peristaltic and non-peristaltic pumps
- Continuous delivery and batch mode dispensing

The following table was designed to answer most questions regarding our continuous flow pumps. Please contact our technical support department for further assistance.

Peristaltic and Continuous Flow Pumps

Traditional peristaltic pumps utilize a series of rollers (1 to 8) to push fluid through tubing held within a pump head. Peristaltic flow is typically pulsatile, but can be made smoother with the use of more rollers in the pumping head. Our Mini-Peristaltic Pump (MPLI, see page 39) features two speed ranges, reversability and dual channel pumping at a very reasonable price. Many pumps offer external control either through the input of an analog signal proportional to the speed or by RS-232 (serial) communication.

Harvard Apparatus now offers an extensive selection of peristaltic and other continuous flow pumps to suit the needs of a wide range of research applications. Pumps which offer features such as multi-channel pumping, computer control, analog control, low electrical noise and a wide range of fluid flow rates are now available. Pump styles include traditional roller type peristaltic pumps, our exclusive double linear sinusoidal peristaltic pump, shuttle pumps which utilize check valves, and diaphragm pumps.

Pump Selection Guide

Pump	MPLI EC1 70-2027	Pump 66 EC1 55-7766	Pump 77 EC1 55-7777	Model 720 EC1 72-0002	Model 720 EC1 61-0098 EC1 61-0239	Model 720 EC1 72-0001 EC1 72-0008	Shuttle Pump EC1 61-0128 EC1 72-0011
Number of Channels	1 to 2	1	1	1 to 2	1 to 2	1 to 2	2
Number of Rollers	4	3	3	3	3	3	1
Tube Size (Inner Diameter)	1.6 mm (1/16 in)	1.6 mm and 3.2 mm (1/16 in and 1/8 in)	3.2 mm and 6.4 mm (1/8 in and 1/4 in)	0.38 mm to 2.4 mm (0.015 in to 0.093 in)	0.38 mm to 2.4 mm (0.015 in to 0.093 in)	0.38 mm to 2.4 mm (0.015 in to 0.093 in)	-
Flow Rate (ml/min/Per Channel):							
Minimum	0.8	0.01	0.01	0.02	0.2	2	1.25
Maximum	12.25	210	750	12	145	1100	25
RS-232 Computer Control	No	Yes	Yes	No	No	No	No
TTL Control	No	Yes	Yes	No	No	No	No
Analog Control	No	No	No	Yes	Yes	Yes	No
Power	115/230 VAC 50/60 Hz	115/230 VAC 50/60 Hz	115/230 VAC 50/60 Hz	120 VAC, 50 Hz 230 VAC, 60 Hz	120 VAC, 50 Hz 230 VAC, 60 Hz	120 VAC, 50 Hz 230 VAC, 60 Hz	120 VAC, 50 H 230 VAC, 60 Hz
Battery Backup	No	No	No	9V Lithium Battery up to 30 hours	9V Lithium Battery up to 30 hours	No	9V Lithium Battery up to 50 hours
Dimensions (H x W x D)	189 x 114 x 105 cm (3.5 x 4.5 x 4 in)	22.9 x 20.6 x 8.9 cm (9 x 8.125 x 3.5 in)	24.1 x 20.6 x 12.7 cm (9.5 x 8.125 x 5 in)	6.4 x 5.7 x 10.2 cm (2.5 x 2.25 x 4 in)	6.4 x 5.7 x 10.2 cm (2.5 x 2.25 x 4 in)	6.4 x 5.7 x 10.2 cm (2.5 x 2.25 x 4 in)	3.3 x 11.4 x 7.2 cm (1.3 x 4.5 x 2.8 in)
Weight	0.96 kg (2.1 lbs)	3.53 kg (7.85 lbs)	5.1 kg (11.25 lbs)	375 g	375 g	375 g	-
Page	39	40	40	41	41	41	42

Peristaltic Pump Questions

How many channels (tubes) will be used simultaneously?

What size tubing will be used (inner diameter)?

What flow rate(s) will be used?

What is the total volume to be delivered?

Do you need continuous flow?

Does the pump need to be battery operated?

Do you need to control the pump with a computer?

Do you need analog control?

Does the pump need to have TTL capabilities (external control of valves, use of footswitch etc)?

peristaltic pumps

Harvard MPII Mini-Peristaltic Pump



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EC1 70-2027 Harvard MPII Mini-Peristaltic Pump



- Continuous low flow rates ideal for:
 - Slow perfusion studies
 - Controlled animal feeding
- Pump can take one or two tubes simultaneously, 1/16 in. ID
- Control knob for pumping speed
- Toggle switches for direction and x1 or x2 speed range selection
- Low electrical and mechanical noise
- Small size

The Harvard MPII Mini-Peristaltic Pump takes only one size of tubing, 1.6 mm ID x 3.2 mm OD (1/16 x 1/8 in). It can be used with either a single tube or two tubes simultaneously. Two of the EC1 55-4148 Pump Head Tubing Pieces are included with the pump. Additional Pump Head Tubing Pieces (EC1 55-4148) may be purchased separately.

Two front panel controls provide flow rates from approximately 0.8 to 24.5 ml/min. The control knob provides variable adjustment from 0 to 100% of the selected flow rate range. The second control is a two position toggle switch marked x1, x2 which selects low or high flow rates, see table to right.

The easy-loading four-roller pump head is on top of the stout metal box. The back of the pump head effortlessly rotates into an 'open' position and either one or two tubes can be dropped into slots. The loaded section simply rotates back against spring loaded jaws and locks into place. The tubing is automatically in proper wiping contact with the pump head rollers. Each Pump is provided with a 12.5 mm (0.5 in) rod clamp on the back so that multiple pumps can be mounted vertically on a lattice rod.

MPII Flow Rates in ml/min

Switch Setting	With One Tube		With Two Tubes	
	Min.	Max.	Min.	Max.
x1	0.8 ml/min	7.00 ml/min	1.6 ml/min	14.00 ml/min
x2	1.5 ml/min	12.25 ml/min	3.0 ml/min	24.50 ml/min

Specifications

Output Pressure	In excess of 20 p.s.i.
Power	12 VDC 800 mA, 2.5 mm Connector, 115/230 VAC, 50/60 Hz, Universal power supply, 10 W
Dimensions, H x W x D	189 x 114 x 105 cm (3.5 x 4.5 x 4 in)
Weight	0.96 kg (2.1 lb)
Tubing ID	1/16 in

Order # Product

EC1 70-2027	MPII, 115/230 VAC, 50/60 Hz
EC1 55-4148	Pump Head Tubing Pieces. These Silicone Pump Head Tubing Pieces Have Connectors on Each End for 1/16 in ID Tubing 2.5 in, pkg. of 10

Harvard Apparatus Peristaltic Pump 66 & 77



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Peristaltic Pumps 66 and 77

- Highly accurate peristaltic pumps $\pm 1\%$
- Unique ramped deceleration and 'slurp back'
- Continuous volume or batch mode operation
- Easy to use

Harvard Apparatus' 66 and 77 Peristaltic Pumps provide highly accurate and repeatable flow rates and are extremely easy to use.

