Fanavaran Nano-Meghyas

Syringe Pump series user's mannual

2013

Fnm.ir

General Information:

Serial Number

All inquiries concerning our product should refer to the serial number of the unit. Serial numbers are located on the rear of the case.

Calibration

All syringe pumps are designed and manufactured to meet their performance specifications at all rated voltages and frequencies. It's necessary to calibrate the instrument every 6 month. It's suggested that choose a 10-mililitre syringe and a 1-mililitre target, then measure the amount of pedal (pusher block) movement forwards in 1, 6, 60 and 120 ml/h. The movement must be 12.73 mm. To measure the accuracy of internal timer, the injection time must be 60, 10, 1 and 0.5 minutes.

Warranty

FNM syringe pump is warranted for a period of one year (for replacing the parts) and 5 years (for repairing) from date of purchasing. At its option, Fnm Co. will repair or replace the unit if it is found to be defective as to workmanship or material.

This warranty does not extend to:

- Damage resulting from transportation, wrong connections with other systems, connection with defective equipments, power fluctuations, fire or intensive heat, water or corrosive chemicals, dust, lightning, natural disasters, collision, misusing the instrument or neglecting the manual description.
- The instruments that have been repaired by other companies.
- The instruments that have been manipulated.
- Damaging the instrument labels or holograms
- Damage resulting from installation or updating the files, software, program and firmware by irresponsible people.
- Services extend to ten years in return for the payment of costs.

Repair Facilities and Parts

Fnm Co. stocks replacement and repair parts. While ordering, please describe parts as completely as possible. Preferably by using the part numbers, a sample or drawing.

CAUTION

This pump is not registered with the FDA and is not for clinical use on human or veterinary patients. It is intended for research use only.

Maintenance and General Safety Summary

GENERAL SAFETY SUMMARY

Please read the following safety precautions to ensure proper use of your syringe pump. To avoid potential hazards and product damage, use this product only as instructed in this manual. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury:

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

Use Proper Power Supply
The pump is supplied with an approved power supply and line cord. To maintain the safety integrity of the device, use only one of the following power supplies:

- Plastic body pumps: 12 Volt DC 3A
- Metal body pumps: 100 – 240 V AC, 50-60 Hz

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

Make Proper Connections
Make sure all connections are made properly and securely.

Use Proper Fuse
Use only specified fuses with product.

Avoid Exposed Circuitry
Do not touch any electronic circuitry inside of the product.

Do Not Operate with Suspected Failures
If damage is suspected on or to the device, do not operate it. Contact with qualified service personnel.

Place the device in Proper Environment
Review the operating manual for guidelines for proper operating environments. Keep the instrument in a dry, clean and flat place. Avoid connecting the ventilation fan near the walls.

High viscosity solutions

Don't use high viscosity solutions and syringes with very low diameter nozzle (High gauges size).

Finishing the solution

Switch off the system after finishing the solution (Note: the target must always set at a suitable value).

Clean the syringe pump

Clean the keyboard and body of the instrument with a medium detergent.

Oiling

Oil the screws and their connections in certain time.

Nozzle Cleaning

After finishing the work, clean inside of nozzle and connections completely, put a piece of thin wire inside the nozzle in order to avoid drying polymeric solution.

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

Using an organic solvent

Notice that the used hose is able to solve in some organic solvents, so use Teflon or Polyethylene hose instead of PVC.

Please inform FNM Co. staff if there is any problem.

The instrument limits:

Accuracy largely depends on the syringe and its diameter. Measurement error will directly cause the injection error.

Warning:

The sound alarm inside the device can be set up to warn the user when completing each order.

Introduction

Theory of Operation

Syringe pump

The syringe pump of Fanavaran Nano-Meghyas co. has been designed as a low cost product in order to use of a variety of syringes. The system is able to inject the certain volume of solution with different rates. All six models in the SP1000 and SP2000 series employ a microcontroller which controls a small step angle stepping motor that drives a lead screw and Pusher Block. Micro-stepping techniques are employed to further reduce the step angle, eliminating flow pulsation. A keypad is used for entering the data to the pump. Data can also be

entered via an USB connector located on the rear panel in S models. The diameter of the syringes is entered via the keypad and the internal microprocessor drives a precision stepper motor to produce accurate fluid flow.

The pump can hold syringes of any make from about 1 μl to 60ml for the dual syringe version and from 1 μl to 50ml for the ten-syringe version. The diameter of the syringes is entered via the keypad and the internal microprocessor drives a precision stepper motor to produce accurate fluid flow. Nonvolatile memory stores the last syringe diameter and flow rate along with other configuration data.

The SP1000/SP2000 Programmable and software models are equipped with all the functions of the ordinary models along with additional features to provide the Withdraw (Refuse) function and along with additional features to provide Programmable functions. The P and S model's additional features include five additional function keys on the keypad, Mode, Program, Refill and two pedal position control keys. Usage of the keys is described in detail in this manual.
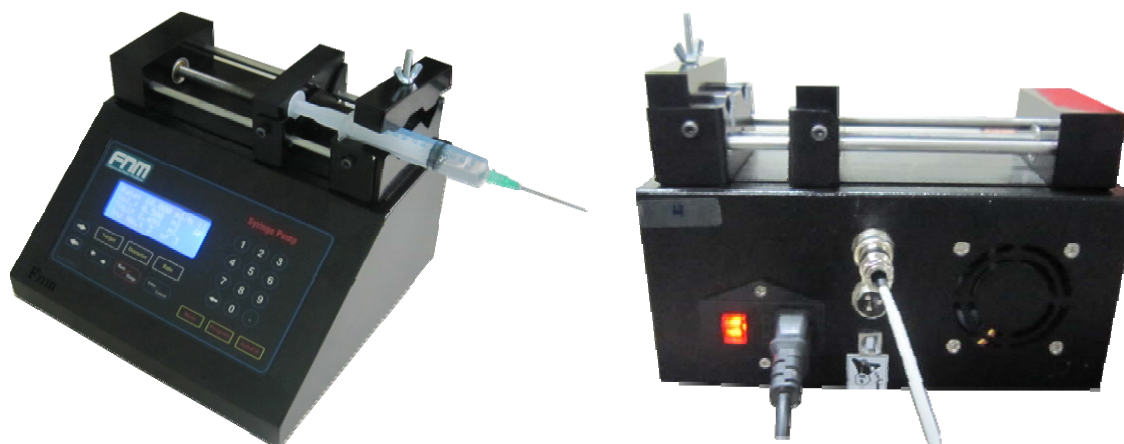
Front and rear of syringe pump

Features

Bright Display and Easy-To-Use Interface

Using a 2- or 4- row display causes to show the essential information, and its background light facilitates the reading of information in the darkness. Using 20-25 keys avoids the need for a multi-menu, so the system will be set and will start to operate by pressing a few keys. Different parameters such as flow rate, syringe diameter, maximum of injection are adjustable.

Pressure and rate

SP1000 can deliver solution up to 1000 ml/hour with a single 60 ml syringe. Maximum pressure is dependent on syringe size.

Syringe Table and Custom Syringes

If a non-standard syringe is to be used, enter the inside diameter of the syringe in millimeters. If a standard syringe is to be used, use the pump's built-in syringe table. Syringes are arranged according to manufacturer and material, and then according to size. (See Appendix A).