High Accuracy

These pumps have the same high quality micro-stepping motor that creates the legendary accuracy of Harvard Apparatus' Syringe Pumps. Other peristaltic pumps have less accurate DC motors. No other peristaltic pump offers this quality of basic motor control. Additional accuracy features include ramped deceleration as the end-point is approached and a 'slurping' feature to prevent end of dispense dripping. As the end-point approaches, the pump slows to drop-by-drop delivery. As the last drop required is delivered, the pump immediately reverses one step and slurps back preventing unintended fluid delivery. Only these Harvard Apparatus innovations enable accuracy approaching that of a syringe pump from a peristaltic pump.

Fast and Easy

Routine work is made fast, easy and convenient with the 66 and 77 peristaltic pumps. Just enter the calibration factor of the tubing and the flow rate desired. The pump takes care of the rest. All settings are stored in non-volatile memory.

Flexibility

The 66 and 77 peristaltic pumps offer three pumping protocols for outstanding flexibility:

- **Continuous flow** – set the flow rate desired and the pump will run continuously until you stop it.
- **Volume Mode** – enter the volume to be delivered and the pump will run until that volume is delivered.
- **Batch Mode** – simply enter the time interval between dispenses and the number of dispenses you want and the pump will take it from there. It couldn't be more simple.

Two Sizes Available

Harvard Apparatus' peristaltic pump is offered in two sizes. The only difference between the two pumps is the flow rates provided. The 66 accepts smaller diameter tubing and provides flow rates from 0.01 to 210 ml/minute. The larger size 77 pump accepts larger diameter tubing to provide flow rates from 0.01 to 750 ml/minute.

Calibration by Volume or Weight

For precise volumetric calibration, measure the actual volume pumped compared to what the pump thinks it has delivered. Enter the exact amount actually delivered into the pump and the pump will automatically recalibrate itself in microliters per pump head revolution. For precise gravimetric calibration, connect the pump to a Mettler, Ohaus or Sartorius scale with a feedback connector. The pump now operates by weight and will recalibrate itself in grams per pump head revolution.

RS-232C Interface and TTL Input/Output

This pump can be controlled remotely by any personal computer via an RS-232C interface. Up to 99 pumps can be daisy-chained using the daisy-chain connector and cables offered as accessories. A connector for TTL input/output permits remote control of all functions.

Specifications

Type	3 roller rotary peristaltic, single channel	
Accuracy	$\pm 1\%$	
Reproducibility	$\pm 1\%$	
RS-232C Interface	Chained dual bi-directional ports	
TTL Connector	9-pin connector	
Display	5 digits and 10 LED indicators	
Selectable Baud Rates	300, 600, 1200, 2400	
Step Rate:		
Minimum	27.3 sec/step	
Maximum	416.7 μ sec/step	
Back Pressure	30 p.s.i. maximum	
Power	115/230 VAC, 50/60 Hz	
Voltage Range	95/130 VAC; 220/260 VAC	
Pump:	Small 66 Pump	Large 77 Pump
Tubing ID (Tygon R-1000 Only)*	1.6 and 3.2 mm (0.0625 and 0.125 in)	3.2 and 6.4 mm (0.125 and 0.25 in)
Flow Rates	0.01 to 210 ml/min	0.01 to 750 ml/min
Dimensions, H x W x D	22.9 x 20.6 x 8.9 cm (9 x 8.125 x 3.5 in)	24.1 x 20.6 x 12.7 cm (9.5 x 8.125 x 5 in)
Weight	3.53 kg (7.85 lb)	5.1 kg (11.25 lb)

Order # Product

EC1 55-7766	Peristaltic Pump 66
EC1 55-7777	Peristaltic Pump 77
EC1 70-2022	RS-232 Connection Cable; Computer to Pump
EC1 72-2478	Daisy Chain Cable; Pump to Pump, 1.8 m (7 ft)
EC1 55-7760	Daisy Chain Cable; Pump to Pump, 0.6 m (2 ft)
EC1 55-7757	Feedback Loop Connector for Mettler Scale
EC1 55-7758	Feedback Loop Connector for Ohaus Scale
EC1 55-7759	Feedback Loop Connector for Sartorius Scale

*Only Tygon R-1000 tubing works with these pumps, see Tubing and Accessories pages 2-10.

peristaltic pumps

Model 720

Compact Peristaltic Pumps



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- Continuous infusion
- Battery back-up (30 hrs)
- Compact pump
- Minimal electromagnetic radiation
- Choose from low, mid, or high flow

The Model 720 Compact Peristaltic pump is a stand-alone pump series with flow rates of 0.02 to 12 ml/hr (Low Flow), 0.2 to 145 ml/hr (Mid-Flow) and 2 to 1100 ml/hr (High Flow). It is an ideal pump for applications which require limited size or weight, low EMI interference, the versatility of single and dual tubes sets (see table below) and/or external analog control.

An internal 9V lithium battery (supplied with EC1 61-0098 and EC1 72-0002) will run the pump for up to 30 hours, protecting your experiments in the event of a power failure. Due to its power requirements, the high flow version is not available with battery backup.

The pump is typically powered by a 1.25 V internal reference voltage. An external reference voltage can be used to regulate flow rate and direction (pump direction can only be reversed by analog control). Under external control the speed dials serve as voltage attenuators to limit the external voltage to ± 1.25 volts.

Tube sets must be purchased separately**. Frequently ordered tube sets are listed below. Other tube sets are available, please see our website or contact technical support. For use with saline and most drugs, use silicone tubing. For use with solutions containing fats, such as IV diets, use C-FLEX® tubing. For use with petroleum-based fluids, use VITON® tubing.

Frequently Ordered Tube Sets

Order #	Flow Rates with 72-0002 Pump	Flow Rates with 61-0098 or 61-0239 Pumps	Flow Rates with 72-0001 or 72-0008 Pumps	Typical Application
EC1 61-0241	0.02 to 0.45 ml/hr	0.2 to 5 ml/hr	2 to 43 ml/hr	IV infusion with 22 ga swivels (lab animals only)
EC1 61-0242	0.04 to 0.95 ml/hr	0.3 to 11 ml/hr	4 to 90 ml/hr	IV infusion with 20 ga swivels (lab animals only)
EC1 61-0243	0.08 to 1.8 ml/hr	0.8 to 21 ml/hr	9 to 170 ml/hr	General laboratory applications
EC1 61-0244	0.9 to 12 ml/hr	7 to 145 ml/hr	90 to 1100 ml/hr	General laboratory applications
EC1 61-0245	0.3 to 6.3 ml/hr	3 to 75 ml/hr	33 to 550 ml/hr	Dual channel laboratory applications

**Tube sets are no longer supplied with the pump. They must be purchased separately.

Specifications

Repeatability	$\pm 3\%$		
Flow Control Range	20:1		
Power Source	Wall-mounted 9 VDC adapter		
Dimensions, H x W x D	6.4 x 5.7 x 10.2 cm (2.5 x 2.3 x 4 in)		
Weight	375 g (1 lb)		
Voltage Range	Universal input 100/240 VAC; 50/60 Hz		
Flow Rate:	High	Mid	Low
Min. (0.015 in. tube)	2 ml/hr	0.2 ml/hr	0.02 ml/hr
Max. (0.093 in. tube)	1100 ml/hr	145 ml/hr	12 ml/hr
	EC1 72-0001	EC1 61-0098	EC1 72-0002



Tube Sets

A wide variety of tube sizes, tube materials and connector types allows you to tailor your peristaltic pump to your particular application.

Tube sets typically last about one month under continuous operation. Dual channel tube sets place more stress on the pump than do single channel tube sets, which may shorten the life of your pump's motor.

Order # Product

EC1 61-0241	Silicone Tubing Set, 1-Ch, Female Luer to 22 ga, pkg. of 5
EC1 61-0242	Silicone Tubing Set, 1-Ch, Female Luer to 20 ga, pkg. of 5
EC1 61-0243	Silicone Tubing Set, 1-Ch, 0.062" ID Barbs, 0.8ml/hr, pkg. of 5
EC1 61-0244	Silicone Tubing Set, 1-Ch, 0.062" ID Barbs, 5ml/hr, pkg. of 5
EC1 61-0245	Silicone Tubing Set, 2-Ch, 0.062" ID Barbs, 3ml/hr, pkg. of 5

Harvard Apparatus/Instech Shuttle Pump



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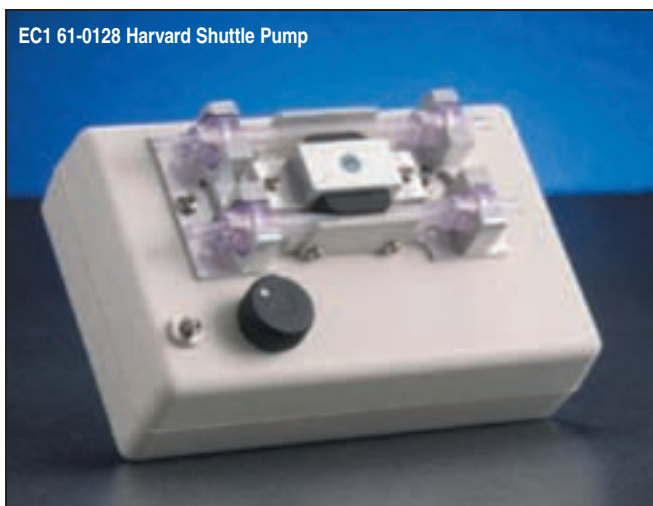
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- Battery powered
- Perfect for cell culture work
- Fits in palm of your hand
- Flow rates up to 50 ml/minute
- Extremely energy efficient
- Gentle pulsatile flow
- Extended tubing life

This Shuttle Pump is based on a patented dual channel shuttle pump mechanism that can deliver flow rates up to 50 ml/min, but is small and incredibly power efficient. This unique pump was designed for cell culture experiments conducted on the Space Shuttle, where weight and power consumption are significant constraints.

Efficient Design

This fluid pump uses two easily removable tube sets (included) on either side of an oscillating shuttle. The balanced tube arrangement, high-efficiency motor, and 4 passive check valves result in a pump that is far more efficient than a typical peristaltic pump: 13 times higher flow rates with 60% lower weight and 90% lower power consumption.

Gentle Pumping Action

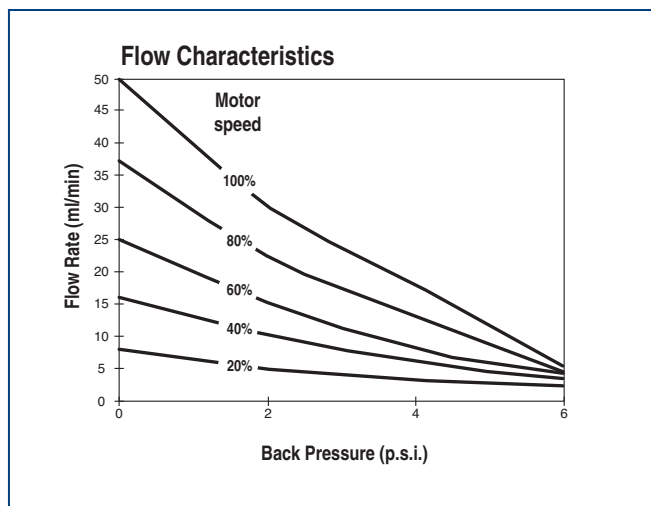
The oscillating shuttle does not squeeze the tubes to occlusion, making this device ideal for pumping cell suspensions and blood. Fluid can freely flow through the pump in the forward direction, simplifying filling and purging, but limiting applications to those where outflow pressure is greater than inflow pressure. Single or dual channel operation. Join the two tubes to form a single input and output and thereby generate twice the flow rate with less pulsation.

Built-In Control Circuitry

Adjust the motor speed over a 20:1 range using the knob on the top of the pump.

OEM

The pump mechanism is also available for OEM applications. Please call Technical Support for details.



Specifications

Flow Rate:	
Both Tubes Combined	2.5 to 50 ml/min (no back pressure)
Single Tube	1.25 to 25 ml/min (no back pressure)
Flow Waveform	Pulsatile
Pumping Chambers	2 per pump
Pulses per Minute	~45 at 6 ml/min (single channel)
Developed Pressure	9 p.s.i. (flow = 0), maximum
Tubing Life	> 3 months
Tubing	0.125 in ID with 1/8 in tapered connectors only
Power Source Provided	9 V battery and AC adapter
Battery Life	50 hrs under continuous operation, 9 V lithium
Dimensions, H x W x D	3.3 x 11.4 x 7.2 cm (1.3 x 4.5 x 2.8 in)
Weight	184 g

Order # Product

EC1 61-0128	Harvard Apparatus Shuttle Pump, 120 VAC
EC1 72-0011	Harvard Apparatus Shuttle Pump, 220 VAC
EC1 72-0012	Replacement 120 VAC Wall Adapter
EC1 72-0013	Replacement 220 VAC Wall Adapter
EC1 61-0271	Replacement Check Valve and Tubing Set for Shuttle Pump, pkg. of 2

Centrifugal Pumps for Blood

blood pumps



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Centrifugal Pump



- Low hemolysis
- Flow rates up to 16 L/min
- Little to no pulsation
- Smooth run, producing only low noise
- Pump heads interchangeable without tool
- Speed setting by a digital switch in 0.1% steps
- "Max Speed" button for quick fill or ventilate
- Robust construction for long life
- Analog interface for remote control

The centrifugal pump is specifically designed for pumping blood and/or erythrocyte suspension solutions in the physiological or pharmacological laboratory. It consists of the pump drive BVP-ZX and a centrifugal pump head which can be replaced without tools. The Pump Drive and Pump Head must be purchased separately. Pump heads are hermetically sealed. The coupling to the motor of the pump drive is carried out via magnetic force; there is no axle.

The pump speed is set using a 3-digit potentiometer switch (000 to 999) or via an analog interface.

The drive is very robust and suitable for continuous speed selection operation.