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 in the Volume mode.

Modes of Operation

Pump

Runs continuously, in the infuse or refill directions, until stopped. Refill not applicable to the Infusion model.

Volume

Runs until a specified volume has been pumped or refilled. Refill not applicable to the Infusion model.

Program

The pump operates according to a specified sequence of instructions.

Nonvolatile Memory

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

Visual/Audible Alarm

The alarm can be selected to be a silent or an audible signal in addition to display alarms in Alarm menu.

Program Storage (Programmable and software models)

Programmable model can store up to 9 program sequences.

Smooth injection:

Using a high accuracy motor and driver profiles deliver very smooth and consistent flow, that is virtually pulse free.

Adjusting the Pusher Block:
Using four keys that move the location of pusher block forward or backward can cause adjusting of its position rapidly.

Package contents:
Contents of the syringe pump package are Power cable, User manual and Fuse. In software models, software CD and USB cable is also included.

Applications
The system is used for small controlled injection of solution. Some applications are:
- Cellular injection
- Controlled injection of drug
- Electrospinning (caution: the earth connection must be completed to avoid the influence of high voltage power supply)
- Controlled injection of a reactant into the reactor
- Lab-on-a-chip

Nomenclature of different models of syringe pumps
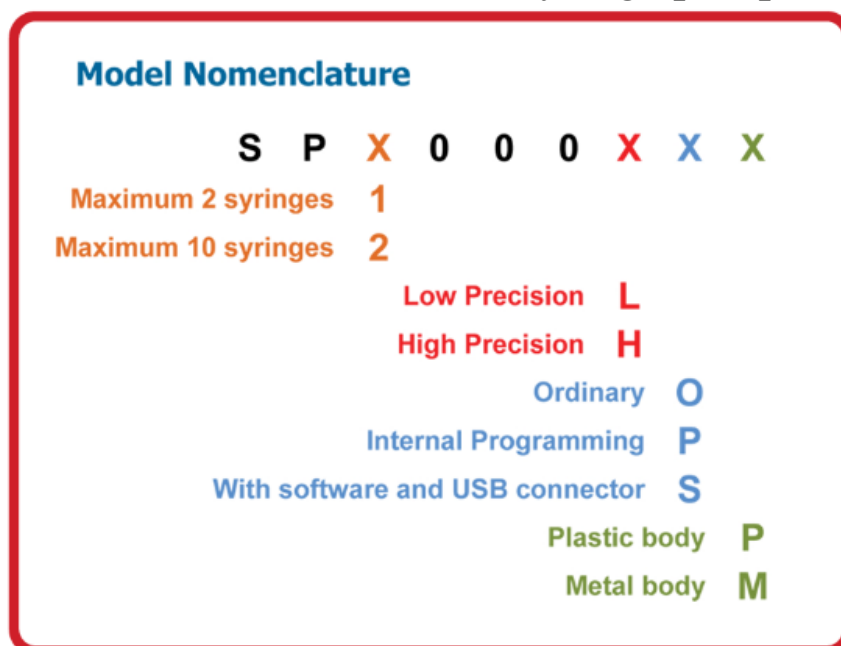
Example: SP1000HPM; maximum 2 syringes, High Precision, Programmable, Metal body

Specifications of different models of syringe pumps

Model	SP2000H SM	SP2000H PM	SP2000L OM	SP1000H SM	SP1000H PM	SP1000H OM	SP1000 HOP	SP1000L OM	SP1000 LOP
Body	Metal	Metal	Metal	Metal	Metal	Metal	Plastic	Metal	Plastic
Max. Syringe No.	10	10	10	2	2	2	2	2	2
Input Voltage	100-240 AC	100-240 AC	100-240 AC	100-240 AC	100-240 AC	100-240 AC	12 V DC	100-240 AC	12 V DC
Display (line * Character)	4 * 20	4 * 20	4 * 20	4 * 20	4 * 20	4 * 20	2 * 16	4 * 20	2 * 16
Keypad (switch numbers)	25	25	20	25	25	20	20	20	20
Internal Programming	✓	✓	–	✓	✓	–	–	–	–
Computer Control	✓	–	–	✓	–	–	–	–	–
Autofill	✓	✓	–	✓	✓	–	–	–	–
Max. syringe size (ml)	50	50	50	60	60	60	50	60	50
Min. injection rate (microliter per hour)	0.5	0.5	128	0.5	0.5	0.5	0.5	128	128
Min. injection rate (mililiter per hour)	640	640	640	1000	1000	1000	640	1000	640
Pedal Resolution per step (nm)	13	13	3125	13	13	13	13	3125	3125
Weight (kg)	4	4	4	3.5	3.5	3.5	2.5	3.5	2.5

Installation:

Physical installation

The following conditions must be noticed at the place where you work.
- A dry, clean and hard surface for keeping the instrument.
- Minimum of one inch (about 2 cm) clearance around the pump
- suitable bio-environmental conditions
- a proper ventilation

Installation steps:

- Plug in the power cable (in metal models) or a 12-volt adaptor (in plastic models), and then connect it to the input voltage of pump.
- Turn on main power switch located on the rear panel. The display will now illuminate indicating that the power connections are correct. The display will indicate FNM Co. internet address for 3 seconds.
- In this step the device is ready to use.

```
Syringe Pump
SP1000HSM

www.fnm.ir
```

Software installation:

There is a computer software program only in HSM models with a CD. when the CD is put into CD-ROM drive, the installation program will run automatically.

The steps are:

1. Click on " software installation" button
2. Click on " Next" button
3. Select the installation path, then click on " Next"
4. Click on " Next"
5. The installation will be started
6. Click on " close" button

Driver installation:

a) Connect the USB cable to the computer and setup
b) Switch on the computer and setup
c) Click on the "Drive Installation" button then, installation will be started.
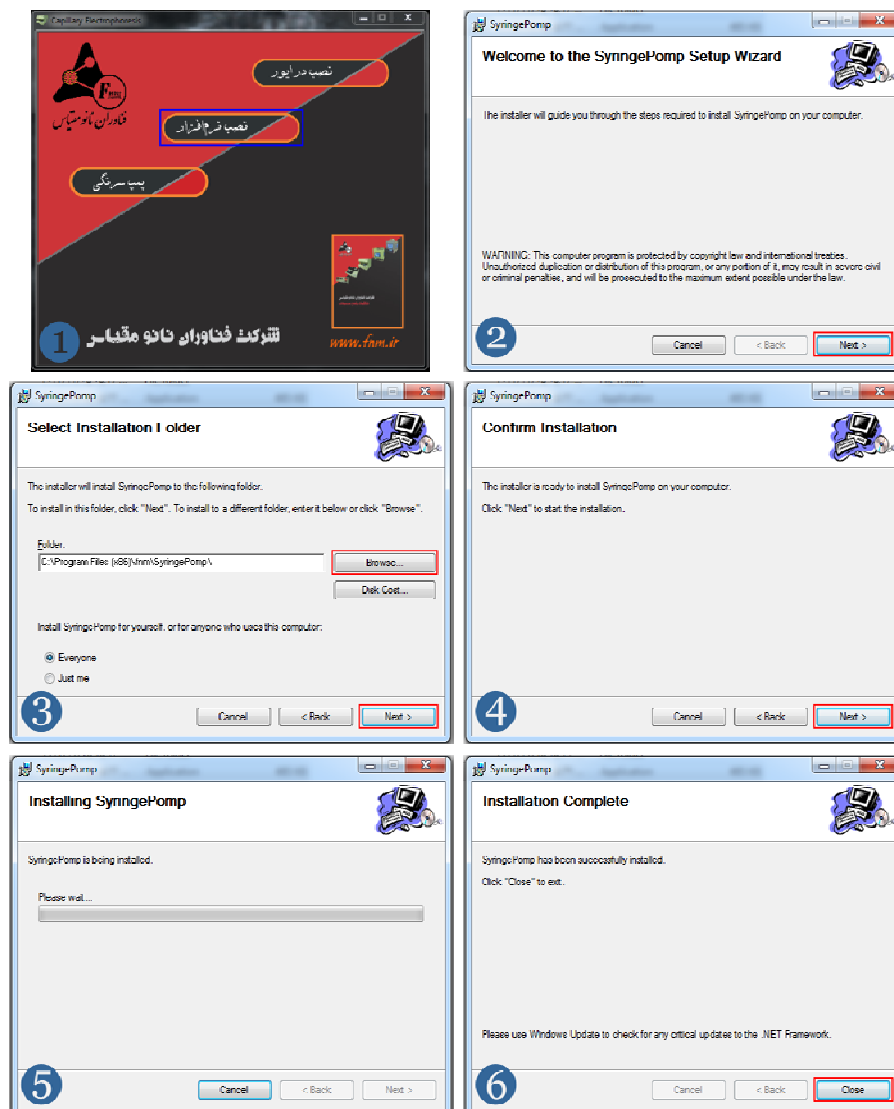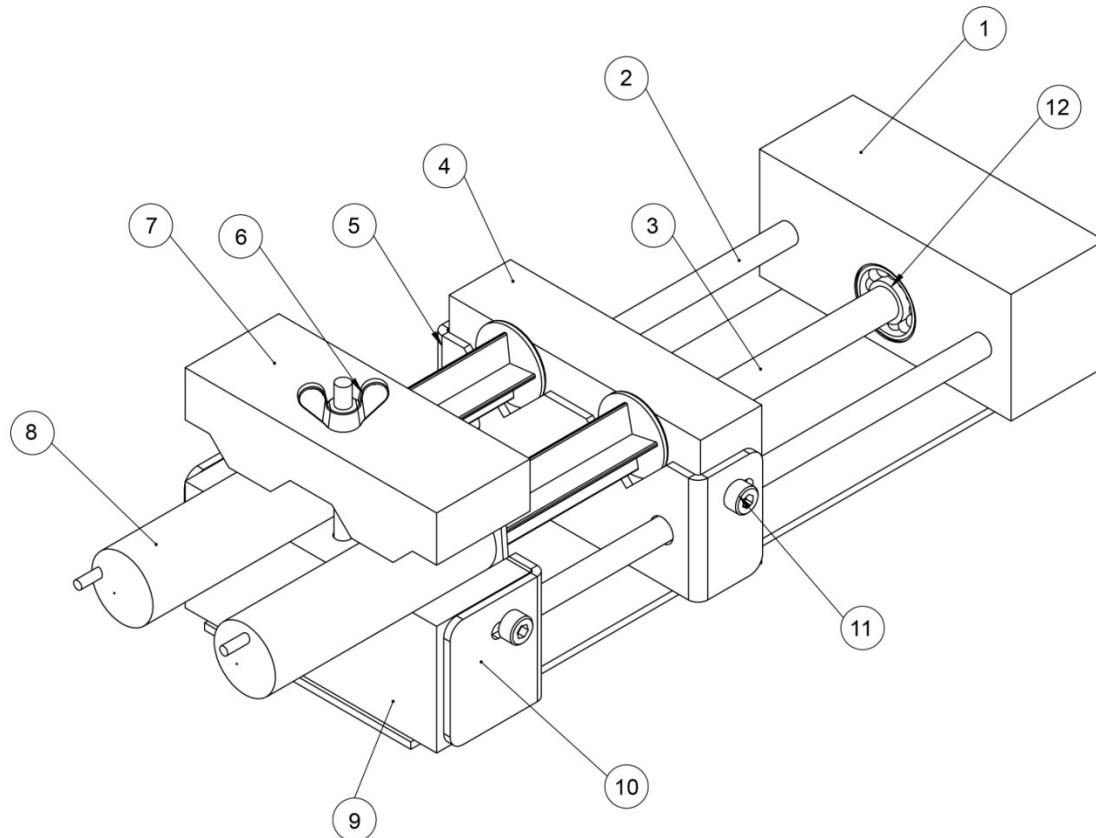
1. Back Block	7. Syringe Clamp
2. Guide	8. Syringe
3. Screw	9. Syringe Holder Block
4. Pusher Blocks	10. Retaining Bracket (Syringe Block)
5. Retaining Bracket (Pusher Block)	11. Allen Screw
6. Syringe Clamps	12. Bearing

Loading the Syringe

1. Adjust the syringe pusher block (4) by pressing the positional switches on the keypad.
2. Raise the spring loaded syringe retainer (7) and swing it out of the way.
3. Lay the loaded syringe in the 'V' shaped syringe block (9).
4. Swing the syringe retainer (7) so it holds the syringe in place.
5. Move the pusher, so it makes contact with the syringe plunger.
6. Adjust pusher block thumbscrews & bracket (5) & (10) until the syringe plunger is completely captured.
7. Tighten down thumbscrews on syringe block bracket so that it captures flanges on syringe barrel.
8. Tighten thumbscrew into place when switch is set.

User Interface

Fnm syringe pumps have 2 types of panels. These panels have 20-25 keys and a 2- or 4-row display.

Programmable and software models Keypad (left). Ordinary model Keypad (Right)

The user interface consists of a keypad with a display area. The panel consists of a 4-row, 20-character alphanumeric vacuum green or blue fluorescent display. The display will show one of three types of messages: Default display, setting display, or an informational message. The first row is divided into three sections: flow rate with 3 decimal points, injection unit and ">>" or "||" part that shows the moving state of the motor.

The second row is injection volume with the unit expressed as 'ml' for milliliters; "ul" for microliter and "nl" for nanoliter. The third row is target volume.
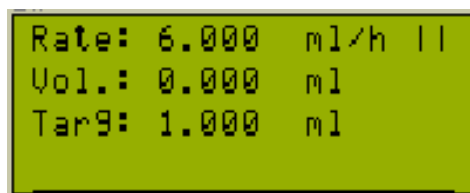
Setting displays are used to facilitate entering data into the pump. Data entry will be discussed in detail later in this section. Informational messages occur at various times to indicate such items as a data setting out of range, or a detected problem such as the pump out of range flow rate. Pressing any key clears the message from the display.

DESCRIPTION OF KEYS

The keypad consists of 20 keys on the ordinary model and 25 keys on the Programmable and software models. The keys are used for entering control information and data into the pump. These keys are grouped into 3 sections: Set keys, operational keys, and Data Entry keys.

Data Entry Keys ⭕

⓪⓪①②③④⑤⑥⑦⑧⑨ Used to enter numeric data values or access special features.
ENTER: Saves and stores displayed data value in memory when setting a data item.
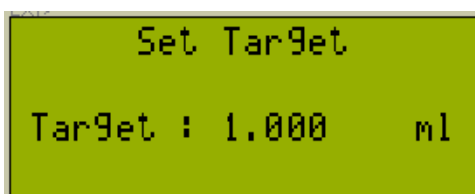Cancel: Cancel the new displayed data and return the stored value.

## *Set Keys* ▭

Three parameters are adjustable:

Target **Target (The Maximum of injection volume)**

If you want to stop the system after injecting a certain volume of solution, you must press
the button *"Target"*

```
        Set Target

Target : 1.000     ml
```

Then enter the volume by numeric keys on the panel (**⓪⓪①②③④⑤⑥⑦⑧⑨**). After
injection, the system will be stopped and the following page wills appeare.

```
Task finished.
```
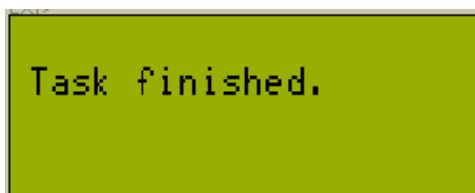
For removing the last entered number, you can use the "<=" key. In order to save the value,
press just "*Enter*" switch. If you want to have the previous value, press just "*Cancel*" key.
Nonstop injection: It must be to set Target in 0 to have a nonstop injection.
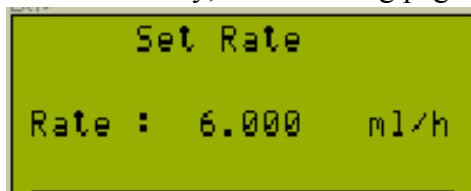
Diameter **Diameter (The diameter of used syringe):**

It's the most important parameter in calculating the flow rate, so it's necessary to measure
and enter it correctly. First, press the button "*Diameter*", then enter the diameter value on the
page (that has been appeared) by pressing the numbers on the panel. When the syringe is
changed, the new diameter value must be set. Units are in millimeters (mm). Enter the inside
diameter (ID) of the syringe you wish to use. If you do not know your syringe diameter, refer to
appendix B for nominal inside diameters of most popular syringes. For the greatest accuracy or if
your syringe is not listed in appendix B, measure the inside diameter with a vernier caliper or
other precision measuring tool. Record this value for future use.

```
        Set Diameter

Diameter : 10.0     mm
```
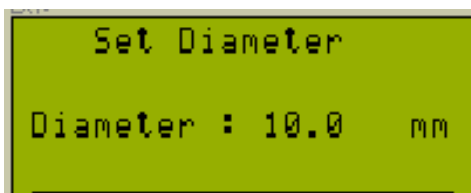
Rate **Flow rate (Infuse rate):**

The unit of flow/infuse rate is milliliter/hour, microlitre/min and nanoliter/second that is volume of the solution that is injected from the syringes per hour, minute and second.

For setting the rate, press the "Rate" key, the following page appears.

```
        Set Rate

Rate :   6.000    ml/h
```

Finally, enter the rate value. Press the "Enter" key while setting. The display shows current programmed rate while running in program mode.

The Max. and Min of rate:

The Maximum and Minimum of rate depend on the syringe diameter. In order to increase injection accuracy, it's better to use a 5-ml syringe for rates less than 10 ml/h, and a 2-ml syringe for rates less than 2 ml/h. For more rates, syringes larger than 5 ml must be used. The information about choosing proper rates is at the end of the manual description.
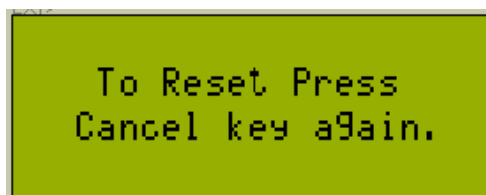
If the chosen rate is more than the definite rate, the display will show "Error". In this case, you must use a larger syringe.

```
        Error
Rate value must be
positive and less
than 175.301   ml/h
```
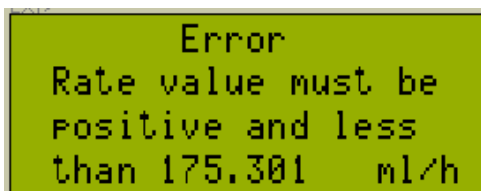
Changing the injection unit in HOM models:

In order to change the unit in SP1000HOM, press the "Rate" switch twice. The unit will be microlitre/min.
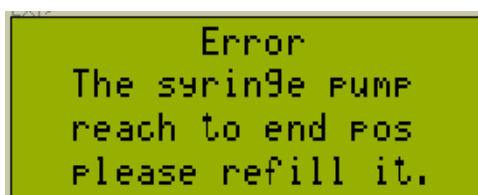
```
        Set Rate

Rate :    100      ul/m
```
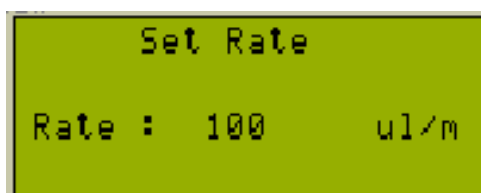
Reset the injected volume: The "Cancel" key must be pressed twice to set the injected volume in zero.

<div align="center">

    To Reset Press
   Cancel key again.

</div>

Finishing the solution: In some models, when the pedal (Pusher Block) reaches to the end position, the system will automatically stop in order to avoid damaging to screws and the motor, so the pedal must be moved backwards by the positional keys and the syringe have to be changed.

<div align="center">

    Error
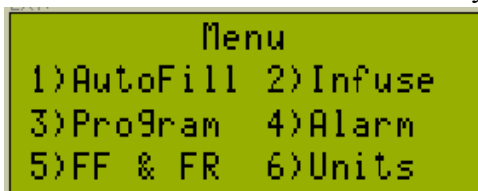   The syringe pump
    reach to end pos
    please refill it.

</div>

Note: The most of models don't have this switch, so be careful of finishing the solution.

The last data is saved in the memory of system. If the unit of volume is changed, the previous data will be removed and "zero" will be replaced. For example, if the last volume is 2000 microliter and the unit is changed to "ml", it will be remove (because 2000 ml is very large) and "zero" will be shown on display.
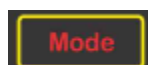
Mode **Mode/Menu:**

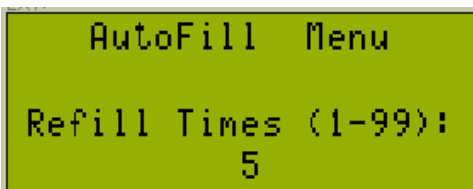There is a menu in HPM and HSM models that is available by pressing the "Mode" key.