Specifications

Pump Drive

Type	BVP-ZX
Speed	3 to 3000 rpm, adjustable in 0.1% steps
Mains Connection	230 (50/60Hz) 115 V (50/60Hz)
Power Consumption	120 W maximum
Analog Interface	Speed control 0–5 V or 0–10 V or 0–20 mA or 4–20 mA, start/stop (TTL contacts)
Protection Rating	IP 30
Operating Conditions	0° to 40 °C (normal environmental conditions)
Dimensions, H x W x D	260 x 155 x 260 mm (10.2 x 6.1 x 10.2 in) without pump-head
Weight	7 kg (15.4 lbs) without pump head

Centrifugal Pump Heads

Type	BP-80	BP-50	SP-45
Manufacturer	Medtronic	Medtronic	Terumo
Pump Technologies	Centrifugal	Centrifugal	Impeller (Centrifugal)
Maximum Flow Rate	10 l/min at 50 mmHg – 16 l/min at 50 mmHg		
	3 l/min at 300 mmHg – 13 l/min at 300 mmHg		
Pulsation	no	no	yes
Priming Volume	80 ml	50 ml	45 ml
Inlet/Outlet ID	9.5 mm	6.4 mm	9.5 mm
Fitting to BVP-ZX	Direct	Direct	Adaper SP-03 Required

Order # Product

EC1 73-2963	BVP-ZX Centrifugal Pump Drive 115 VAC
EC1 73-2470	BVP-ZX Centrifugal Pump Drive 230 VAC
EC1 73-2807	BP-80 Centrifugal Pump Head
EC1 73-2954	BP-50 Centrifugal Pump Head
EC1 73-2955	SP-45 Centrifugal Pump Head
EC1 73-2956	SP-03 Adaptor for SP-45 Head

Harvard Apparatus Pulsatile Blood Pumps



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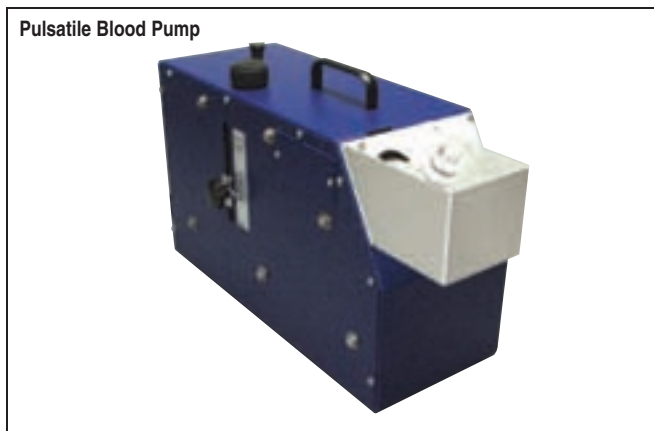
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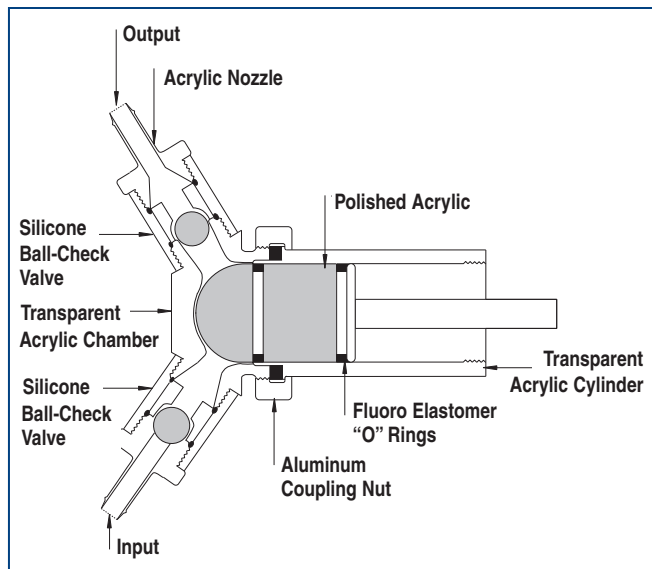


- Pulsatile output truly simulates the ventricular action of the heart
- Minimal hemolysis
- Models for mice to large animals
- Ideal for moving emulsions, suspensions, and non-Newtonian fluids such as blood

If you are performing cardiovascular work, this is the pump for you. It truly simulates the pumping action of the heart. It features silicone rubber-covered heart-type ball valves and smooth flow paths which minimize hemolysis. Only inert materials like silicone rubber, acrylic plastic, and Teflon contact the fluid. The pumping head is easy to take apart and reassemble and can be sterilized.

Outstanding Performance

The pulsatile output closely simulates the ventricular action of the heart. This action provides physiological advantages in blood flow for perfusion



in cardiovascular and haemodynamic studies. It is ideal for isolated organ perfusion, whole body perfusion, blood transfers, hydration/dehydration procedures, and blood cellular profile studies.

Pump Mechanism

A positive piston actuator and ball check valves provide the proportioning action. The product of stroke rate times stroke volume is an accurate indicator of the flow rate. Positive piston action prevents changes in flow rates, regardless of variations in resistance or back pressure. The piston always travels to the end of the ejection stroke, independent of the volume pumped. The Pump completely empties at each cycle.

Specials - A special motor control module can be used for external 0-10 VDC control for those customers that wish to control with a computer or other device.

Harvard Apparatus Pulsatile Blood Pump

Specifications

	Mice/Rats	Rabbits	Dogs/Monkeys		Large Animals; Hemodynamic Studies	
Stroke Volume, Adjustable	0.05 to 1.0 ml	0.5 to 10 ml	4 to 30 ml	---	15 to 100 ml	---
Rate, Stroke/Min.	20 to 200	20 to 200	20 to 200	---	10 to 100	---
Minute Volume, Stroke Vol. x Rate	1 to 200 ml	10 to 2,000 ml	80 to 6,000 ml	---	150 to 10,000 ml	---
Phasing	Fixed Phase	Fixed Phase	Adjustable Phase	---	Adjustable Phase	---
Systole/Diastole Ratio	35% systole, 65% diastole	35% systole, 65% diastole	35% to 50% of total cycle	---	35% to 50% of total cycle	---
Tube ID	8 mm (.31 in)	8 mm (.31 in)	13 mm (.5 in)	---	15.9 mm (.625 in)	---
Dimensions, H x W x D	312 x 156 x 250 mm (12.5 x 6.25 x 10 in)	312 x 156 x 250 mm (12.5 x 6.25 x 10 in)	500 x 212 x 337 mm (20 x 8.5 x 13.5 in)	---	500 x 212 x 337 mm (20 x 8.5 x 13.5 in)	---
Weight	7.3 kg (16 lb)	7.3 kg (16 lb)	13.6 kg (30 lb)	---	32 lb (14.5 kg)	---
Voltage	115/230 VAC, 50/60 Hz	115/230 VAC, 50/60 Hz	115 VAC, 60 Hz	230 VAC, 50 Hz	115 VAC, 60 Hz	230 VAC, 50 Hz
Order #	EC1 52-9552	EC1 55-1838	EC1 55-3321	EC1 55-3339	EC1 55-3305	EC1 55-3313

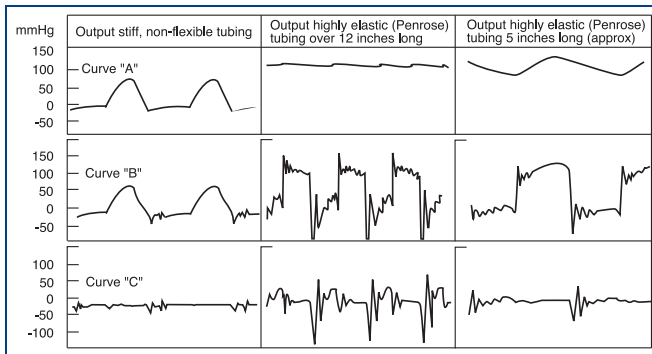
Harvard Apparatus Pulsatile Blood Pumps (continued)



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Pressure Curves

The shape of the output pressure curve is a function of both the pump action and the characteristics of the external system on the output valve side. The following set of curves were obtained with Model 1421, using water as the pumped medium. In the tests, "Sanborn" pressure transducers were inserted in three places, and continuous records obtained under varying conditions.

- Curve A** Pressure just beyond the output valve
- Curve B** Pressure within the pump chamber
- Curve C** Pressure just before the intake valve

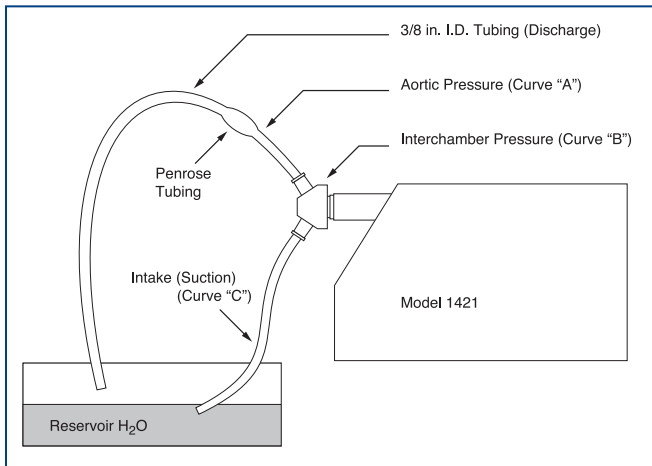
By variation of parameters involved (peripheral resistance, stroke rate, stroke volume and phase ratio), an infinite number of output flow characteristics can be obtained.

Hemolysis Test Conditions Models 1421 (EC1 55-3321) and 1423 (EC1 55-3305)

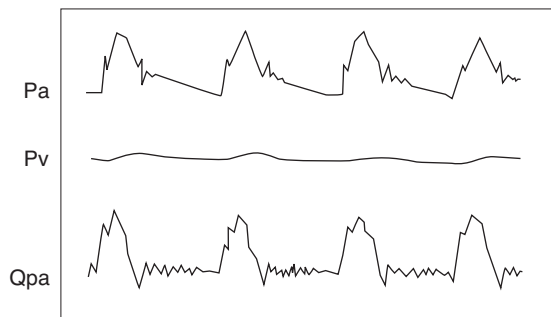
Hemolysis ranged from 0.114 mg% to 0.29 mg% per pass through the various pumps, with an error of $\pm 10\%$.

To put these results in perspective, most physiological perfusions are run with flow rates and total blood primes, such that the number of passes through the pump will range from about 1/4 to 3/4 per minute. Assuming one pass in two minutes and no physiological removal of the products of hemolysis, then hemolysis rates would range from 3.4 mg% to 8.7 mg% per hour of pump use.

In these studies a reservoir of 500-800 cc of fresh dog blood was used, connected to the pump by 3/8" PVC tubing. Samples at room temperature were taken at 15 and 30 minute intervals for 4 to 5 hours. Samples were spun down and hemolysis measured immediately using the method of Flink and Watson. Since the rate of hemolysis depends on the amount of blood in the system and the flow rate, the results are reported as mg% per pass. The flow rate divided by the volume of blood in the system determines the number of passes through the pump per minute.



Pressure and Flow Curves Using Harvard Model 1421 Pulsatile Blood Pump in Isolated Perfusion of Left Lower Lobe of Dog Lung*



- Pa** Pulmonary Artery Pressure
- Pv** Pulmonary Venous Pressure
- Qpa** Pulmonary Artery Blood Flow

Instrumentation:

- Pressure** Statham
- Flow** Biotronex Electromagnetic Flowmeter
- Recording** Electronics for Medicine

*Note: The above data is supplied through the courtesy of Cardiorespiratory laboratory Columbia-Presbyterian Medical Center New York, New York, Dr. Alfred P. Fishman, Director.

How to Calculate The Pressure Requirement of Your Experiment

The following chart will help you determine the pressure requirement of your experiment. This is important in selecting the correct pump with the proper psi capability for your application. Choose the selections that are the closest to your experimental conditions or write in your actual values. Once you have filled in the chart call us for technical assistance if needed.

1. Nature of the sample you are flowing into (Application)
2. The flow rate of the material
3. The surface area of the syringe and the linear force capability of the pump
4. The tubing diameter
5. The tubing length
6. Viscosity of the material being pumped
7. The temperature of the material being pumped

NORMAL PRESSURE	HIGH FORCE	XTREME HIGH PRESSURE
0 to 30 psi (0 to 2 bar)	31 to 150 psi (2.1 to 10.2 bar)	151 to 2000 psi (10.3 to 137 bar)

1. APPLICATION

LOW	Flow into open containers i.e. titrations, food trays filling	
	Inject into Tissue i.e. Drug infusion into muscle, brain	
HIGH	Flow into closed container, i.e. Reaction Chamber 350 to 400 psi	
	High viscosity solutions at high flow rates in a short period of time, i.e. Corn syrup	

2. FLOW RATE - Pumping Speed (The faster the flow rate, the higher the pressure)

0.003 µl/hr to 140 ml/min	
141 ml/min to 220 ml/min	

3. SYRINGE SIZE (Syringe volume/plunger area + linear force of pump)

10 µl to 1 ml ie. 500 µl/min x 20 Lbs = 500	
---	--

4. TUBING SIZE (Inner diameter, Smaller ID = higher pressure)

Small - capillary (the longer more pressure)	
Large - Hose	

5. TUBING LENGTH - DISTANCE (Depends on ID Smaller ID = higher pressure)

Short, < 1M	
Long, > 1M	

6. VISCOSITY OF MATERIAL TO BE PUMPED (Higher viscosity = higher pressure)

Air	18°C = 0.0182 cP	
Water	20°C = 1.002 cP	
Olive Oil	20°C = 84 cP	
Pancake Syrup	20°C = 2500 cP	
Honey	20°C = 10000 cP	
Peanut Butter	20°C = 250000 cP	

7. TEMPERATURE OF SOLUTIONS BEING PUMPED (Higher temperature = lower viscosity = lower pressure)

0 to 15°C	
15 to 80°C	

Syringe Pump Pressure and Flow Rate



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How to Calculate the Pressure of Various Syringe Sizes

The pressure that a syringe pump can generate is a function of both the force of the pump (measured at the pusher block in pounds) as well as the physical characteristics of the syringe and setup used. The following table compares various syringe pumps and the pressures in PSI (pounds per square inch). Each data point was calculated by dividing the average pump force by the surface area (in square inches) of syringes with diameters from 0.1 to 50 mm. Diameters and surface areas for a variety of syringes

can be found in the table on page 50. This table is intended to be a guide of total pressures generated. Actual values may be higher or lower than the listed pressures due to the influence of other factors such as tubing diameter and length. When using more than one syringe sharing the same pusher block, the pressure is calculated by dividing the force (lbs) by the total surface area (square inches) of all syringes on the pump. For example, nominal pressure obtained using two 25 ml Hamilton Gastight® syringes on a PHD 22/2000 standard pressure syringe pump would be: 50 lbs / (0.644 in² X 2) = 38.81 PSI (2.68 bars).