<div align="center">

    Menu
    1)AutoFill 2)Infuse
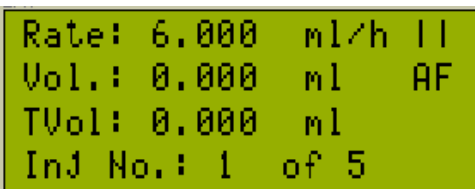   3)Program   4)Alarm
    5)FF & FR   6)Units

</div>

1. Autofill:

In some cases, it's necessary to return the syringe to its first position because of refilling it. At first, enter "Autofill", then select from 1 to 99 and press "Enter". The chosen number is times of repetition.

```
      AutoFill   Menu


 Refill Times (1-99):
          5
```
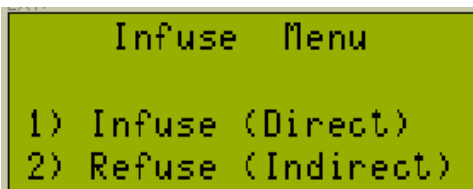
Finally, press "Autofill" on the menu. The "AF" will be appeared on the right of 2nd row.

```
Rate: 6.000   ml/h ||
Vol.: 0.000   ml    AF
TVol: 0.000   ml
InJ No.: 1   of 5
```

2. Infuse/Refuse (Pumping Direction):

"Infuse" section on the menu is used for changing the motor direction. If the key ❶ is chosen, the pusher block will move forwards, and by choosing the key ❷, the pusher block will move backwards.

```
      Infuse   Menu


 1) Infuse (Direct)
 2) Refuse (Indirect)
```
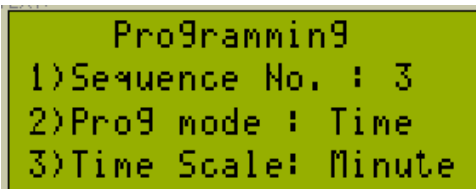
3. Programming:

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

Program Description

A program is made up of a set of sequences. Each sequence is a set of operating instructions for the pump to follow. When the pump starts in the PROGRAM mode, the pump will start at sequence 1 and execute the operating instructions in that sequence. When the pump has completed the instructions for a sequence, it will go to the next sequence and execute the instructions in that sequence. The pump continues this process until the pump is manually or remotely stopped, or the last sequence has been completed.

As shown on Programming page above, the first row is the Sequence No. that is chosen by pressing the key❶. The 2ⁿᵈ row (Prog Mode) shows two states of injection: Time and volume mode that are chosen by pressing the key❷. One of two strategies may be chosen for a sequence's target. Strategy 1 (Target Volume) pumps until a target volume is reached, while

Strategy 2 (Time Interval) pumps until a target time interval has elapsed. In this mode enter the time unit in hour, minute and second.

```
        Programming
1)Sequence No. : 3
2)Prog mode : Time
3)Time Scale: Minute
```
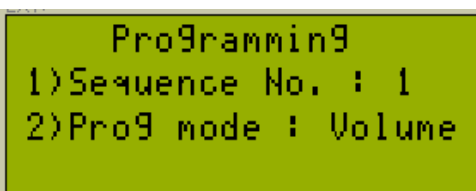
Programming in Time mode:

The unit of time can be changed by pressing the key❸. Press the "Enter" key to begin entering a program. When the required operation is displayed, press the "Enter" key. Extra information may be requested.

According to the chosen Sequence No. And Time unit, the proper time and rate of injection are selected. After selecting each value, the "Enter" key must be pressed. In order to exit each step, the "cancel" key must be pressed.
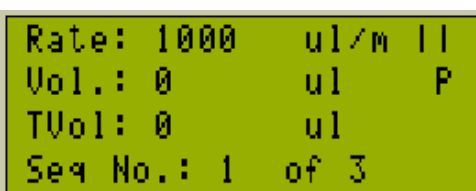
Programming in Volume mode:

Dispense specified volume. Runs at selected flow rate until a volume is pumped, then pump will stop. The maximum volume and proper rate of injection are selected. After selecting each value, the "Enter" key must be pressed. In order to exit each step, you must press the "cancel" key.

```
        Programming
1)Sequence No. : 1
2)Prog mode : Volume
```

By pressing the "Program" key on the main menu, the "P" will be appeared on the right of the 2nd row that is the state of motor in "Pragram".

```
Rate: 1000    ul/m ||
Vol.: 0       ul     P
TVol: 0       ul
Seq No.: 1   of 3
```

4. **Alarms:**

There are four types of alarms in the system:

Key	Name	Description
1	End Task	Alarm after completing every task
2	Refill	Alarm while refilling the syringe
3	Target	Alarm after injecting the target volume of solution
4	Limit Sw	Alarm when end switch is pressed

By pressing the keys 1-4, the alarm state will be changhed from On to Off or Off to On.

```
1)End Task Alarm:On
2)Refill    Alarm:On
3)Target    Alarm:On
4)Limit Sw Alarm:Off
```

5. **Fast Forward & Fast Reverse (Pusher Block adjustment)**

The pedal can be shifted by pressing the [←] and [→] keys. The FF & FR menu is used for having a certain shift.

```
FastForward length
(1-99 mm): 10
FastReverse length
(1-99 mm): 10
```

Note: when a certain pedal shift is performed, it won't be able to stop, so be careful, if a wrong shift is occurred, the pedal will hit the back or front of the instrument that can cause a mechanical damage.

6. **Units:**

A unit menu is used for defining the unit of injection rate and volume.

```
      Unit Menu
1)ml/h      4)nl/sec
2)ul/min  5)mm/min
3)ml/min  6)mm/hour
```

key	Flow Rate Unit	Flow Volume Unit	key	Flow Rate Unit	Flow Volume Unit
1	ml/h	Mililiter	4	nl/sec	Nanoliter
2	ul/min	Microliter	5	mm/min	Milimeter
3	ml/min	Mililiter	6	mm/hour	Milimeter

Note 1: If the syringe diameter is less than 4 mm, you can choose the key 4.

Note 2: If you choose the keys 5 or 6, the injection rate and volume will NOT depend on the syringe diameter.

Operational Keys
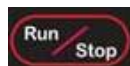
RUN/STOP (Starting the flow)

In order to start, press "Run" key. By pressing this key, the injection will start and by repressing it, the injection will stop.

Note: There is only one switch located in the middle of this key.

Enter/Cancel

In order to save the value, press "Enter" key. If you want to have the previous value, press "Cancel" key.