Pump Average PressureA (PSI)B

Syringe Size	Syringe Dia (mm)	Pump 11 Plus	Pump 11 Pico Plus	Pump 22	Pump 33	PHD 22/2000	PHD 22/2000 Hpsi	PHD 4400 Hpsi
0.5 µl	0.1	>1000	>1000	>1000	>1000	>1000	–	>1000
10 µl	0.5	>1000	>1000	>1000	>1000	>1000	–	>1000
50 µl	1	>1000	>1000	>1000	>1000	>1000	–	>1000
1 ml	5	526	821	>1000	>1000	>1000	–	>1000
5 ml	10	131	205	386	468	394	–	1438
10 ml	15	58	91	172	208	175	–	639
50 ml	25	21	33	62	75	63	569	230
Force (lbs)		16	25C	47	57	48	433	200
See page		8	9	12	14	16	20	21

A. Calculated pressure based on pump force at average speed

- Higher pressures may be achieved at minimum speed and lower pressures at maximum speed.
- Pump speed and force are inversely proportional.
- Most syringes are pressure rated and may not be able to tolerate pressure generated by the syringe pump. Consult Harvard Apparatus or your syringe manufacturer for syringe details and specifications.

B. To convert pressure from PSI to bars use the following equation: bar pressure = PSI x 0.0690.

C. Actual force is higher. Use of pump with greater back pressure may result in premature wear of syringe pump halfnut.

Minimum/Maximum Flow Rates By Pump and Syringe Size

Flow rates were calculated based on the pusher block travel rate for each pump (rate at which the syringe pump moves the syringe plunger) and the diameter of the syringe.

Pump 11 Pico Plus Flow Rates

Syringe Size	Nominal Diameter, mm*	Minimum	Maximum
0.5 µl	0.10	1.3 pl/min	20.00 nl/min
1 µl	0.15	3.0 pl/min	46.00 nl/min
10 µl	0.46	27.0 pl/min	400.00 nl/min
100 µl	1.46	270.0 pl/min	0.004 ml/min
1000 µl	4.61	2,690.0 pl/min	0.043 ml/min
10 ml	14.57	27.0 nl/min	0.439 ml/min

* Note: These figures have been rounded and therefore may not exactly match the Syringe Diameter Chart on page 50.

PHD 22/2000 Hpsi Flow Rates* (High Volume and Pressure)

Syringe Size	Diameter, mm	Minimum, µl/hr	Maximum, ml/min
20 ml	19.13	1.5	20
50 ml	28.60	3.4	46
100 ml	34.90	5.0	68
200 ml	44.75	8.2	112

*The Rates listed are for single stainless steel syringe

Syringe Pump Pressure and Flow Rate

Minimum/Maximum Flow Rates By Pump and Syringe Size (continued)



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Pump 11 Plus Flow Rates

Syringe Size	Diameter, mm*	µl/hr Min to Max	µl/min Min to Max	ml/hr Min to Max	ml/min Min to Max
0.5 µl	0.10	0.0014 to 22.35	0.0001 to 0.3725	0.0001 to 0.0223	0.0001 to 0.0003
1 µl	0.15	0.0031 to 50.29	0.0001 to 0.8383	0.0001 to 0.0502	0.0001 to 0.0008
2 µl	0.21	0.0061 to 98.58	0.0002 to 1.6430	0.0001 to 0.0985	0.0001 to .0016
5 µl	0.33	0.0149 to 243.4	0.0003 to 4.057	0.0001 to 0.2434	0.0001 to 0.0040
10 µl	0.46	0.0289 to 473.0	0.0005 to 7.883	0.0001 to 0.4730	0.0001 to 0.0078
25 µl	0.73	0.0728 to 1191	0.0013 to 19.85	0.0001 to 1.191	0.0001 to 0.0198
50 µl	1.03	0.1448 to 2371	0.0025 to 39.52	0.0002 to 2.371	0.0001 to 0.0395
100 µl	1.46	0.2909 to 4765	0.0049 to 79.41	0.0003 to 4.765	0.0001 to 0.0794
250 µl	2.30	0.7218 to 9999	0.0121 to 197.0	0.0008 to 11.82	0.0001 to 0.1970
1000 µl	4.61	1.451 to 9999	0.0242 to 395.7	0.0015 to 23.75	0.0001 to 0.3959
1 ml	5.00	2.900 to 9999	0.0484 to 791.8	0.0029 to 47.50	0.0001 to 0.7918
2.5 ml	7.28 to 9.6	7.232 to 9999	0.1206 to 1974	0.0073 to 118.4	0.0002 to 1.974
3 ml	8.66 to 9.0	10.24 to 9999	0.1706 to 2794	0.0103 to 167.6	0.0002 to 2.794
5 ml	10.3 to 13.0	14.50 to 9999	0.2413 to 3952	0.0145 to 237.1	0.0003 to 3.952
10 ml	14.57 to 15.9	28.97 to 9999	0.4828 to 7909	0.0290 to 474.5	0.0005 to 7.909
20 ml	19.13 to 20.05	54.86 to 9999	0.9142 to 9999	0.0549 to 898.6	0.0010 to 14.97
30 ml	21.7 to 23.2	72.81 to 9999	1.214 to 9999	0.0729 to 1192	0.00013 to 19.88
50 ml	26.7 to 32.6	97.27 to 9999	1.622 to 9999	0.0973 to 1576	0.0017 to 26.56

* Note: These figures have been rounded and therefore may not exactly match the Syringe Diameter Chart on page 50.

Pump 22 Flow Rates

Syringe Size	Diameter, mm*	µl/hr Min to Max	µl/min Min to Max	ml/hr Min to Max	ml/min Min to Max
0.5 µl	0.10	0.002 to 23.8	–	–	–
1 µl	0.15	0.003 to 47.8	–	–	–
2 µl	0.21	0.006 to 95.2	–	–	–
5 µl	0.33	0.015 to 238.0	–	–	–
10 µl	0.46	0.029 to 474.0	–	–	–
25 µl	0.73	0.073 to 1193.0	–	–	–
50 µl	1.03	–	0.002 to 39.7	–	–
100 µl	1.46	–	0.005 to 79.7	–	–
250 µl	2.30	–	0.012 to 197.8	–	–
500 µl	3.26	–	0.024 to 397.0	–	–
1000 µl	4.61	–	0.048 to 795.0	–	–
1 ml	5.00	–	0.049 to 805.0	–	–
2 ml	9.00	–	–	0.011 to 186.6	–
2.5 ml	7.28 to 9.6	–	–	0.10 to 168.2	–
3 ml	8.66 to 9.0	–	–	0.011 to 181.4	–
5 ml	10.3 to 13.0	–	–	0.019 to 317.0	–
10 ml	14.57 to 15.9	–	–	0.028 to 461.0	–
20 ml	19.13 to 20.05	–	–	0.050 to 821.0	–
30 ml	21.7 to 23.2	–	–	0.074 to 1208.8	–
50 ml	26.7 to 32.6	–	–	–	0.002 to 28.4
100 ml	34.9 to 35.7	–	–	–	0.003 to 47.6
140 ml	38.40	–	–	–	0.004 to 55.1

* Note: These figures have been rounded and therefore may not exactly match the Syringe Diameter Chart on page 50.

Syringe Pump Pressure and Flow Rate

Minimum/Maximum Flow Rates By Pump and Syringe Size (continued)



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Pump 33 Flow Rates

Syringe Size	Diameter, mm*	µl/hr Min	µl/min Max	ml/hr Max	ml/min Max
0.5 µl	0.103	0.0004	0.79	–	–
1 µl	0.1457	0.0008	1.58	–	–
2 µl	0.206	0.0015	3.1	–	–
5 µl	0.3257	0.0037	7.93	–	–
10 µl	0.46	0.0073	950.05	–	–
25 µl	0.73	0.0183	2386.10	–	–
50 µl	1.03	0.0365	4772.50	–	–
100 µl	1.46	0.0731	9570.50	–	–
250 µl	2.30	0.1813	–	23.751	–
500 µl	3.26	–	–	–	–
1000 µl	4.61	0.7281	–	95.418	–
1 ml	5.00	0.7828	–	102.580	–
2 ml	9.00	2.8493	–	373.430	–
2.5 ml	7.28 to 9.6	1.8156	–	237.950	–
3 ml	8.66 to 9.0	2.5691	–	336.710	–
5 ml	10.3 to 13.0	4.9824	–	653.010	–
10 ml	14.57 to 15.9	7.2024	–	–	15.733
20 ml	19.13 to 20.05	12.536	–	–	27.384
30 ml	21.7 to 23.2	16.131	–	–	35.236
50 ml	26.7 to 32.6	24.4201	–	–	53.346
100 ml	34.9 to 35.7	–	0.087	–	91.20
140 ml	38.40	–	0.1053	–	110.41

* Note: These figures have been rounded and therefore may not exactly match the Syringe Diameter Chart on page 50.

PHD 22/2000 and PHD 4400 Hpsi Flow Rates

Syringe Size	Diameter, mm*	µl/hr Min	µl/min Max	ml/hr Max	ml/min Max
0.5 µl	0.10	0.0001 to 95.330	–	–	–
1 µl	0.15	0.0002 to 190.70	–	–	–
2 µl	0.21	0.0004 to 381.30	–	–	–
5 µl	0.33	0.0010 to 953.17	–	–	–
10 µl	0.46	0.0019	–	1.901	–
25 µl	0.73	0.0046	–	4.775	–
50 µl	1.03	0.0092	–	9.551	–
100 µl	1.46	0.0183	–	19.153	–
250 µl	2.30	0.0454	–	47.532	–
500 µl	3.26	0.0911	–	95.492	–
1000 µl	4.61	–	0.0031	190.950	–
1 ml	5.00	–	0.0033	205.30	–
2 ml	9.00	–	0.0119	747.35	–
2.5 ml	7.28 to 9.6	–	0.0076	476.21	–
3 ml	8.66 to 9.0	–	0.0100	–	11.231
5 ml	10.3 to 13.0	–	0.0208	–	21.781
10 ml	14.57 to 15.9	–	0.0301	–	31.486
20 ml	19.13 to 20.05	–	0.0523	–	54.804
30 ml	21.7 to 23.2	–	0.0673	–	70.518
50 ml	26.7 to 32.6	–	0.1019	–	106.76
100 ml	34.9 to 35.7	–	0.1740	–	182.40
140 ml	38.40	–	0.2106	–	220.82

* Note: These figures have been rounded and therefore may not exactly match the Syringe Diameter Chart on page 50.

Common Syringe Data

Diameter and Plunger Surface Area

The following list is a guide to common syringes and their associated diameters and surface area. Syringe diameter data, in mm, is listed below for each syringe. All Harvard Apparatus microprocessor syringe pumps require the user to input syringe diameter information. The pump uses this diameter data to set flow rates. The PHD 22/2000 series of syringe pumps also has this information built into the pump memory in a handy Syringe Look Up Table. Surface area information was used to calculate PSI

(pounds per square inch) data for the pressure table on page 53. Average pressures for any syringe pump and syringe combination can be calculated by dividing the average (nominal) syringe pump force by the syringe diameter (in square inches) to obtain PSI. Example, nominal pressure obtained using a 25 ml Hamilton Gastight® Syringe on a PHD 22/2000 standard pressure syringe pump would be: 50 lbs / 0.644 in² = 77.6 PSI (5.35 bars).

Common Syringes and Their Diameters

Volume	Dia. (mm)	Surface Area (in ²)
BD Plastic		
1 ml	4.78	0.027815
3 ml	8.66	0.091297
5 ml	12.06	0.177059
10 ml	14.5	0.255952
20 ml	19.13	0.445505
30 ml	21.7	0.573247
50/60 ml	26.7	0.867851
BD Glass		
0.5 ml	4.64	0.026209
1 ml	4.64	0.026209
2.5 ml	8.66	0.091297
5 ml	11.86	0.171235
10 ml	14.34	0.250335
20 ml	19.13	0.445505
30 ml	22.7	0.627298
50 ml	28.6	0.995760
100 ml	34.9	1.482768
SGE Glass		
25 µl	0.73	0.000649
50 µl	1.03	0.001292
100 µl	1.46	0.002595
250 µl	2.3	0.006440
500 µl	3.26	0.012938
1 ml	4.61	0.025872
2.5 ml	7.28	0.064519
5 ml	10.3	0.129151
10 ml	14.57	0.258429
Harvard Apparatus Stainless Steel		
2.5 ml	4.791	0.027937
8 ml	9.525	0.110447
20 ml	19.13	0.445505
50 ml	28.6	0.995760
100 ml	34.9	1.482768
200 ml	44.75	2.438382

Volume	Dia. (mm)	Surface Area (in ²)
Ranfac Glass		
2 ml	9.12	0.101254
5 ml	12.34	0.185376
10 ml	14.55	0.257720
20 ml	19.86	0.480154
30 ml	23.2	0.655237
50 ml	27.6	0.927343
Terumo Plastic		
3 ml	8.95	0.097514
5 ml	13	0.205735
10 ml	15.8	0.303904
20 ml	20.15	0.494279
30 ml	23.1	0.649601
60 ml	29.1	1.030881
Air-Tite All Plastic		
2.5 ml	9.6	0.112193
5 ml	12.45	0.188695
10 ml	15.9	0.307763
20 ml	20.05	0.489386
30 ml	22.5	0.616293
50 ml	29	1.023808
Popper & Sons Perfectum Glass		
0.5 ml	3.45	0.014490
1 ml	4.5	0.024652
2 ml	8.92	0.096862
3 ml	8.99	0.098388
5 ml	11.7	0.166646
10 ml	14.7	0.263061
20 ml	19.58	0.466711
30 ml	22.7	0.627298
50 ml	29	1.023808
100 ml	35.7	1.551525

Volume	Dia. (mm)	Surface Area (in ²)
Hamilton Gastight Glass		
0.5 µl	0.103	0.000013
1 µl	0.1457	0.000026
2 µl	0.206	0.000052
5 µl	0.3257	0.000129
10 µl	0.46	0.000258
25 µl	0.729	0.000647
50 µl	1.031	0.001294
100 µl	1.46	0.002595
250 µl	2.3	0.006440
500 µl	3.26	0.012938
1000 µl	4.61	0.025872
2.5 ml	7.28	0.064519
5 ml	10.3	0.129151
10 ml	14.57	0.258429
25 ml	23	0.643989
50 ml	32.6	1.293772
Unimetrics - 4000 and 5000 Glass		
10 µl	0.46	0.000258
25 µl	0.729	0.000647
50 µl	1.031	0.001294
100 µl	1.46	0.002595
250 µl	2.3	0.006440
500 µl	3.26	0.012938
1000 µl	4.61	0.025872
Kendall Monoject Plastic		
1 ml	4.65	0.026323
3 ml	8.94	0.097297
6 ml	12.7	0.196350
12 ml	15.9	0.307763
20 ml	20.4	0.506621
35 ml	23.8	0.689567
60 ml	26.6	0.861362
140 ml	38.4	1.795084