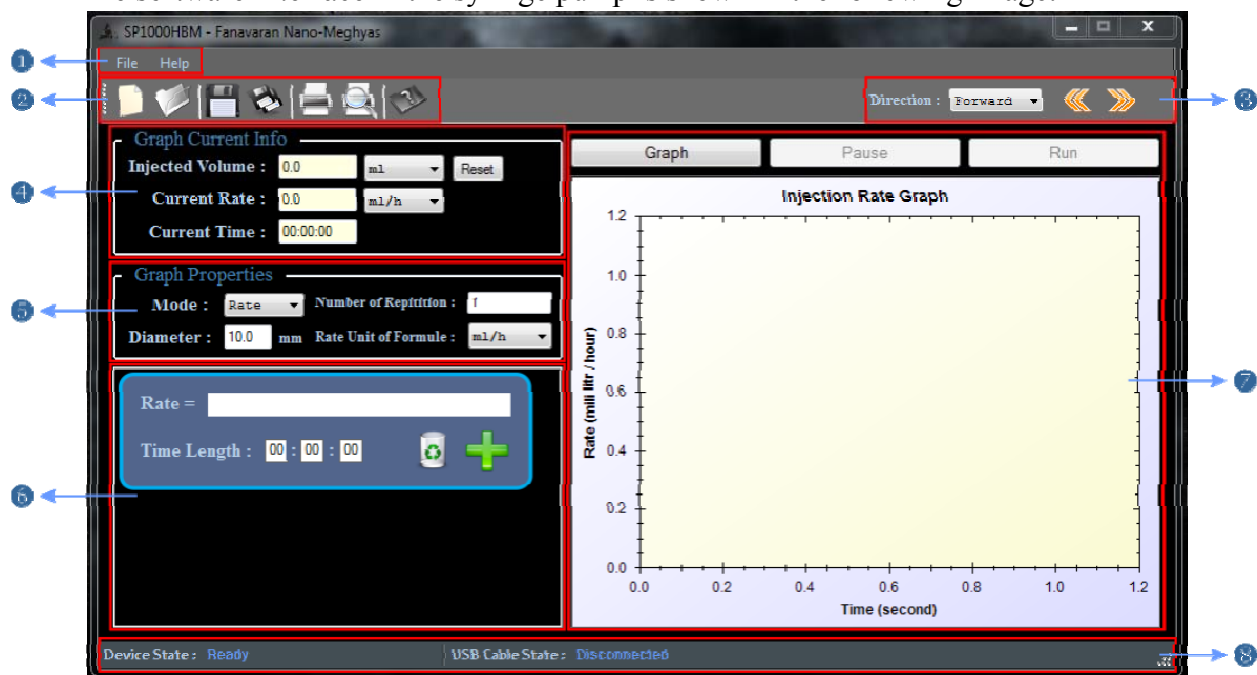Note: There are two switches located under "Enter" and "Cancel" keys.

Pusher Block adjustment

Use these switches for adjusting the position of pedal (pusher block)

Software interface:

The software interface in the syringe pump is shown in the following image:

①	Menu
②	Tool Box
③	adjust the position of pedal (pusher block) and direction of movement
④	Displaying the current information
⑤	Setting the parameters to draw a Rate-Time curve
⑥	Setting the curve equations and their time range
⑦	Rate-Time curve display and the related keys
⑧	Device state and computer connection display

Toolbar:
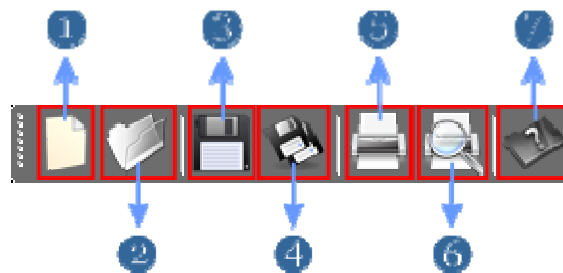
①	Removing the information and creating a new document with empty fields
②	Opening the previous saved document
③	Saving the data
④	Saving the data with a new name
⑤	Printing the data
⑥	Exhibiting the printed page
⑦	Help

Controlling the direction of movement and fast relocation:
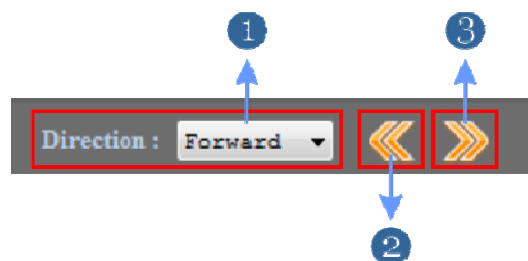
①	Determining the movement direction of the syringe
②	Fast relocation of the pusher block to backwards
③	Fast relocation of the pusher block to forwards

Current Data:

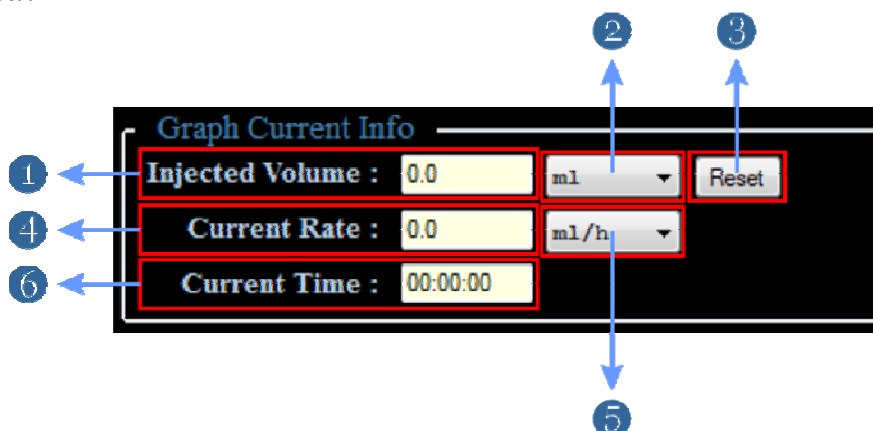| ①	Injected volume of solution
②	Unit of injected volume milliliter and micro-liter
③	Reset the injected volume to zero
④	Exhibiting the current rate of injection
⑤	Determining the unit of injection rate: ml/h and μl/min
⑥	The rest of time to complete the injection

Graph specifications:
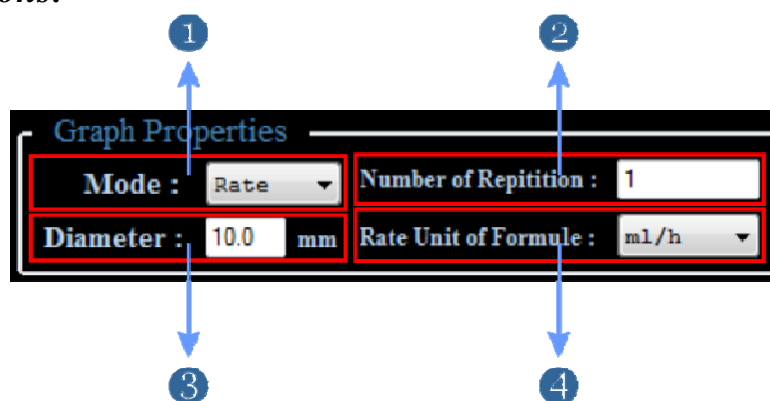
①	Determining the type of graph Rate: drawing the rate-time curve until specific time Volume: drawing the rate-time until specific volume
②	Number of repetition of the curve
③	Determining the syringe diameter (mm)
④	Determining the unit of flow rate

Rate-Time Curve:
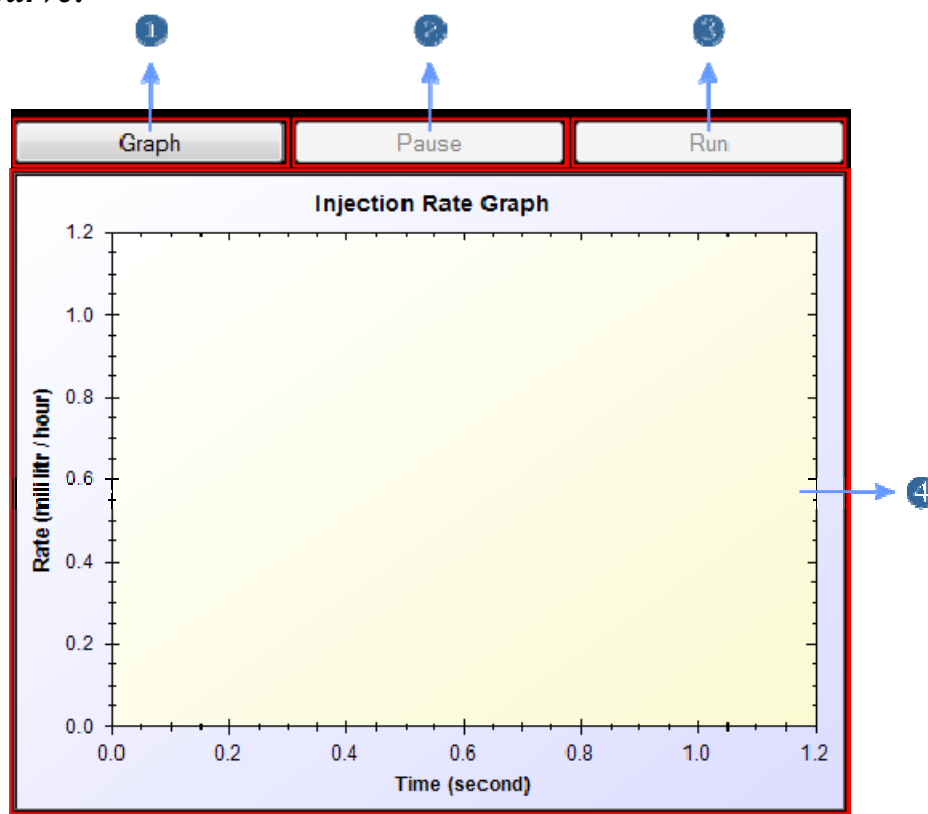
①	Drawing the graph by using the equations
②	Restarting/Pausing the injection
③	Starting/Stopping the injection
④	Rate-Time Curve

The curve equations:

If chosen graph is 'Rate', the curve equation and its time range will be needed. And if chosen graph is 'Volume', the curve equation and its injection volume range will be needed.
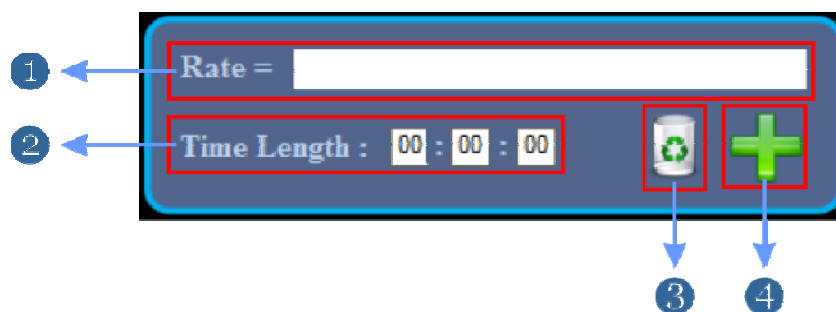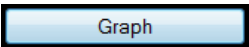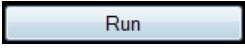
① Determining the curve equation
② Determining time range of the curve
③ Removing the current equation
④ Adding another equation after the last one

① Rate =
② Max Volume : 0.0   ml ▼   ○   +
③   ④   ⑤

① Determining the curve equation
② Determining the maximum volume of injected solution
③ Determining the unit of maximum injected volume: 1) ml and 2) µl
④ Removing the current equation
⑤ Adding another equation after the last one

Setting the specifications to inject a solution:

1. Setting the graph specifications (type of graph, sequence number of curves, syringe diameter and unit of flow rate).
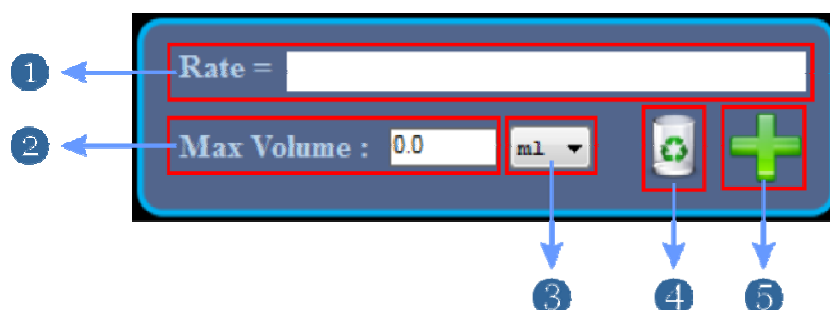2. Determining curve equations and their time/volume range
3. Drawing graphs by using the key `Graph`
4. Operating the injection by using the key `Run`

Example 1:

Imagine that an injection must be done by a 10-mm-diameter syringe, according to the following equation: (Unit of flow rate is microliter/min)

$$\begin{cases} t^2 + 1.5 \times t & 0 \le t < 10 \\ 10 \times \sin(t) + 20 & 10 \le t < 50 \\ 20 & 50 \le t < 70 \end{cases}$$

At first, in the graph specifications section, we choose syringe diameter=10 mm, type of graph: Rate, and unit of flow rate: ul/min. The rate equation is: Rate = 1.5*t+t^2 , t(time)=10 s, then we press the ✚ key. In this step, we choose the 2nd equation as Rate = sin[t]*10+20,

t=40s, and repress the ✚ key. Then, we choose the 3rd equation as: Rate = 20, and t=20s. The final result is shown in figure.
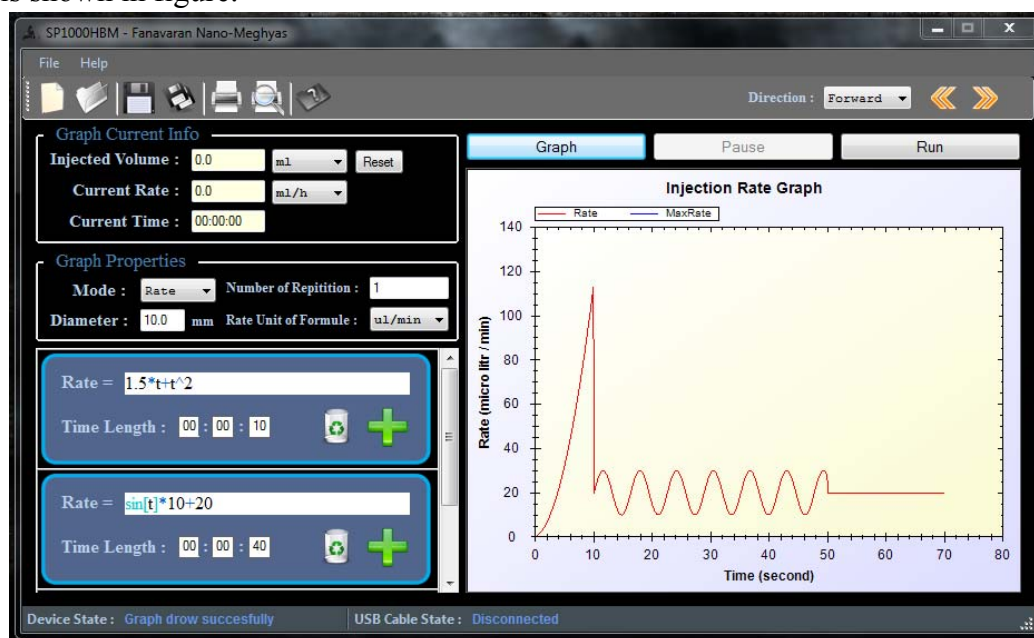
Example 2:

Imagine that an injection must be done three times by a 20-mm-diameter syringe, according to the following equation: (Unit of flow rate is microliter/hour).

$$\begin{cases} \left|10 \times t^2 \times \cos(t)\right| & Max\,Volume = 0.1ml \\ 2000 & Max\,Volume = 0.2ml \end{cases}$$

At first, in the graph specifications section, we choose syringe diameter=20 mm, type of graph: Rate, unit of flow rate: ul/min. and sequence No. =3. The rate equation is: Rate = abs[(10*t^2)*cos[t]] and the max of volume=0.1 ml. Then, we press the ✚ key. In this step, we choose the 2nd equation as: Rate=2000 and the max of volume=0.2 ml. The final result is shown in below image.

Appendix A: Equations

Use "t" as variant.

Name	Description	Example
+	Computes the sum of its two operands.	1.2 + 3.1 == 4.3
-	Computes the subtract of the second operand from the first.	57.3 – 26.8 == 30.5
*	Computes the product of its two operands.	4.5 * 3.0 == 13.5
/	Computes the divide of the second operand from the first.	60 / 0.3 == 200
^	Computes the first operand rose to the second operand.	2 ^ 10 == 1024
%	Computes the remainder after dividing its first operand by its second.	11 % 3 == 2

Name	Description	Example
abs	Returns the absolute value of a specified number.	abs[-1] == 1
acos	Returns the angle whose cosine is the specified number.	acos[1] == 0
asin	Returns the angle whose sine is the specified number.	asin[1] == 1.5708
atan	Returns the angle whose tangent is the specified number.	atan[1] == 0.7854
atan2	Returns the angle whose tangent is the quotient of two specified numbers.	atan2[-1, -1] == 3.9270
avg	Return the average of input numbers.	avg[1, 11, -2.5, -7.5, 8] == 2
ceiling	Returns the smallest integer greater than or equal to the specified number.	ceiling[-1.2] == -1
cos	Returns the cosine of the specified angle.	cos[3.1415] == -1
cosh	Returns the hyperbolic cosine of the specified angle.	cosh[2] == 3.7622
exp	Returns **e** raised to the specified power.	exp[1] == e
floor	Returns the largest integer less than or equal to the specified number.	floor[-1.2] == -2
ln	Returns the natural logarithm of a specified number.	ln[2] == 0.6931
log10	Returns the base 10 logarithm of a specified number.	log10[100] == 2
max	Returns the larger of input numbers.	max[1, -7.5, 8] == 8
mid	Returns the middle of input numbers.	mid[1, 11, -2.5, -7.5, 8] == 1
min	Returns the smaller of numbers.	min[1, 11, -2.5, -7.5] == -7.5
round	Rounds a value to the nearest integer or specified number of decimal places.	round[3.6] == 4
sign	Returns a value indicating the sign of a number.	sign[-5] == -1
sin	Returns the sine of the specified angle.	sin[3.1415] == 0
sinh	Returns the hyperbolic sine of the specified angle.	sinh[2] == 3.6269
sqrt	Returns the square root of a specified number.	sqrt[25] == 5
tan	Returns the tangent of the specified angle.	tan[0.7854] == 1
tanh	Returns the hyperbolic tangent of the specified angle.	tanh[2] == 0.9640

Appendix B: Syringe inside Diameter

Terumo

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

Sherwood Monoject Plastic

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

Popper & Sons, Inc. "Perfektum" Glass

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

Stainless Steel

Size	Diameter
8 cc	9.525 mm
20 cc	19.130
50 cc	28.600
100 cc	34.900

Becton Dickinson Plastic "Plasticpak"

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

Air Tite "All Plastic"

Size	Diameter
2.5 cc	9.60 mm
5.0	12.45
10	15.90
20	20.05
30	22.50
50	29.00

Unimetrics Series 4000 & 5000

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

SGE Scientific Glass Engineering

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

Hamilton Microliter Series Gastight

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

Appendix C: Syringe Needle Conversion Chart

Needle	Nominal Outer Diameter			Nominal Inner Diameter			Nominal Wall Thickness		
Gauge	inches	mm	tol. inches (mm)	inches	mm	tol. inches (mm)	inches	mm	tol. inches (mm)
7	0.180	4.572	±0.001 (±0.025)	0.150	3.810	±0.003 (±0.076)	0.015	0.381	±0.001 (±0.025)
8	0.165	4.191	"	0.135	3.429	"	"	"	"
9	0.148	3.759	"	0.118	2.997	"	"	"	"
10	0.134	3.404	"	0.106	2.692	"	0.014	0.356	"
11	0.120	3.048	"	0.094	2.388	"	0.013	0.330	"
12	0.109	2.769	"	0.085	2.159	"	0.012	0.305	"
13	0.095	2.413	"	0.071	1.803	"	"	"	"
14	0.083	2.108	"	0.063	1.600	"	0.01	0.254	"
15	0.072	1.829	±0.0005 (±0.013)	0.054	1.372	±0.0015 (±0.038)	0.009	0.229	±0.0005 (±0.013)
16	0.065	1.651	"	0.047	1.194	"	"	"	"
17	0.058	1.473	"	0.042	1.067	"	0.008	0.203	"
18	0.050	1.270	"	0.033	0.838	"	0.0085	0.216	"
19	0.042	1.067	"	0.027	0.686	"	0.0075	0.191	"
20	0.03575	0.9081	±0.00025 (±0.0064)	0.02375	0.603	±0.00075 (±0.019)	0.006	0.1524	±0.00025 (±0.0064)
21	0.03225	0.8192	"	0.02025	0.514	"	"	"	"
22	0.02825	0.7176	"	0.01625	0.413	"	"	"	"
22s	"	"	"	0.006	0.152	"	0.0111	0.2826	"
23	0.02525	0.6414	"	0.01325	0.337	"	0.006	0.1524	"
24	0.02225	0.5652	"	0.01225	0.311	"	0.005	0.1270	"
25	0.02025	0.5144	"	0.01025	0.260	"	"	"	"
26	0.01825	0.4636	"	"	"	"	0.004	0.1016	"
26s	0.01865	0.4737	"	0.005	0.127	"	0.0068	0.1734	
27	0.01625	0.4128	"	0.00825	0.210	"	0.004	0.1016	"
28	0.01425	0.3620	"	0.00725	0.184	"	0.0035	0.0889	"
29	0.01325	0.3366	"	"	"	"	0.003	0.0762	"
30	0.01225	0.3112	"	0.00625	0.159	"	"	"	"
31	0.01025	0.2604	"	0.00525	0.133	"	0.0025	0.0635	"
32	0.00925	0.2350	"	0.00425	0.108	"	"	"	"
33	0.00825	0.2096	"	"	"	"	0.002	0.0508	"
34	0.00725	0.1842	"	0.00325	0.0826	"	"	"	"