How to Select the Correct Syringe for Your Application



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Syringe Type/Size	Swage Lock	Luer Lock	RN	Threaded 1/4" 28	Luer Slip Fit	Pressure Maximum p.s.i.	Compatibility with Substance in Syringe	Accuracy 1%	Accuracy 5%	Materials
Stainless Steel Syringes, see Syringes and Needles pages 2 to 3										
2.5 ml	•					7,500	Maximum	•		316 / St. Steel
8 ml	•					1,500	Maximum	•		316 / Perfluoroelastomer
20 ml	•	•				750	Maximum	•		316 / Viton or Perfluoroelastomer
50 ml	•	•				750	Maximum	•		316 / Viton or Perfluoroelastomer
100 ml	•	•				750	Maximum	•		316 / Viton or Perfluoroelastomer
200 ml	•	•				750	Maximum	•		316 / Viton or Perfluoroelastomer
Perfluoroelastomer										
Glass GasTight Syringes, see Syringes and Needles pages 4 to 7										
1 to 100 µl		•	•	•	•	1,000	Maximum	•		Glass and Teflon
250 to 500 µl		•	•	•	•	500	Maximum	•		Glass and Teflon
1 to 10 ml		•	•	•		200	Maximum	•		Glass and Teflon
25 to 100 ml		•	•	•		100	Maximum	•		Glass and Teflon
Glass Multifit Syringes, see Syringes and Needles page 8										
2 to 50 ml		•				100	Maximum	•		Glass Only
Plastic Syringes, see Syringes and Needles pages 9 to 10										
1 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber
5 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber
10 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber
20 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber
30 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber
50/60 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber
140 ml		•			•	125	Minimum		•	Polypropylene and Natural Rubber

Needle Cross Reference Chart



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French Scale and Needle Gauge Cross Reference Chart

French Scale*	Exact French OD		Needle Gauge	Exact Gauge OD		Exact Gauge ID		Volume μ /in
	in	mm		in	mm	in	mm	
–	0.0083	0.21	33	0.0083	0.21	0.0040	0.11	0.20
–	0.0093	0.24	32	0.0093	0.24	0.0043	0.11	0.20
–	0.0103	0.26	31	0.0103	0.26	0.0053	0.13	0.34
–	0.0123	0.31	30	0.0123	0.31	0.0063	0.16	0.45
1	0.013	0.33	29	0.013	0.33	–	–	–
–	0.014	0.36	28	0.014	0.36	0.0073	0.18	0.63
–	0.016	0.41	27	0.016	0.41	0.0083	0.21	0.80
–	0.018	0.46	26	0.018	0.46	0.0103	0.26	1.25
1.8	0.024	0.61	25	0.023	0.51	0.0103	0.26	1.25
–	0.022	0.57	24	0.022	0.57	0.0123	0.31	1.80
2	0.026	0.66	23	0.025	0.64	0.0133	0.34	2.17
–	0.028	0.72	22	0.028	0.72	0.0163	0.41	3.35
2.4	0.031	0.79	21	0.032	0.82	0.0203	0.51	5.19
2.9	0.038	0.97	20	0.036	0.91	0.0238	0.60	6.71
3	0.039	0.99	–	0.039	0.99	–	–	–
3.3	0.043	1.09	19	0.042	1.07	0.0270	0.69	–
3.7	0.048	1.22	–	0.048	1.22	–	–	–
3.8	0.050	1.27	18	0.050	1.27	0.0330	0.84	14.08
4	0.052	1.32	–	0.052	1.32	–	–	–
4.6	0.060	1.52	17	0.058	1.47	0.0420	1.07	22.84
4.7	0.062	1.57	–	0.062	1.57	–	–	–
5	0.066	1.68	16	0.065	1.65	0.0470	1.19	28.25
5.1	0.067	1.70	–	0.067	1.70	–	–	–
5.7	0.075	1.91	15	0.072	1.83	0.0540	1.37	–
5.9	0.078	1.98	–	0.078	1.98	–	–	–
6	0.079	2.01	–	0.079	2.01	–	–	–
6.2	0.082	2.08	14	0.083	2.11	0.0630	1.60	51.07
7	0.092	2.34	–	0.092	2.34	–	–	–
7.2	0.095	2.41	13	0.095	2.41	0.0710	1.80	64.63
8	0.105	2.67	–	0.105	2.67	–	–	–
8.1	0.106	2.69	–	0.106	2.69	–	–	–
–	0.109	2.77	12	0.109	2.77	0.0850	2.16	93.07
8.4	0.118	3.00	11	0.120	3.05	0.0940	2.39	113.00
9.8	0.128	3.25	–	0.128	3.25	–	–	–
10	0.131	3.33	10	0.134	3.40	0.1060	2.69	143.28
11	0.145	3.68	–	0.145	3.68	–	–	–
11.7	0.153	3.89	–	0.153	3.89	–	–	–
12.3	0.161	4.09	–	0.161	4.09	–	–	–
13	0.171	4.34	–	0.171	4.34	–	–	–
14	0.184	4.67	–	0.184	4.67	–	–	–
15	0.197	5.00	–	0.197	5.00	–	–	–
16	0.210	5.33	–	0.210	5.33	–	–	–
17	0.223	5.66	–	0.223	5.66	–	–	–
18	0.236	5.99	–	0.236	5.99	–	–	–

* French Scale = OD (in) x 76.211 - 0.0014

Pressure Unit Conversion Chart



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Pressure Cross Reference Chart

Pressure Unit Cross Reference Chart

	atm	psi	cm H ₂ O	mm Hg	kPa	inch H ₂ O	inch Hg	mbar
1 atm =	1	14.696	1033.228	760	101.325	406.783	29.921	1013.25
1 psi =	0.068	1	70.307	51.715	6.895	27.68	2.036	68.948
1 cm H ₂ O =	0.001	0.0142	1	0.7356	0.0981	0.3937	0.0291	0.9807
1 mm Hg =	0.0013	0.0193	1.36	1	0.133	0.5352	0.039	1.333
1 kPa =	0.0099	0.145	10.197	7500.616	1	4.015	0.295	10
1 inch H ₂ O =	0.0025	0.036	2.54	1.868	0.2491	1	0.0736	2.491
1 inch Hg =	0.0334	0.4912	34.532	25399	3.386	13.595	1	33.864
1 mbar =	0.001	0.015	1.02	0.7501	0.1	0.4015	0.0295	1

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Force Conversion Table

Conversion Table for Force Units

mN	mg-force	mp
0.1	10	10.2
0.2	20	20.39
0.3	30	30.59
0.4	40	40.79
0.5	50	50.99
0.6	60	61.18
0.7	70	71.38
0.8	80	81.58
0.9	90	91.77
1	100	101.97
2	200	203.94
3	300	305.91
4	400	407.89
5	500	509.86
6	600	611.83
7	700	713.8
8	800	815.77
9	900	917.74

1N = 1 Newton = 1 kg m/s²

1p = 1 Pond

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